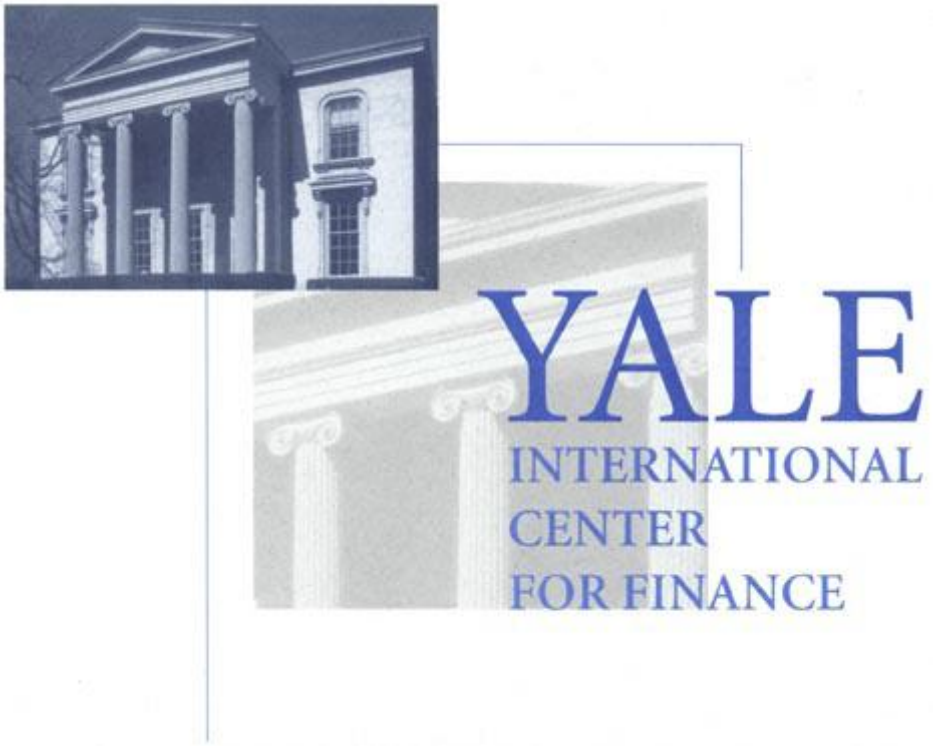

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James J. Choi, Yale School of Management, International Center for Finance and NBER

David Laibson, Harvard University and NBER

Brigitte C. Madrian, Harvard University and NBER

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The Flypaper Effect in Individual Investor Asset Allocation

Abstract: We document a flypaper effect in asset allocation: securities received in kind "stick where they hit." We study a firm that twice changed the rules governing the securities in which its 401(k) matching contributions were initially invested. Both of these rule changes were economically neutral: employees were always free to immediately reallocate their match account balances. However, we find that most employees neither reallocate their match balances, nor offset employer-initiated changes in the match allocation by adjusting the allocation of their own contributions. Consequently, these rule changes caused dramatic shifts in participants' 401(k) portfolio risk. After examining several alternative explanations for this flypaper effect, we conclude that it is largely due to a combination of passivity and mental accounting.

James J. Choi
Yale School of Management
135 Prospect Street
P.O. Box 208200
New Haven, CT 06520-8200
james.choi@yale.edu

David Laibson
Department of Economics
Harvard University
Littauer Center
Cambridge, MA 02138
dlaibson@harvard.edu

Brigitte C. Madrian
Kennedy School of Government
Harvard University
79 JFK Street
Cambridge, MA 02138
brigitte_madrian@harvard.edu

In this paper, we document a *flypaper effect* in the asset allocation of individual investors. Like the flypaper effects of public finance, corporate finance, and intra-household consumption (see Hines and Thaler, 1995, for a literature review, and Duflo and Udry, 2004, for evidence on the flypaper effect in intra-household consumption), we find that "money sticks where it hits" (this phrase is attributed to Arthur Okun). Individual investors given securities in kind hold onto those securities for a long time with minimal offsets in other parts of their portfolio. As a result, in-kind security transfers can cause dramatic shifts in the risk profile of an investor's portfolio. This is inconsistent with investors having a clear target asset allocation for their entire portfolio which they maintain through periodic rebalancing.

We identify the asset allocation flypaper effect by exploiting two natural experiments at a large firm. Throughout the period that we consider, for each dollar an employee contributed to the company's 401(k) savings plan up to a limit, the company made an additional matching contribution. The employee's own contributions to the 401(k) and the company's matching contributions were maintained in separate accounts.

Before March 2003, all matching contributions were made in the stock of the employer. After the match was received, however, all 401(k) participants were free to immediately trade out of the employer stock and into any of the other available investment options. In March 2003, the company implemented the first policy change that we study in this paper: it ceased requiring that 401(k) participants accept matching contributions in the form of employer stock. Instead, going forward, new participants were required upon enrollment to explicitly choose an asset allocation for their matching contribution flows, just as they did for their own-contribution flows.[1] Employees already enrolled in the 401(k) plan could also freely choose the asset allocation for their future matching contribution flows, but if they did not, their matching contributions continued to be directed entirely into employer stock.

Note that this plan change was economically neutral. Any asset allocation of *balances*—the allocation that determines investment returns—that was feasible in the new regime could be replicated under the old regime. In practice, however, the change was far from neutral. Employees who enrolled in the plan during February 2003 (one month before the rule change) chose to direct 23% of their 2003 own-contribution flows to employer stock; in contrast, 95% of

[1] Throughout this paper, we draw a distinction between the asset allocation for contribution flows and the asset allocation for balances. The former is the mix of assets in which incremental 401(k) contributions are initially invested. The latter is the mix of all accumulated assets currently held in the portfolio.

their 2003 matching contribution flows were directed into employer stock. This resulted in their holding 24% of their own-contribution balances and 94% of their match balances in employer stock at year-end 2003 (ten months after the rule change). In contrast, employees who enrolled in the plan during March 2003 (the first month after the rule change) chose to direct 20% of their 2003 own-contribution flows and 27% of their 2003 matching contribution flows to employer stock, resulting in 20% of their own-contribution balances and 27% of their match balances being held in employer stock at year-end 2003. Integrating the two 401(k) accounts, the fraction of total 2003 contributions going into employer stock—an undiversified, highly risky asset—dropped by more than half from 56% to 23% across the two enrollment cohorts, and the fraction of total year-end 2003 balances held in employer stock fell similarly, from 56% to 22%.

In April 2005, the company made a second change. For participants who had not yet actively elected an asset allocation for their matching contribution flows, the company automatically set the matching contribution flow asset allocation equal to what participants had previously selected for their own-contribution flows. The vast majority of participants who enrolled before the first plan change had not chosen an asset allocation for their matching contribution flows by this time, and most also remained passive in the face of this second change. As a result, matching contribution flows to employer stock plummeted overnight for these individuals to the much lower level that they had selected for their own contributions.

The asset allocation flypaper effect is primarily driven by two forces: passivity and narrow framing within mental accounts. Passivity among individual investors has been extensively documented (Samuelson and Zeckhauser, 1988; Madrian and Shea, 2001; Choi, Laibson, Madrian, and Metrick, 2002, 2004a; Choi, Laibson, and Madrian, 2005a,b; Agnew, Balduzzi and Sundén, 2003; Mitchell, Mottola, Utkus, and Yamaguchi, 2006). In the flypaper context, passivity manifests itself as the failure of investors to reallocate whatever securities are deposited into their match account. When the match is made in employer stock, 94% of match account balances remain in employer stock. Similarly, when the company changes match flow allocations to equal own-contribution flow allocations, almost nobody exercises their freedom to reverse this change. Passivity, however, cannot explain why decisions made *at enrollment*—a point when people have overcome their passivity and are taking an action—about the asset allocation of total contribution flows differ between the first two match allocation regimes.

We interpret this difference across the first two regimes as arising from mental accounting, which is the psychological segregation of subsets of the wealth portfolio (Thaler, 1985, 1990, 1999). Individuals then engage in "narrow framing" (Kahneman and Lovallo, 1993; Barberis, Huang, and Thaler, 2006) within these mental accounts, making decisions for each account without considering their other accounts. Because money is fungible, a rational agent should instead consider a financial decision's impact on her *entire* wealth portfolio, not just its effect on a subset of her portfolio. Before March 2003, enrollees only had to choose a flow allocation for their own-contribution account, making it easy for them to ignore the match flow allocation when making that decision. Starting in March 2003, enrollees were forced to simultaneously choose flow allocations for both accounts, making the two salient and encouraging them to be psychologically integrated. Consistent with this story, February 2003 enrollees directed 23% of their own-contribution flows to employer stock, while March 2003 enrollees directed 23% of their *combined* own-contribution and match flows to employer stock. Participants appear to have allocated roughly one quarter of their contributions to employer stock in whatever set of portfolios was salient, whether that set was narrow (own contributions) or broad (matching and own contributions). A pre-March 2003 enrollee who was not a narrow framer would have chosen a *lower* employer stock allocation for her own-contribution flows to compensate for the fact that she was constrained to a 100% employer stock allocation in her match flows.

The flypaper effect can help explain the high levels of employer stock ownership in some 401(k) plans, an outcome that runs contrary to the logic of diversification. Fidelity Investments (2002) reports that 44% of employer matching contributions are made in employer stock, like in the first regime of our study company. Even though 66% of companies that match in employer stock do not restrict the subsequent sale of employer stock, the flypaper effect causes diversification to be rare even when allowed.[2]

Our results complement those of Card and Ransom (2007), who study contributions to university defined contribution pension plans. Using across-plan comparisons, they find that lump-sum contributions that are labeled "employer contributions" crowd out discretionary employee contributions to the plan less than contributions labeled "mandatory employee

[2] See also Choi, Laibson, and Madrian (2005b) for evidence on passivity in the face of relaxed diversification restrictions.

contributions." They interpret this difference as arising because employees consider mandatory employee contributions a closer substitute for discretionary employee contributions than employer contributions, due to mental accounting.

