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The Inattentive Participant: Portfolio Trading Behavior in 401(k) Plans

Olivia S. Mitchell
The Wharton School, University of Pennsylvania, mitchelo@wharton.upenn.edu

Gary R. Mottola
Vanguard Center for Retirement Research, gmottola@vanguard.com

Stephen P. Utkus
Vanguard Center for Retirement Research, steve_utkus@vanguard.com

Takeshi Yamaguchi
The Wharton School, University of Pennsylvania, tyamaguc@wharton.upenn.edu

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Disciplines
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Pension Research Council
The Wharton School, University of Pennsylvania
3620 Locust Walk, 3000 SH-DH
Philadelphia, PA 19104-6302
Tel: 215.898.7620 Fax: 215.573.3418
Email: prc@wharton.upenn.edu
http://prc.wharton.upenn.edu/prc/prc.html

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Most workers in defined contribution retirement plans are inattentive portfolio managers: only a few engage in any trading at all, and only a tiny minority trades actively. Using a rich new dataset on 1.2 million workers in over 1,500 plans, we find that most 401(k) plan participants are characterized by profound inertia. Almost all participants (80%) initiate no trades, and an additional 11% makes only a single trade, in a two-year period. Even among traders, portfolio turnover rates are one-third the rate of professional money managers. Those who trade in their 401(k) plans are more affluent older men, with higher incomes and longer job tenure. They tend to use the internet for 401(k) account access, hold a larger number of investment options, and are more likely to hold active equity funds rather than index or lifecycle funds. Some plan features, including offering own-employer stock, also raise trading levels.

Olivia S. Mitchell (corresponding author)
International Foundation of Employee Benefit Plans Professor
Professor of Insurance & Risk Management
Department of Insurance and Risk Management, The Wharton School, University of Pennsylvania
3620 Locust Walk, Suite 3000-SHDH, Philadelphia, PA 19104
Tel. 215-898-0424
mitchelo@wharton.upenn.edu

Gary R. Mottola
Researcher, Vanguard Center for Retirement Research
100 Vanguard Boulevard, M38
Malvern, PA 19355
Tel. 610-503-4808
gmottola@vanguard.com

Stephen P. Utkus
Principal, Vanguard Center for Retirement Research
100 Vanguard Boulevard, M38
Malvern, PA 19355
Tel. 610-669-6308
steve_utkus@vanguard.com

Takeshi Yamaguchi
Pension Research Council
The Wharton School, University of Pennsylvania
3620 Locust Walk, Suite 3000-SHDH
Philadelphia, PA 19104
tyamaguc@wharton.upenn.edu

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While many studies have explored the determinants of employee saving behavior in US defined contribution (DC) saving plans,[1] far less attention has been devoted to understanding how workers manage their assets in these plans. Nevertheless, plan sponsors, recordkeepers, money managers, and policymakers would benefit from a deeper understanding of how some 60 million employees manage the $2.5 trillion in their DC pension accounts.[2] This paper draws on a rich new dataset of more than 1,500 retirement plans to analyze trading patterns of some 1.2 million active participants in 401(k) plans over the 2003-04 period. We relate a number of portfolio outcomes to employee characteristics as well as plan design features and participant investment choices. Our results suggest that most 401(k) plan participants exhibit high levels of inertia: over our two-year period, most people never execute any trades in their pension portfolios, and even among traders, portfolio turnover rates are one-third the rate of professional money managers. In this period of rapidly rising stock prices, there is no evidence of portfolio rebalancing among the vast majority of participants. The few who do trade in their 401(k) plans are more affluent, older men, with higher incomes and longer job tenure. They tend to use the internet for 401(k) account access, hold a larger number of investment options, and are more likely to hold active equity funds rather than index or lifecycle funds. Certain plan design features, notably the presence of company stock, raise trading levels, even after controlling for differences in employee demographic characteristics. In general, most workers tend to buy and hold their pension portfolios and are inattentive to ongoing portfolio management.

Our findings suggest several questions worthy of future research. First, while it is clear that most participants are inattentive to their portfolios, it remains to be seen whether this

inactivity is motivated by lack of awareness regarding recommended practices such as rebalancing, or whether it signals interia, implying that despite being aware of best practices participants require additional assistance to manage their portfolios. Second, our analysis underscores the importance of distinguishing between alternative measures in evaluating the impacts of portfolio trading. Factors such as employee demographics, plan design, or participant holdings, can all have quite different effects depending on whether the measure is the propensity to trade, the propensity to be an active trader, the number of portfolio trades, or portfolio turnover. Third, because only a tiny minority of participants trades actively, any efforts to address the costs due to excessive trading would need to be targeted on the small group of active participants.