Our paper is also related to other work that has shown that narrow framing affects asset allocation. The reluctance to realize paper losses (the "disposition effect") has been documented in many settings (e.g. Odean, 1998; Grinblatt and Keloharju, 2001; Wermers, 2003; Coval and Shumway, 2005; Frazzini, 2006) and seems inconsistent with investors caring only about their total wealth portfolio. Likewise, risk aversion over small gambles is a common behavior that is hard to rationalize for individuals who are concerned only with total wealth (Rabin, 2000).

Finally, our paper is adds to the literature on the determinants of employer stock holding in defined contribution savings plans. Benartzi (2001) and Huberman and Sengmueller (2004) show that past employer stock returns are positively correlated with current employer stock contribution allocations, suggesting that employees naively extrapolate past employer stock returns into the future. Choi, Laibson, Madrian, and Metrick (2004b) find that contribution flow allocations to employer stock are increasing in recent returns, but reallocation of balances into or out of employer stock is on average contrarian with respect to recent returns. Benartzi (2001) suggests that when companies require matching contributions to be made in employer stock, employees interpret this as an endorsement of employer stock that then drives employees to invest more of their own contributions in employer stock. (We will present evidence in Section IV that the endorsement effect is not a primary driver of the flypaper effect). Choi, Laibson, and Madrian (2005b) show that even when employees are allowed to diversify out of employer stock, the average portfolio response is small. Huberman (2001) argues that employer stock holdings are motivated by the comfort of investing in a familiar asset. Lastly, Cohen (forthcoming) shows that employees' loyalty to their company also plays a role in their willingness to hold employer stock.

The remainder of this paper proceeds as follows. Section I describes the features of the 401(k) savings plan at our study company, and Section II describes our data. Section III analyzes the impact of the two match policy changes on asset allocation outcomes. Section IV discusses the mechanisms underlying the flypaper effect. Section V concludes.

I. 401(k) Savings Plan Features at a Large U.S. Corporation

The company we study is a large publicly traded company in the retail sector. In December 2005, this firm had locations in all fifty U.S. states, as well as the District of Columbia and Puerto Rico. Table 1 lists the major 401(k) plan features at this company. Employees must actively opt into savings plan participation—there is no automatic enrollment. The company offers a generous employer match of 150% on the first 1% of pay contributed and 50% on the next 4% of pay, resulting in a total matching contribution of 3.5% of pay for participants contributing at least 5% of their pay. At year-end 2005, 59% of eligible employees participated in the 401(k).

Besides the two 401(k) plan changes discussed in the introduction that are the focus of this paper's analysis, there are three other plan changes that merit mention. First, before April 2003, employees were eligible to participate in the 401(k) starting 12 months after hire, provided they had worked at least 1,000 hours at the company. In April 2003, this eligibility requirement was reduced to 90 days of employment, although eligibility for the employer match was still restricted to those with 12 months of tenure and 1,000 hours of service.[3] The eligibility change affects savings plan participation for employees with lower levels of tenure, and one might worry that it confounds our estimates of the effect of the March 2003 plan change. We will show in Section III, however, that this eligibility change does not in fact alter our conclusions; the measured flypaper effect is virtually identical when we restrict our sample to an enrollment window over which eligibility requirements were constant.

The second noteworthy plan change was an increase in the maximum employee contribution rate from 15% to 50% of pay in January 2002. This change affects only the 4% of sample participants who contributed between 16% and 50% of pay after the higher maximum took effect. The third plan change also occurred in January 2002: an expansion in the number of 401(k) investment options. Prior to January 2002, participants had six investment options from which to choose, including employer stock. In January 2002, the company added two investment options, allowing participants to choose among a stable value fund, a balanced fund, five equity funds, and employer stock. Because we identify the flypaper effect from discontinuities in employer stock allocations chosen around March 2003 (the first plan change) and April 2005 (the second plan change), these two January 2002 plan changes should not contaminate our

[3] For a few small sub-groups of employees, this eligibility change did not take effect until later in 2003.

analysis. Moreover, we do not observe significant changes in employer stock allocations between employees enrolling just before and just after January 2002.

II. Data Description

Our data come from Hewitt Associates, a large benefits administration and consulting firm. The main data are a series of year-end cross-sections from 2002 to 2005 of all employees eligible to participate in the 401(k) plan at the study company. These cross-sections contain demographic information such as birth date, hire date, gender, and compensation.[4] They also contain information on each individual's 401(k), including participation status in the plan at year-end, date of first participation, monthly contribution rates, total dollars contributed to each investment option during the calendar year, and balances held in each investment option at year-end. The contribution flow and balance allocation information is given separately for the own-contribution account and the match account. We also make some limited use of data from year-end 1998.[5]

We impose three restrictions to obtain the plan participant sample used in our analysis. First, we consider only employees who enrolled in the plan between November 1998 and December 2005. We exclude participants who enrolled prior to November 1998 because the matching contribution in the plan was significantly changed at that time, and the focus of our analysis is on the asset allocation of matching contributions. Second, we drop 401(k) participants who are ineligible to receive matching contributions—those who have not completed 12 months at the company and 1,000 hours of service. We infer match eligibility from whether participants actually received a matching contribution. In a given year, about 16% of participants do not receive a matching contribution and are presumed ineligible for the match.[6] Finally, we purge the data of participants who are likely to have joined the company as a result of acquisitions (the firm made several acquisitions between 2002 and 2005) because these individuals may not be

[4] We only have data on compensation in the 2004 and 2005 year-end extracts.
[5] The 1998 data are only available for a random sub-sample of employees who were at the firm at year-end 1998.
[6] Of the plan participants in our year-end 2004 data extract who did not receive matching contributions, 72% had less than 1 year of tenure, 23% had 1 to 2 years of tenure, and only 5% had more than 2 years of tenure, a pattern that is consistent with the eligibility requirements for receipt of an employer match.

comparable to employees who joined the company organically.[7] Our results are qualitatively similar, however, even if we include participants who were potentially acquired.

Because the empirical analysis of the March 2003 plan change consists of comparing the asset allocation of employees who enrolled in the 401(k) before this change with those who enrolled after, we want to establish the comparability of these two groups. Table 2 presents demographic statistics as of year-end 2003 for employees who enrolled in the 401(k) during the month before and the month after the 2003 plan change (columns 1 and 2), as well as for employees who enrolled during the six months before and the six months after the plan change (columns 3 and 4). The broader group of enrollees who joined in the six months before and the six months after the plan change are similar in average age (38 years) and gender composition (61% male), and average and median incomes differ by no more than 4% between groups. The more recent enrollees are slightly less likely to be married (27% versus 33% for the earlier cohort) and, as expected, have a little less tenure at the company (2.3 years versus 3.0 years). The subset of employees who enrolled in the month before and the month after the plan also look similar, although the later group is slightly older than the earlier group. These numbers indicate that there were no significant changes in the company's 401(k) participant composition around March 2003.[8]

III. Empirical Results: The Impact of Match Policy on Asset Allocation

A. March 2003 Plan Change

Prior to March 2003, all employer matching contributions to the 401(k) plan were made in the form of employer stock, although employees had the ability to immediately trade out of

[7] Unfortunately, our data do not explicitly identify how employees joined the firm. To screen out acquired individuals, we drop employees whose initial appearance in our 2002-2005 data does not correspond to when they would have become eligible to participate if they were full-time employees, given their coded hire date. For example, full-time employees hired by the company in 2002 should first appear in our data in 2003 because the service requirement for plan eligibility was 12 months prior to April 2003. Employees who first appear in our data in 2003 but who were hired prior to 2002 are presumed to have been acquired sometime in 2003 and are excluded from our analysis. In 2003, the eligibility requirement was lowered from 12 months to 90 days of service. Thus, starting in 2003, we exclude individuals hired prior to the last 90 days of the calendar year who do not appear in that year's data (e.g., employees hired in June 2004 who do not make their first appearance until the 2005 data). We also drop employees hired during the last 90 days of a calendar year who do not appear in the subsequent year's data (e.g., employees hired in November 2003 who do not make their first appearance until the 2005 data).

[8] The larger number of post-March 2003 enrollees relative to pre-March 2003 enrollees is due to seasonal enrollment patterns coupled with the company's growing size over the sample period. Enrollees' average asset allocations do not follow a seasonal pattern when there are no plan changes, indicating that seasonality does not confound our plan change effect estimates.

the employer stock in their match account and into any of the plan's other investment options. Starting in March 2003, all participants were given the ability to choose an asset allocation other than 100% employer stock for their future matching contribution flows. Employees enrolling in the 401(k) after this change were *required* to specify an asset allocation for their matching contribution flows during enrollment, when they were also choosing an asset allocation for their own-contribution flows. The company's enrollment system would not allow the employee to complete the enrollment process unless an asset allocation was explicitly chosen for both own- and matching contribution flows. In contrast, employees who enrolled prior to the plan change were *not* required after the plan change to explicitly specify an asset allocation for future matching contribution flows, although they had the option to do so. If they did not make an active election, the company continued to direct these participants' matching contributions entirely into employer stock.

Figure 1 shows the impact of the 2003 plan change on asset allocation. The solid lines show, by month of plan enrollment (the *x*-axis), the average fraction of 2003 contribution flows that was allocated to employer stock for employees' own contributions (the grey line) and for their employer matching contributions (the black line).[9] Similarly, the dashed lines show own- and matching contribution flow allocations to employer stock in 2004.

We first consider the allocations to employer stock for the employees' *own* contributions in 2003 and 2004 (the grey solid and dashed lines). Across all enrollment cohorts, the average fraction of own-contribution flows allocated to employer stock was 37% in 2003 and 34% in 2004. Few employees changed their own-contribution flow allocation between these two years; 87% of participants observed at both year-end 2003 and year-end 2004 have the same annual contribution allocation to employer stock at both points in time. Thus, most of the variation in contribution flow allocations across enrollment cohorts reflects variation in allocation decisions made at the time of enrollment. Indeed, among November to December 1998 enrollees who were participants in the 401(k) plan at both year-end 2003 and five years earlier at year-end 1998, 76% had the same own-contribution allocation to employer stock in both years, and the average own-contribution flow allocation to employer stock was virtually unchanged over this period, 59% in 1998 and 61% in 2003.

[9] All figures weight each employee equally. Analogous figures with dollar-weighted averages are qualitatively similar and are available from the authors by request.

Consistent with the findings of Benartzi (2001) and Choi, Laibson, Madrian, and Metrick (2004b), the own-contribution flow allocation to employer stock tends to be higher among employees who enrolled when the company's stock had performed well in the recent past (to maintain the anonymity of the study company, stock market performance is not shown in the figure). The most important thing to notice, however, is that there is no discontinuity in own-contribution flow allocations to employer stock between the cohort enrolling immediately before the March 2003 plan change and the cohort enrolling immediately afterwards.

The picture for match flow allocations (the black lines) is strikingly different. The average fraction of annual matching contributions allocated to employer stock for employees who enrolled between November 1998 and March 2003 was 98% in 2003 and 94% in 2004. There is remarkably little variation in this average by enrollment month. At year-end 2004, 22 months after the company gave employees the option to direct their matching contribution flows to something other than employer stock, only 9% of participants who enrolled prior to March 2003 had done so. In contrast, employees who enrolled in the savings plan in March 2003 or later allocated a much lower fraction of their matching contribution flow to employer stock: 34% on average in 2003 and 35% in 2004. The sharp discontinuity in the matching contribution allocations to employer stock between employees enrolling before the March 2003 plan change and those enrolling afterwards is readily apparent in Figure 1.

The top panel of Table 3 shows the magnitude of the effect that the 2003 plan change had on the contribution flows allocated to employer stock. If we measure the effect of the 2003 plan change by comparing February 2003 enrollees to March 2003 enrollees, we obtain a 67.9 percentage point decline in the fraction of matching contribution flows allocated to employer stock. The difference between these two enrollment cohorts offers the cleanest comparison available, since neither group was affected by the April 2003 reduction in the waiting period for plan eligibility.[10] However, broadening the before and after groups to include employees who enrolled in the two months before and the two months after the plan change, or the six months before and the six months after the plan change, yields very similar estimates of 67.6 and 66.5 percentage points respectively. Interestingly, pre-March 2003 enrollees' average own-contribution allocation to employer stock and post-March 2003 enrollees' average *total*

[10] Although the waiting period for plan eligibility was reduced in April 2003, there was no change in the waiting period for eligibility to receive matching contributions. Because our sample is restricted to participants who receive a match, this April 2003 plan eligibility change should have little effect on our estimates.

contribution allocation to employer stock (matching plus own-contribution) are nearly identical; the two numbers are no more than a percentage point apart, regardless of the comparison groups used. The histogram in Figure 2 shows that this similarity holds not only for the means, but also for the distributions of pre-March 2003 enrollees' own-contribution allocations and post-March 2003 enrollees' total contribution allocations to employer stock.

There is no reason to believe that individuals enrolling immediately before the 2003 plan change had systematically different investment preferences than those enrolling immediately afterwards. As Table 2 shows, the observable characteristics of these employees are very similar, and the 401(k) plan administration team member with whom we corresponded was not aware of any shift in enrollee characteristics around March 2003. If the presumption of comparable investment preferences is correct, then both groups should have the same target level of total employer stock exposure, and the lower matching contribution flow into employer stock for the post-change enrollees should be offset by an increase in their own-contribution flow to employer stock. This is not what we observe. Table 3 and Figure 1 show that own-contribution flows to employer stock in fact *fall* by a small amount after the plan change (3.3 percentage points using the one-month comparison groups). The result is that the combined own- and employer match contribution flow to employer stock falls by 33.4, 33.2, and 31.3 percentage points using the one, two, and six-month comparison groups in Table 3.

Even though contribution flow allocations are dramatically different for those enrolling after the 2003 plan change than for those enrolling before, the allocation of *balances*, not flows, is what ultimately determines portfolio returns. It is possible that employees were reallocating their 401(k) assets after contributions were made in order to undo the discrepancies in flow allocations. Recall that even prior to March 2003, employees had the ability to transfer their accumulated match balances out of employer stock.

Figure 3 shows that such *ex post* rebalancing was not an important factor. The fraction of total balances held in employer stock at year-ends 2003 and 2004 looks remarkably similar to the contribution flow allocations to employer stock in Figure 1. For employees who enrolled prior to March 2003, the vast majority of employer match balances are invested in employer stock even at year-end 2004, 22 months after the plan change. This finding is consistent with the results of Choi, Laibson, and Madrian (2005b), who document that when employees are given the ability to diversify out of employer stock, almost none do. The fact that balance allocations closely track

flow allocations even for those who enrolled early in the sample period (e.g. 1998) demonstrates that flow allocation decisions (which are largely made upon enrollment and rarely revisited) are not much more likely to be reversed as 401(k) balances grow larger and the absolute dollar consequences of the 401(k) asset allocation increase.

The bottom panel of Table 3 shows the estimated impact of the 2003 plan change on the balances held in employer stock. We compare holdings of groups who enrolled in the month before and the month after the plan change, the two months before and the two months after the plan change, and the six months before and the six months after the plan change. As suggested by Figure 3, the balance results are nearly identical to the contribution flow results. The fraction of match balances held in employer stock falls by between 65.7 and 67.6 percentage points—an effect only slightly smaller than that measured for contribution flow allocations—whereas the fraction of own-contribution balances held in employer stock falls by at most 3.8 percentage points. Integrating the own-contribution and employer match accounts, the impact on total 401(k) balances is a 32.0 to 34.2 percentage point reduction in employer stock holdings.

We have also estimated the regression-adjusted impact of the 2003 plan change for each of the comparison groups and accounts listed in Table 3, controlling for demographic characteristics.[11] These unreported results differ little from the raw effects—the flypaper effect is not arising due to differences in the demographic composition of employees before and after the 2003 plan change. Moreover, we also find that the magnitude of the flypaper effect is similar across different demographic subgroups. Of particular note, even higher-income participants—who are probably the most financially literate—exhibit a flypaper effect that is comparable in size to the company-wide average flypaper effect. Finally, the flypaper effect is not arising from the fact that some participants may not value the employer match (and thus pay little attention to it) because they have not yet met the company's vesting requirements—we find that the magnitude of the flypaper is similar even when we restrict the sample to employees whose matching contributions are fully vested upon enrollment.[12]

One might expect that starting in March 2003, when new enrollees were required to simultaneously choose an asset allocation for their own-contribution and matching contribution

[11] The regression-adjusted results control for gender, marital status, age, tenure, income, and plan balances. These results are available from the authors upon request.

[12] Plan participants at our study company are 100% vested in their employer matching contributions once they reach 3 years of service. If they leave the firm before reaching 3 years of service, they forfeit all of their accumulated employer match balances.

flows, it would be natural to choose the same allocation for both flows. However, we see in Table 3 that on average, post-change enrollees allocate 7 percentage points more to employer stock in their match account than in their own-contribution account. In fact, about three-quarters of post-change enrollees do have identical allocations in both accounts. It is unclear why the remaining quarter choose different allocations, and why they tend to allocate more to employer stock in their match account. The demographic characteristics of those who choose the same versus different allocations are similar, although those who allocate more to employer stock in their match account are slightly younger (1.3 years) and slightly higher paid (about $2,400).

One potential explanation is that employees are willing to take more risk in their match account, which they perceive as "house money" that can be lost without much regret (Thaler and Johnson, 1990; Clark, 2002). This explanation assumes that employees perceive employer stock to be a riskier investment than the other options available in the plan. However, several surveys document that individuals on average believe that employer stock is *less* risky than a well-diversified stock mutual fund (John Hancock Financial Services, 2002; Benartzi et al., 2007). We also find that the likelihood of holding more employer stock in the match account than in the own-contribution account does not depend on the vesting status of participants. If the match feels less like house money once the participant is vested, then the lack of such a relationship is further evidence against the house money hypothesis in this context.

Another possible explanation is a gift-exchange motive. If the match is perceived to be a gift from the employer, then employees may reciprocate the kindness by holding more employer stock in their match account. Cohen (forthcoming) argues that employee loyalty increases the holding of employer stock.

B. April 2005 Plan Change

We turn now to the second plan change that affected the asset allocation of matching contributions. In April 2005, the company identified participants who had not yet actively elected an asset allocation for their matching contribution flows (and as a result had 100% of their matching contribution flows directed into employer stock). The company then set the asset allocation for these participants' matching contribution flows equal to the asset allocation that they had selected for their own-contribution flows. Participants who had already actively chosen an asset allocation for their matching contribution flows were unaffected.

This plan change affected almost all of the participants who had enrolled before March 2003. By the end of March 2005 (two years after the 2003 plan change), 91% of these participants had received all of their 2003, 2004, and January to March 2005 matching contributions in employer stock. In contrast, post-March 2003 enrollees were required to select an asset allocation for their matching contributions when enrolling in the plan and were thus untouched by the change.

We measure the impact of the April 2005 plan change by comparing participants' contribution allocations before the plan change and after the plan change. Our data separate 2005 matching contribution flows into those made before this plan change (January 1 to March 31, 2005) and those made after this plan change (April 1 through December 31, 2005). For own-contribution flows, however, we have only an aggregate figure for the entire year. We therefore assume that the 2004 own-contribution flow allocation to employer stock was still in effect for the first three months of 2005. Given the high levels of inertia in employer stock allocations we have already documented, this assumption seems reasonable. We then calculate what the own-contribution allocation to employer stock must have been for the last nine months of 2005 (after the plan change).

Figure 4 shows that the fraction of 2005 matching contribution flows allocated to employer stock is similar before April 2005 (the solid black line) and after April 2005 (the dashed black line) for participants who enrolled *after* the first plan change in 2003. Recall that these employees were required to make an active allocation decision for their matching contributions. The picture is very different for employees who enrolled *before* the March 2003 plan change. Their matching contributions in the first three months of 2005 (the solid black line) are still almost entirely allocated to employer stock, even though 22 months have elapsed since they were allowed to choose their own matching contribution flow allocation. In contrast, their matching contributions in the last nine months of 2005 (the dashed black line) are dramatically lower and, as expected, mirror their own-contribution allocations. Table 4 shows that among those who enrolled between November 1998 and February 2003, the fraction of matching contribution flows allocated to employer stock plummeted 55.7 percentage points—from 94.1% to 38.4%—starting in April 2005.[13]

[13] This 56 percentage point decline is about 10 percentage points smaller than the decline in the share of matching contribution flows allocated to employer stock following the 2003 plan change. There are two factors that account

Did pre-March 2003 enrollees offset these dramatic match flow allocation changes by increasing the employer stock allocations of their own-contribution flows? Figure 4 shows that they did not. The fraction of own-contribution flows allocated to employer stock in 2005 before the second plan change (the solid gray line) is very similar to the fraction allocated to employer stock after the plan change (the dashed gray line). As a result, Table 4 shows that the total flow allocation (matching plus own-contribution) to employer stock fell from 62.4% to 37.3% among pre-March 2003 enrollees after the 2005 plan change. Note that these effects hold regardless of participants' enrollment dates, suggesting the flypaper effect is not driven by participants' having insufficient plan balances to care about the 401(k) or by a lack of experience within the plan. Moreover, as with the 2003 plan change, the effects of the April 2005 plan change are similar in magnitude if we restrict our sample to participants whose match balances were fully vested at the time of the change.

Despite the large drop in matching contribution flow allocations to employer stock among pre-March 2003 enrollees, Figure 5 and Table 4 show that the 2005 plan change caused a much smaller decline in the share of match balances held in employer stock, from 93.4% before the plan change (at year-end 2004) to 81.4% after the plan change (at year-end 2005), a difference of only 12.0 percentage points. This discrepancy between the impact on contribution flow allocations and the impact on balance allocations is due to the fact that the plan change only affected the allocation of contribution flows going forward, not the allocation of balances already accumulated before April 2005. If participants made no active 401(k) allocation changes in response to the plan change, the fraction of balances allocated to employer stock would diminish only gradually over time, with a more rapid decline for participants whose contribution flow is large relative to their previously accumulated balances. Consistent with near-universal passivity,

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for the smaller magnitude of the 2005 plan change effect. The first is that the 2003 plan change affected all new enrollees going forward, whereas the 2005 plan change affected only the 91% of pre-March 2003 enrollees who had not already actively chosen their matching contribution flow allocation. The second is that we measure the effect of the 2003 plan change and that of the 2005 plan change on different samples of enrollees. The effect of the 2003 plan change is computed by comparing the 2003 allocations of employees who enrolled in the one, two, or six months before March 2003 to those who enrolled in the one, two, or six months after March 2003. We measure the effect of the 2005 plan change by comparing the January to March 2005 allocations of employees who enrolled in the 401(k) from November 1998 to February 2003 to those same enrollees' allocation over the April to December 2005 period. Note that employees who enrolled prior to September 2002 had a much higher fraction of their own contributions allocated to employer stock than those who enrolled later, probably due to the stock's strong performance in earlier years. As a result, when the company set matching contribution allocations equal to own-contribution allocations, pre-September 2002 enrollees' matching contribution allocations to employer stock declined by less. If we had restricted our sample to September 2002 to February 2003 enrollees when computing the 2005 plan change effect, the two plan changes' effects would have a similar magnitude.

if we stratify pre-March 2003 enrollees into thirds based on the ratio of their 2005 contributions to their year-end 2004 balances, the decline in the fraction of balances held in employer stock from year-end 2004 to year-end 2005 is 17 percentage points for participants with the highest ratio of contributions to balances, 13 percentage points for those in the middle, and 7 percentage points for those with the lowest ratio of contributions to balances.

In contrast to the disparate impact of the 2005 plan change on contribution flow allocations to employer stock and balance allocations to employer stock, we found little discrepancy between the effects of the 2003 plan change on these two outcomes. The reason for the similarity in the two effects for the 2003 plan change is that we identified the 2003 plan change effect by comparing the cohort who enrolled immediately before the 2003 plan change to the cohort who enrolled immediately afterwards. The later cohort never contributed to the plan under the old regime, and hence had no accumulated balances under the old regime to attenuate the effect of the 2003 plan on balances. When identifying the 2005 plan change effect, we are comparing pre-March 2003 enrollees' balance allocations at year-end 2004 (when they had at least 22 months of accumulated contributions) to their balance allocations at year-end 2005.

Another difference between the 2003 and 2005 plan changes is the magnitude of the discrepancy between the fraction of own- and matching contributions allocated to employer stock among affected employees. Recall that after the 2003 plan change, post-March 2003 enrollees allocated 7 percentage points more of their matching contributions to employer stock than they did of their own contributions. Table 4 shows that this difference remains about 6 to 7 percentage points just prior to and after the 2005 plan change. For the pre-March 2003 enrollees, however, this gap is a much smaller 1.5 percentage points after the 2005 plan change.

This discrepancy in outcomes between the 2003 and 2005 plan changes is largely mechanical. As noted above, 91% of the pre-March 2003 enrollees were affected by the April 2005 plan change. These affected employees had their match flow allocation going forward set equal to their own-contribution flow allocation. We would thus expect almost no difference between the match flow allocation and the own-contribution flow allocation to employer stock for this group. The small discrepancy between the fraction of contributions allocated to employer stock from April to December 2005 in the own- and matching contribution accounts is due to the 9% of pre-March 2003 enrollees who were not affected by the 2005 plan change. Consistent with

the pattern observed for post-March 2003 enrollees, the employer stock flow allocation is higher in the match account (36.4%) than in the own-contribution account (18.9%) for this group.

IV. Discussion: Passivity, Mental Accounting, Ignorance, and Endorsement Effects

What drives the asset allocation flypaper effect? The most obvious force is passivity. Before the 2003 plan change, savings plan participants had the ability to transfer their match account balances out of employer stock, yet very few chose to do so. At year-end 2002, two months before the first plan change, 97% of participants in our sample had 100% of their match balances allocated to employer stock. Surprisingly, the fraction of participants at year-end 2002 with all their match balances invested in employer stock is *not* sensitive to tenure within the savings plan; newer and older participants alike were almost completely passive within their match account. We also see after the 2005 plan change that almost all employees who had not previously made an active match flow allocation decision passively accepted the company's change to their match flow allocation.

The March 2003 rule change generated large asset allocation differences between enrollment cohorts that had a material impact on their portfolio risk. We have already noted that employees enrolling on either side of this first rule change look very similar in their observable characteristics, so it is unlikely that enrollment cohorts immediately before and after the rule change had extremely different investment preferences. The April 2005 rule change affected the asset allocation of pre-March 2003 enrollees. We doubt that the pre-March 2003 enrollees' optimal asset allocation changed in April 2005 in a way that happened to coincide with the result of passively accepting the company's match allocation choice. The passivity we document is consistent with other evidence in the savings literature (Samuelson and Zeckhauser, 1988; Madrian and Shea, 2001; Choi, Laibson, Madrian, and Metrick, 2002, 2004a; Choi, Laibson, and Madrian, 2005a,b; Agnew, Balduzzi, and Sundén, 2003; Mitchell, Mottola, Utkus, and Yamaguchi, 2006).

However, passivity cannot be the entire explanation for the dramatic shift in portfolio allocations caused by the first plan change in March 2003. An employee in the process of enrolling in her 401(k) plan has momentarily overcome passivity. The cost of explicitly stating an asset allocation preference is already sunk, so there is no reason not to choose an allocation that is closest to what the employee thinks is optimal. An enrollee before March 2003 thus

should have reduced the fraction of her own contributions allocated to employer stock upon enrollment to compensate for the fact that all of her matching contributions would be made in employer stock. We instead see that own-contribution allocations to employer stock among pre-March 2003 enrollees are similar to own-contribution allocations among post-March 2003 enrollees, even though post-March 2003 enrollees allocate less than a third of their matching contributions to employer stock. Thus, there must be some other factor at play as well.

One candidate is the short-sales constraint imposed by the 401(k). Suppose pre-March 2003 enrollees want to reduce their own-contribution flow allocation to employer stock in order to compensate for their match flow allocation. However, they are unable to allocate less than zero to employer stock in their own-contribution flows. Therefore, in the absence of a willingness to trade in the match account after enrollment, they are "constrained" to hold a large fraction of their portfolio in employer stock. Once employees can (and are required to) specify a matching contribution flow allocation, this short-sales constraint is effectively relaxed, and they are able to hold less employer stock.

Could such a short-sales constraint explain the flypaper effect? Appendix A describes the calculation of how much employer stock allocations would be expected to drop if only a short-sales constraint were operative. We find that such a constraint cannot come close to quantitatively generating a drop equal to what we observe.

However, passivity combined with narrow framing within mental accounts (Thaler, 1985, 1990, 1999) *can* explain all of this paper's key results (except for the fact that participants voluntarily choose to hold employer stock in the first place, an issue we do not focus on here). Prior to the 2003 plan change, enrollees made an asset allocation decision for only their own-contribution flows. Therefore, it was easy to put own-contributions into their own mental account and to make flow allocation decisions for these contributions while ignoring the match flow allocation. After the 2003 plan change, enrollees were forced to simultaneously choose allocations for both accounts, which made both salient and encouraged integration of the two into the same mental account when making those decisions. Consistent with this story, participants who enrolled in the 401(k) just before March 2003 allocated about 25% of their own-contribution flows to employer stock, whereas those enrolling just after allocated about 25% of their *total* contribution flows to employer stock. The average participant appears to want to allocate roughly one quarter of their assets to employer stock in whatever portfolios are

salient, whether the set of salient portfolios is narrow or broad. Figure 3 shows that this scale-invariance applies not only to the mean, but also to the distribution of allocations to employer stock. That is, the distribution of own-contribution flow allocations to employer stock among pre-March 2003 enrollees is very similar to the distribution of total contribution flow allocations to employer stock among post-March 2003 enrollees.

Note that mental accounting alone cannot explain all of the flypaper effect. Mental accounting explains why choices in the own-contribution account do not respond to what happens in the match account when the match account is not salient, while passivity explains why the match account's allocation is influenced by employer defaults (and changes in those defaults).

Of course, without direct measurement of participant knowledge about the employer match, mental accounting in the pre-March 2003 regime is observationally equivalent to participant ignorance of the match's existence or its asset allocation. Although we find some degree of ignorance plausible, ignorance alone cannot account for the magnitude of the 2003 flypaper effect. In Appendix B, we calculate a lower bound on the fraction of ignorant participants required to generate the 2003 flypaper effect. Our lower bound estimates range from 92% to 94%, which we deem an implausibly large fraction of participants that are unaware of a major feature of their 401(k) plan.

There is a final candidate explanation for the 2003 flypaper effect: employees may have perceived the 2003 plan change as removing the company's implicit endorsement of its stock as an attractive investment. The perception of such an endorsement could explain why so few participants diversified out of employer stock in their match account before the 2003 plan change. And the removal of the endorsement could have generated the large drop in employer stock allocations after the change.

Past research has documented the existence of such endorsement effects. For example, Benartzi (2001) shows that among companies that offer employer stock in their 401(k) investment menu, savings plan participants allocate 18% of their own contributions to employer stock when the employer match's allocation is left to the participants' discretion, and 29% when the match must be accepted in employer stock, a difference of 11 percentage points. Brown, Liang, and Weisbenner (forthcoming) document a similar 7 percentage point effect using across-firm variation in match allocation policy. On the other hand, Brown, Liang, and Weisbenner find

that the endorsement effect disappears after controlling for firm fixed effects. Madrian and Shea (2001) show that the employer's choice of a default investment fund under automatic 401(k) enrollment also creates an endorsement effect. Looking only at participants who were not subject to automatic enrollment, they find that the fraction of 401(k) assets allocated to the default fund is 12 to 14 percentage points higher for participants who enrolled after the fund was designated as the default than for participants who enrolled before. The implied endorsement of the automatic enrollment default is also corroborated in Beshears et al. (2008).

Based on this evidence, it is plausible that our participants preferred a higher contribution allocation to employer stock before the March 2003 plan change than after. However, the endorsement effect magnitudes found in other studies are much smaller than the 33 percentage point effect of the 2003 plan change. It would also be a remarkable coincidence if the 2003 plan change generated an endorsement effect at our company that by itself caused total employer stock allocations among post-March 2003 enrollees to almost *exactly* equal the own-contribution employer stock allocations among pre-March 2003 enrollees.

Moreover, participant behavior after the 2003 plan change is inconsistent with an endorsement effect of such a large magnitude. If employer stock was perceived to be much less attractive starting in March 2003, there should have been a corresponding change in the asset allocation for pre-March 2003 enrollees'. Despite high levels of passivity among individual investors, about one-sixth of those automatically enrolled in the 401(k) plans analyzed by Choi, Laibson, Madrian, and Metrick (2004a) trade out of the default asset allocation within a year, and Carroll et al. (2007) find that the further away the status quo is from a participant's optimum, the faster the participant will make a change.

Figure 6 shows no evidence that trading out of employer stock increased following the 2003 plan change. This figure plots the fraction of participants who on net traded out of employer stock[14] during calendar years 2002, 2003, or 2004 against their tenure in the plan at year-end. Consistent with an *sS* action rule, trading frequency increases with tenure in the plan, as participants' asset allocation drifts over time away from their perceived optimum. Pre-March 2003 enrollees span the entire 2002 series, the range greater than or equal to 10 months of tenure in the 2003 series, and the range greater than or equal to 22 months of tenure in the 2004 series.

[14] In other words, we subtract the dollar value of trades out of employer stock from the dollar value of trades into employer stock during the year, and see if that difference yields a negative number.

We see that on a plan-tenure-adjusted basis, pre-March 2003 enrollees were *less* likely to trade out of employer stock in 2003 and 2004 than in 2002. Figure 7 shows that on a plan-tenure-adjusted basis, the average dollar size of net transfers out of employer stock (including net transfers in as negative values) is also no larger in 2003 or 2004 than in 2002. It therefore seems unlikely that an endorsement effect accounts for a large portion of the March 2003 plan change effect.

We conclude that the large flypaper effect documented in this paper is primarily driven by a combination of passivity and mental accounting. A short sales constraint combined with passivity, ignorance of the match's existence or its asset allocation, and the removal of an endorsement effect may have played smaller roles. Note that the latter two explanations work against each other; a large endorsement effect implies that most participants know what their match asset allocation is, ruling out extreme ignorance. The coexistence of ignorance and endorsement effects thus limits the size of either of these effects.

V. Conclusions

This paper documents a large flypaper effect in the asset allocation of individual investors. We do so by examining the asset allocation of 401(k) participants at a large firm that initially directed all matching contributions into employer stock, but subsequently allowed employees to choose their own asset allocation for matching contribution flows. The company later made a second change, automatically making the matching contribution flow allocation equal the own-contribution flow allocation for participants who had never actively chosen their matching contribution flow allocation.

We have two key findings. First, consistent with previous research, the asset allocation of 401(k) investors is extremely persistent. Even when participants are given the ability to trade out of employer stock, few do so, despite the fact that employer stock initially comprised about 56% of their total 401(k) portfolio. Second, the allocation to employer stock in participants' own-contribution accounts is unrelated to the allocation in their match accounts when participants do not actively choose their match account allocation. Despite the fact that the firm's two rule changes dramatically reduced employer stock allocations in match accounts, employer stock allocations in the own-contribution accounts did not correspondingly rise to offset this reduction.

This lack of integration across two very similar accounts is consistent with the theory of mental accounting.

This second result has implications for the interpretation of empirical research that focuses on only part of an investor's portfolio. For example, many papers in recent years have examined asset allocation outcomes in only one set of financial accounts—for example in 401(k) plans (e.g., Madrian and Shea, 2001; Choi, Laibson, Madrian, and Metrick, 2002, 2004a; Choi, Laibson, and Madrian, 2005a,b; Agnew, Balduzzi, and Sundén, 2003; Mitchell, Mottola, Utkus, and Yamaguchi, 2006; Brown, Liang, and Weisbenner, forthcoming) or in retail brokerage accounts (e.g., Odean, 1998; Barber and Odean, 2000; Goetzmann and Kumar, 2005). One concern is that many behaviors in these accounts that appear irrational in isolation may be justified by offsetting effects in the rest of the individual's portfolio. Although we do not observe the entire portfolio of individuals in this paper, we do observe two separate accounts and document that outcomes in one account are not offset by outcomes in the other account when investors are not forced to simultaneously make active decisions for both. The lack of integration across two accounts within the 401(k) plan suggests that a similar lack of integration may often apply across other financial accounts as well.

We find the lack of integration in this context particularly striking given the relatively low costs of actually performing the integration across the own-contribution and match accounts—both accounts are described to employees in the same set of plan documents, both accounts are reported in the financial statements mailed to participants on a regular basis, and both accounts are equally accessible to employees who desire to make a change to either one. Integrating across other types of financial accounts is likely to be a much more complicated and time consuming task.

This paper's results also have implications for public policy. The risks of having a portfolio with significant exposure to employer stock have been well-documented (Brennan and Torous, 1999; Poterba, 2004; Meulbroek, 2005). After bankruptcies at companies like Enron wiped out the 401(k) assets of their employees, who held much of their 401(k) in employer stock, many companies relaxed rules that restricted the ability of 401(k) participants to diversify out of employer stock. The subsequently enacted Pension Protection Act also contains provisions capping mandatory holding periods of employer stock in 401(k) plans. In particular, the Act requires that employee contributions to employer stock must be immediately diversifiable, and

employer contributions must be diversifiable after three years. It does not cap overall exposure to employer stock in the 401(k), and it does not preclude employers from directing their matching contributions into employer stock. The evidence presented in this paper, along with that in Choi, Laibson, and Madrian (2005b), suggests that these provisions of the Pension Protection Act and similar company-sponsored initiatives will only have a modest impact on 401(k) employer stock holdings. Because of passivity, the ability to diversify does not by itself lead to diversification.

In contrast, the policy implemented by the company studied in this paper is an interesting private sector alternative to reducing employer stock exposure in savings plans. Many companies, while cognizant of the diversification problems that employer stock creates for their 401(k) participants, are reluctant to immediately eliminate employer stock holdings in their plan out of concern that such a measure will lower their stock price. This paper's company chose to reduce the employer stock share of contributions *going forward*, while leaving existing employer stock holdings untouched. Furthermore, the contribution allocation changes were implemented in two phases, each phase affecting only a subset of the firm's employees. If the firm were to make no more changes, the fraction of total balances held in employer stock would fall over time, reaching an asymptote equal to the employer stock allocation of ongoing contribution flows. This gradual approach minimizes short-term selling pressure from the 401(k) that might reduce the company's stock price.

Of course, there are other approaches to reducing employer stock holdings than the one implemented by this company. These alternatives include the wholesale elimination of employer stock from the investment menu, capping the fraction of balances that can be held in employer stock (e.g., 20%), or allowing employees to opt into a gradual and automatic reduction of their employer stock holdings (Benartzi and Thaler, 2003). For some firms, however, the approach taken by this paper's company may be preferred over these other options, since it is gradual and does not require action on the part of plan participants.

APPENDIX A. An Upper Bound on the Role of a Short Sales Constraint in the 2003 Plan Change Effect

Suppose that pre-March 2003 enrollees want to reduce their own-contribution flow allocation to employer stock in order to compensate for the 100% employer stock allocation in their matching contribution flows. However, they are unable to allocate less than zero to employer stock in their own-contribution flows, and they are unwilling to reallocate their balances after contributions are made. After March 2003, enrollees could allocate less than 100% to employer stock in their matching contribution flows, effectively relaxing this short-sales constraint. How much of the reduction in total employer stock flow allocations among post-March 2003 enrollees could be accounted for by this relaxing of the short sales constraint?

To answer this question, we start with the null hypothesis that the short sales constraint is the only reason for the observed differences between the flow allocations to employer stock of pre-March 2003 and post-March 2003 enrollees. We then calculate what pre-March 2003 enrollees' total flow allocation to employer stock would have been in the absence of a short sales constraint.

Let S_i be the actual 2003 total employer stock flow allocation of a pre-March 2003 enrollee *i*. Let S_i^* be *i*'s latent desired total employer stock flow allocation in the absence of the short-sales constraint. Note that $S_i^* = S_i$ for enrollees with a positive own-contribution allocation to employer stock, since such enrollees are not constrained. We estimate any unobserved S_i^* using the distribution of total employer stock flow allocations among post-March 2003 enrollees. Thus,

$$\widehat{S_i^*} = \begin{cases} S_i & \text{if own-contribution employer stock share} > 0 \\ E(S_{post} \mid S_{post} < S_i) & \text{if own-contribution employer stock share} = 0 \end{cases}, \qquad (1)$$

where S_{post} is the 2003 total employer stock flow allocation of post-March 2003 enrollees.

Using $\widehat{S_i^*}$ values derived from March 2003 enrollees' choices, we estimate an average unconstrained total employer stock flow allocation for the February 2003 enrollment cohort of 35%. This is substantially higher than the 23% average allocation observed for the March 2003 enrollment cohort. The estimated unconstrained average for the January to February 2003 enrollees is 37% when using March to April 2003 enrollees to estimate $\widehat{S_i^*}$, which is again higher than the 25% average allocation the March to April 2003 enrollment group chose. For

September 2002 to February 2003 enrollees, the unconstrained average is 40% when using March to August 2003 enrollees to estimate $\widehat{S_i^*}$. The March to August 2003 enrollees actually allocated only 27% on average. In sum, short-sales constraints cannot quantitatively generate the drop in total employer stock allocations we observe starting in March 2003.

Note that short-sales constraints will *mechanically* appear to explain a substantial fraction of the flypaper effect even if no pre-March 2003 enrollee thinks she wants a lower total flow allocation to employer stock and the March 2003 plan change effect is entirely due to mental accounting. Mental accounting predicts that the distribution of post-March 2003 enrollees' total flow allocations will be similar to pre-March 2003 enrollees' own-contribution flow allocations. Consistent with this prediction, about half of pre-March 2003 enrollees allocated nothing to employer stock for their own-contribution flows, and about half of post-March 2003 enrollees allocated nothing to employer stock for their total contribution flows. An econometrician wanting to confirm the short-sales constraint null hypothesis will count as constrained the 50% of pre-March 2003 enrollees who allocated none of their own contributions to employer stock. The econometrician would then impute $\widehat{S_i^*}$ for these ostensibly constrained investors as being close to 0, since so many of the post-March 2003 enrollee total allocations are close to 0. Therefore, the pre-March 2003 enrollees' estimated unconstrained allocations will be considerably lower than their actual allocations even if none of the pre-March 2003 enrollees were actually thinking that they wanted a lower total employer stock allocation.

APPENDIX B. A Lower Bound on the Prevalence of Ignorant Employees Needed to Generate the 2003 Plan Change Effect

This appendix calculates a lower bound on the proportion of pre-March 2003 enrollees who need to be ignorant of the match's existence in order to quantitatively generate the portfolio effect of the 2003 plan change.

Let x_i be the fraction of participant *i*'s 401(k) contribution flow that is her own contributions (rather than the employer match). Let S_i^* be the desired employer stock proportion of the total contribution flow (own plus matching contribution flow), and S_i be the actual employer stock proportion of total contribution flow. When ignorant of the match's existence, a participant believes that her own-contribution flow allocation equals the total contribution flow allocation. In fact, the match is directed entirely to employer stock. Thus, the actual total flow allocation to employer stock of an ignorant participant is

$$S_i = x_i S_i^* + (1 - x_i) . \tag{2}$$

Starting in March 2003, it became impossible for an enrollee to be ignorant of the match's existence because enrollees had to actively choose an asset allocation for their matching contribution flow. Assume that a participant who is aware of the match's existence allocates her match and own-contribution flows so that $S_i = S_i^*$. For a participant who would have been ignorant in the pre-March 2003 regime, the difference in the total employer stock share between the two regimes is:

$$\Delta S_i = (1 - x_i) S_i^* - (1 - x_i) . \tag{3}$$

What is the resulting population average change in employer stock share? Let *p* be the fraction of ignorant people among pre-March 2003 enrollees. Assuming that non-ignorant people would choose the same allocation in both regimes, it is straightforward to show that

$$p = \frac{E(\Delta S_i)}{E(S_i^* \mid \text{ignorant}) - E(x_i S_i^* \mid \text{ignorant}) - 1 + E(x_i \mid \text{ignorant})} . \tag{4}$$

Let p_x be the fraction of participants with an own-contribution share of *x* who would be ignorant in the first regime. By conditioning on *x*, we can pull it out of the expectations operator and get

$$p_x = \frac{E(\Delta S_i \mid x_i = x)}{(1 - x)[E(S_i^* \mid \text{ignorant}, x_i = x) - 1]} . \tag{5}$$

We can observe $E(\Delta S_i \mid x_i = x)$ directly from the data by calculating the change across regimes in total employer stock allocations among people whose own-contribution percent of total contributions is *x*. Therefore, the only unobserved parameter in (4) is $E(S_i^* \mid \text{ignorant}, x_i = x)$.

The assumption that S_i^* has the same distribution among pre- and post-March 2003 enrollees imposes restrictions on $E(S_i^* \mid \text{ignorant}, x_i = x)$. Specifically, suppose a fraction p_x of pre-March 2003 enrollees with $x_i = x$ are ignorant. Then there must be some subset of post-March 2003 enrollees with $x_i = x$ which (a) contains exactly a fraction p_x of all post-March 2003 enrollees with $x_i = x$, and (b) has an average total employer stock allocation equal to $E(S_i^* \mid \text{ignorant}, x_i = x)$. Because p_x is increasing in $E(S_i^* \mid \text{ignorant}, x_i = x)$, a lower bound on p_x will minimize this expectation by classifying as ignorant those with the lowest S_i^*. The following establishes a lower bound on p_x:

$$\underline{p}_x = \min_{p_x} \frac{E(\Delta S_i \mid x_i = x)}{(1-x)[E(S_i^* \mid x_i = x,\ F_x(S_i^*) < p_x) - 1]}, \tag{6}$$

where F_x is the cdf of the S_i^* distribution among post-March 2003 enrollees for whom $x_i = x$.

To calculate $\underline{p}_x$, we start with the guess that there are no ignorant people for whom $x_i = x$, so $\underline{p}_x = 0$. If equation (5) is not satisfied under this guess, we add the post-March 2003 enrollee with the lowest S_i^* value to the ranks of the ignorant and check to see if (5) is now satisfied. We continue to add to the ranks of the ignorant from the left of the S_i^* distribution until (5) is satisfied or there are no more people who can be added, in which case we set $\underline{p}_x = 1$.

Now we have, for each *x*, a lower bound on the fraction of ignorant people. We can calculate a lower bound for the ignorant proportion of the entire population by integrating over *x*:

$$\underline{p} = \int \underline{p}_x g(x) dx, \tag{7}$$

where $g(x)$ is the pdf of the *x* distribution. We implement the above by discretizing the *x* space on a grid whose values are those that would arise from contributing at an integer contribution rate for the entire year. We find that a lower bound on the fraction of participants who must be ignorant to fully explain the flypaper effect is 92%, 94%, or 93% using the 2003 contribution

flows of the one-month, two-month, or six-month comparison groups in Table 3, respectively, to estimate the flypaper effect.

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TABLE 1. 401(k) Plan Features

Eligibility	
Eligible employees	U.S. employees
First eligible to enroll in plan	Before April 2003: 12 months after hire, minimum 1,000 hours of work at company
	Starting in April 2003: 90 days after hire
First eligible to receive matching contributions	12 months after hire, minimum 1,000 hours of work at company
Enrollment default	Not enrolled unless employee opts into plan
Contributions	
Maximum employee contribution	Before January 2002: 15% of salary
	Starting January 2002: 50% of salary
Employer match	150% match on first 1% of pay contributed, plus 50% match on next 4% of pay contributed
Vesting	
Employee contributions	Immediate
Employer matching contributions	100% vested upon 3 years of service, 0% before
Other	
Loans	Available
Hardship withdrawals	Available
Investment options	Before January 2002: 6 options, including employer stock
	Starting January 2002: 8 options, including employer stock

Source: Summary Plan Description and personal communication with plan administrator.

TABLE 2. Characteristics of Match-Eligible 401(k) Participants by Plan Enrollment Date

	Enrolled in February 2003	Enrolled in March 2003	Enrolled September 2002 - February 2003	Enrolled March 2003 - August 2003
Average age (years)	38.3	41.1	38.7	38.2
Fraction male	59.1%	62.0%	60.6%	61.3%
Average tenure (years)	2.7	2.4	3.0	2.3
Fraction married	33.3%	31.6%	33.2%	26.6%
Avg. annual income	$27,393	$29,069	$28,835	$28,149
Median annual income	$25,865	$26,000	$26,603	$25,584
Number of participants	1,015	2,234	6,911	10,753

Source: Authors' calculations. The sample is match-eligible 401(k) plan participants who enrolled in the 401(k) in the months specified and satisfy the other sample selection criteria discussed in the text. Income reported is for calendar year 2004. All other variables are observed at year-end 2003.

TABLE 3. Impact of the 2003 Plan Change on Employer Stock Allocations

Participant sample	Percent of 2003 Contribution Flow Allocated to Employer Stock: Own Contributions	Matching Contributions	All Contributions
One-month enrollment groups			
Before group (Feb 2003 enrollees)	23.2%	94.7%	55.9%
After group (Mar 2003 enrollees)	19.9%	26.8%	22.5%
Difference	3.3%	67.9%	33.4%
	(1.1%)	(1.1%)	(1.0%)
Two-month enrollment groups			
Before group (Jan-Feb 2003 enrollees)	24.6%	96.9%	57.7%
After group (Mar-Apr 2003 enrollees)	21.7%	29.3%	24.5%
Difference	2.9%	67.6%	33.2%
	(0.8%)	(0.8%)	(0.7%)
Six-month enrollment groups			
Before group (Sep 2002-Feb 2003 enrollees)	26.4%	98.2%	58.7%
After group (Mar-Aug 2003 enrollees)	24.6%	31.7%	27.4%
Difference	1.8%	66.5%	31.3%
	(0.5%)	(0.4%)	(0.4%)

Participant sample	Percent of Year-End 2003 Balances Held in Employer Stock: Own Balances	Employer Match Balances	All Balances
One-month enrollment groups			
Before group (Feb 2003 enrollees)	23.6%	94.4%	56.4%
After group (Mar 2003 enrollees)	19.8%	26.8%	22.4%
Difference	3.8%	67.6%	34.0%
	(1.2%)	(1.2%)	(1.1%)
Two-month enrollment groups			
Before group (Jan-Feb 2003 enrollees)	25.0%	96.4%	58.4%
After group (Mar-Apr 2003 enrollees)	21.5%	29.1%	24.2%
Difference	3.5%	67.3%	34.2%
	(0.9%)	(0.8%)	(0.8%)
Six-month enrollment groups			
Before group (Sep 2002-Feb 2003 enrollees)	26.4%	97.5%	59.3%
After group (Mar-Aug 2003 enrollees)	24.6%	31.8%	27.4%
Difference	1.8%	65.7%	32.0%
	(0.5%)	(0.5%)	(0.5%)

Source: Authors' calculations. The sample is match-eligible 401(k) plan participants who enrolled in the 401(k) in the months specified and satisfy the other sample selection criteria discussed in the text. The standard errors of the differences are reported in parentheses.

TABLE 4. Impact of the 2005 Plan Change on Employer Stock Allocations

Participant sample and time period over which flows are measured	Percent of Contribution Flow Allocated to Employer Stock: Own Contributions	Matching Contributions	All Contributions
Pre-March 2003 enrollees			
Flows before 2005 plan change (Jan-Mar 2005)	39.8%	94.1%	62.4%
Flows after 2005 plan change (Apr-Dec 2005)	36.7%	38.4%	37.3%
Difference	3.0%	55.7%	25.1%
	(0.1%)	(0.2%)	(0.1%)
Post-March 2003 enrollees			
Flows before 2005 plan change (Jan-Mar 2005)	25.6%	32.1%	28.2%
Flows after 2005 plan change (Apr-Dec 2005)	24.2%	29.8%	26.6%
Difference	1.4%	2.3%	1.6%
	(0.1%)	(0.1%)	(0.1%)

Participant sample and time at which balances are measured	Percent of Balances Held in Employer Stock: Own Contributions	Matching Contributions	All Contributions
Pre-March 2003 enrollees			
Balances before 2005 plan change (year-end 2004)	36.6%	93.4%	61.4%
Balances after 2005 plan change (year-end 2005)	33.0%	81.4%	53.0%
Difference	3.6%	12.0%	8.4%
	(0.1%)	(0.1%)	(0.1%)
Post-March 2003 enrollees			
Balances before 2005 plan change (year-end 2004)	26.8%	34.5%	29.9%
Balances after 2005 plan change (year-end 2005)	23.8%	32.6%	27.2%
Difference	3.1%	1.9%	2.7%
	(0.1%)	(0.1%)	(0.1%)

Source: Authors' calculations. The sample is 401(k) plan participants who initiate savings plan participation during the period specified, are match-eligible in both 2004 and 2005, and satisfy the other sample selection criteria discussed in the text. The standard errors of the differences are reported in parentheses. Pre-2003 plan change enrollees are those who enrolled in the 401(k) from 11/1/1998 through 2/28/2003. Post-2003 plan change enrollees are those who enrolled in the 401(k) from 3/1/2003 through 12/31/2004.

FIGURE 1. Fraction of Annual Contribution Flow Allocated to Employer Stock (Person-Weighted Means) in 2003 and 2004

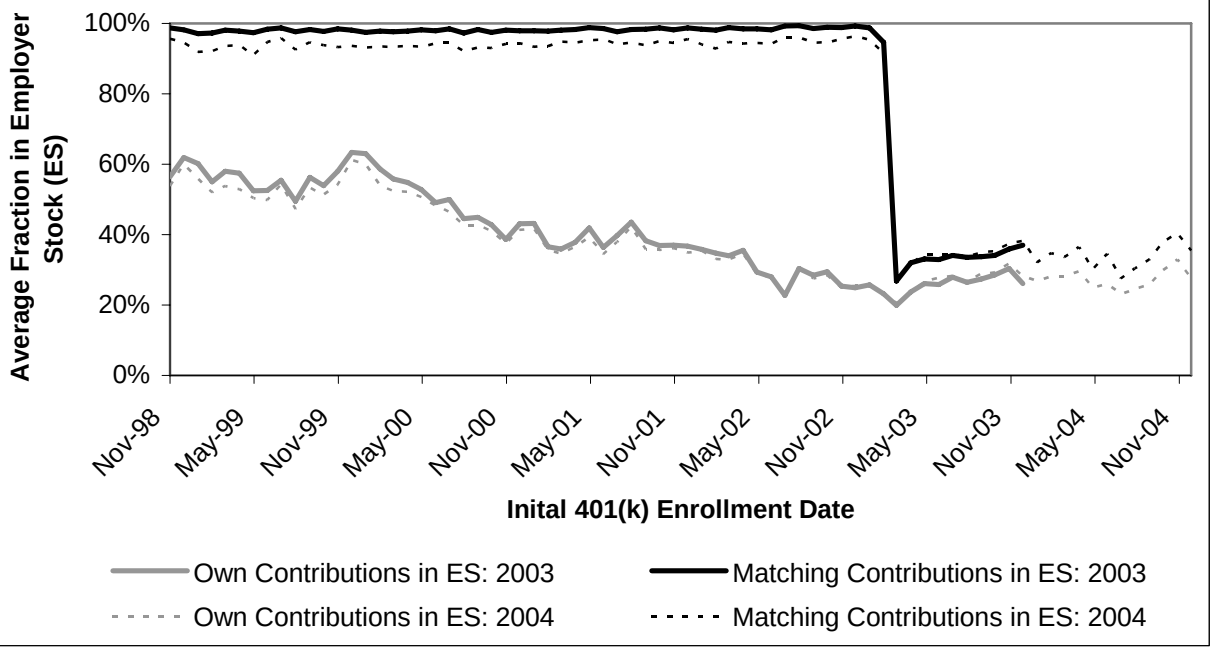

FIGURE 2. Histogram of Annual Contribution Flow Allocated to Employer Stock in 2003

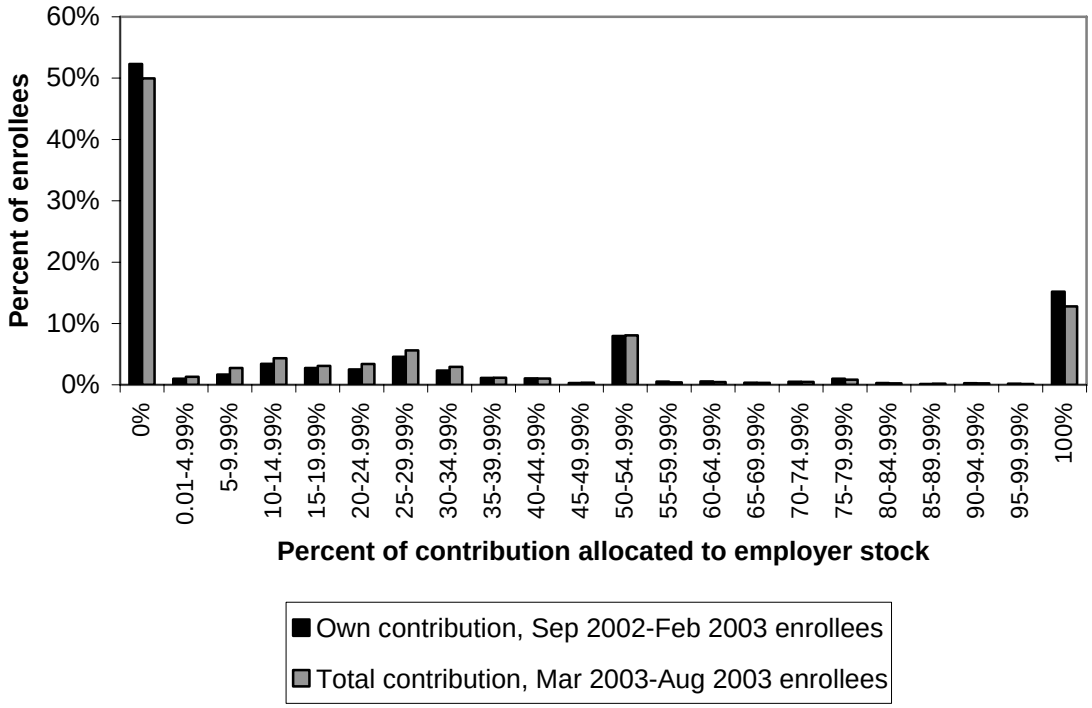

FIGURE 3. Fraction of Balances Held in Employer Stock (Person-Weighted Means) at Year-Ends 2003 and 2004

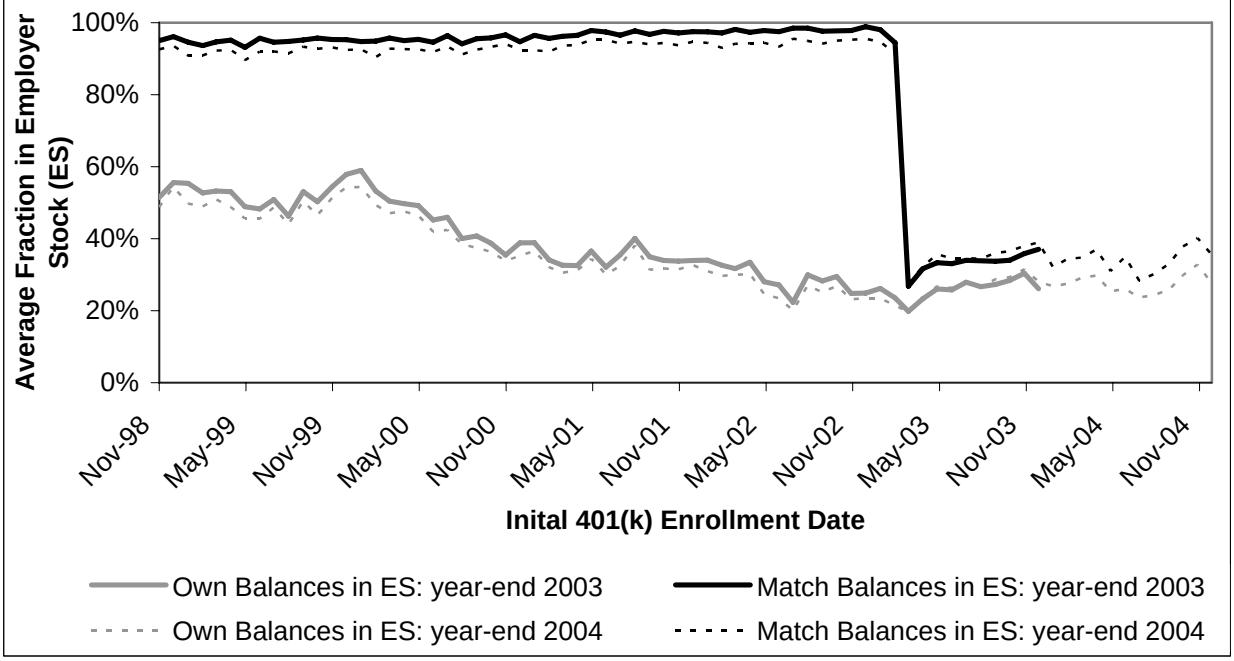

FIGURE 4. Fraction of Annual Contribution Flow Allocated to Employer Stock (Person-Weighted Means) in 2005

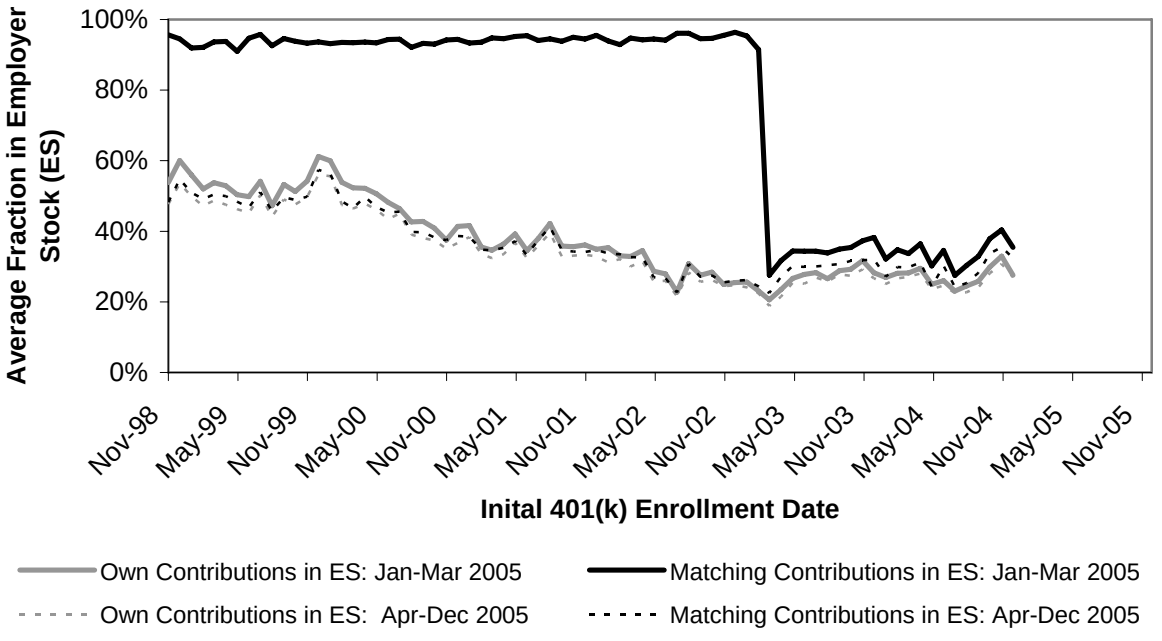

FIGURE 5. Fraction of Balances Held in Employer Stock (Person-Weighted Means) at Year-Ends 2004 and 2005

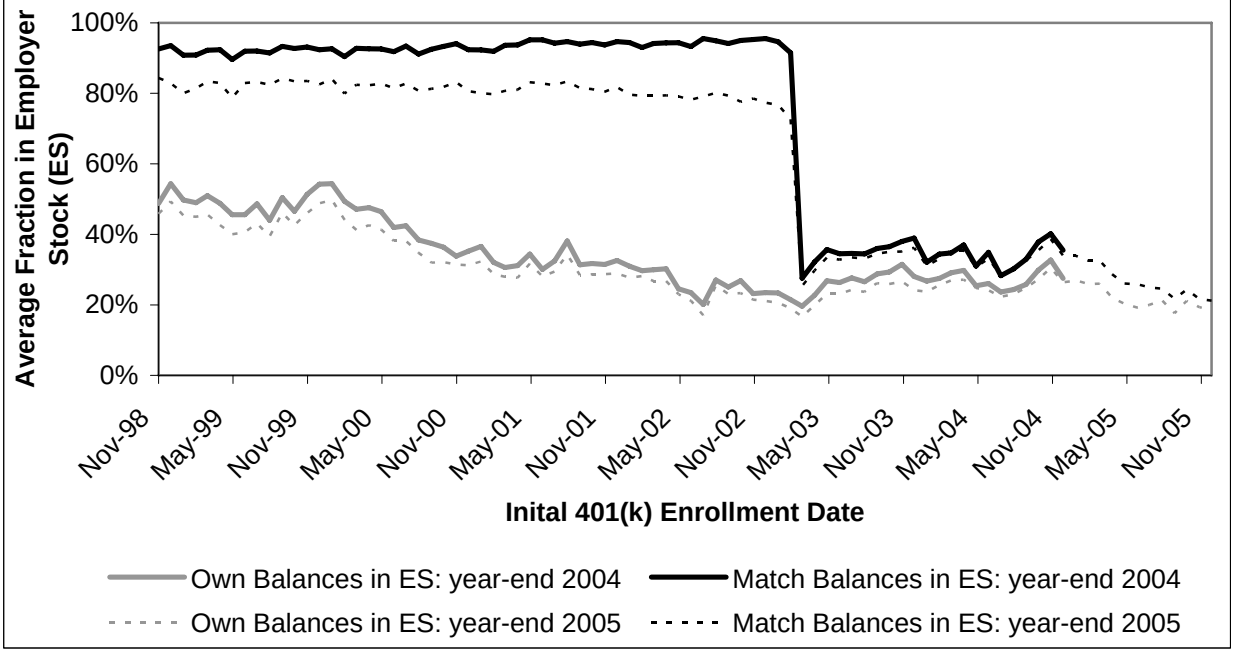

FIGURE 6. Fraction of Participants with a Net Transfer Out of Employer Stock During 2002, 2003, and 2004

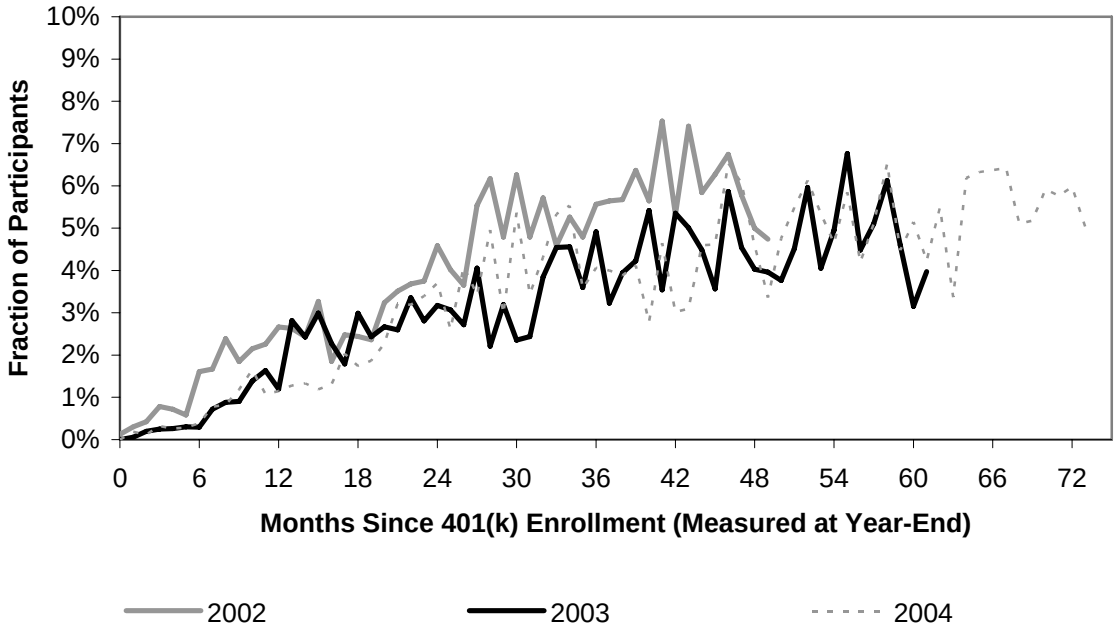

FIGURE 7. Value of Net Transfers Out of Employer Stock Conditional on a Non-Zero Transfer (Person-Weighted Means) During 2002, 2003, and 2004