In what follows, we first offer an overview of related literature, and then we turn to a high-level description of trading activity in our dataset. Next we describe our empirical approach, discuss findings, and outline implications.

Related Studies

Why might retirement investors alter their portfolios or 'trade' their pension accounts? Theoretical finance explanations have built on the capital asset pricing framework, where portfolio choice is believed to reflect investor risk preferences, given an efficient set of available investment opportunities. From this perspective, portfolio shifts are predicted if preferences change or when investors alter their forecasts of expected returns and risk (taking into account the transaction costs of trading). In other words, the rational investor trades when the marginal benefit of trading equals or exceeds his marginal cost (Grossman and Stiglitz, 1980).

Whether these costs and benefits change systematically as investors age is a point of some debate. For instance, Samuelson's (1969) theoretical approach argued that rational investors would hold a fixed equity allocation over their lifetime, regardless of age or wealth (and given identically and independently distributed returns over time, among other assumptions). From this viewpoint, portfolio reallocations or trading would then be attributable to changing return expectations, rebalancing due to fluctuating asset prices, or perhaps the reassessment of manager skill (if the investor employs active portfolio managers). More recent research suggests that an inverse correlation between age and human capital risk should lead investors to hold less risky portfolios as they age, generating age-related trading away from equities.[3] This latter view is consistent with advice offered by many retirement calculators and advisers, who recommend that investors design their portfolio allocations as a function of their goals, risk tolerance, and other factors such as the job security or presence of some other pension plan. From this perspective, portfolio trading other than periodic rebalancing would be expected to occur relatively rarely, and it might be particularly associated with an investor's age.[4]

Empirical studies on investor trading behavior are quite recent, and some of the most widely-cited research relies on data from investors with self-directed brokerage accounts. In one influential paper, Barber and Odean (2000) concluded that active traders realize substantially lower returns than do nontraders.[5] Their sample also turned over more than 75% of its common stock portfolio annually. This finding lends support to "overconfidence theory," whereby overly-optimistic investors trade too frequently and to their detriment, as a result of a too-rosy estimation of their own investment skills (Odean 1999; Gervais and Odean, 2001). Follow-up research, again on discount brokerage accountholders, reported a raw male/female gap of 45% in portfolio turnover (Barber and Odean 2001); the gap diminishes somewhat, to 23%, when

controlling for demographic factors.[6] The overall average turnover rate for this sample of brokerage investors was quite high, about 6% on a monthly basis (or 72% annually).[7]

On the face of it, it seems quite unlikely that 401(k) plan participants would exhibit turnover rates as high as a group of self-directed brokerage account holders, yet relatively few studies have evaluated this issue. In an analysis of participants in higher-education 403(b) plans, Ameriks and Zeldes (2004) report that almost three-quarters of those participants never changed their investment holdings over a 10-year period. Whether their findings may be generalized to the broader 401(k) universe is not yet known. In a study of a single large corporate 401(k) pension, Madrian and Shea (2001) report that participants who were automatically enrolled did not change their investment allocations much over time, instead remaining in the conservative cash fund selected by their employer as the default account. Another study of a single plan by Agnew, Balduzzi, and Sundén (2003) again finds strong evidence of 401(k) participant inertia, with almost 90% of plan participants making no trades in a given year. Those authors also report an average of 0.26 trades per year (or about one trade every four years), with a mean annualized portfolio turnover rate of 16%. Interestingly, men trade 56% more often than women, and portfolio turnover of male traders is 53% higher than female traders. Whether these results can be generalized is again unclear, since that company had previously permitted participants to invest only in a stable-principal investment contract fund, so participants held only one-quarter of their plan money in equities. This is a low fraction compared to 401(k) plans generally.[8]

Two studies have explored the role of internet access on account trading behavior. Barber and Odean (2002) focus again on discount brokerage investors, and they conclude that investors who switch to internet trading are also those who trade more frequently, hold more speculative investments, and see their investment performance deteriorate. Choi, Laibson, and Metrick

(2002b) compare trading patterns prior to and post internet trading access, and they suggest that trading frequency doubles, while turnover rises only by half when online trading is introduced, particularly among young, male, and wealthier participants. As we note below, of course, it is unclear whether investors planning to trade also choose to adopt internet account access, or whether internet access in and of itself induces more trading.

Another factor of particular interest in 401(k) plans is whether there are the links between employee trading patterns and plan design decisions made by the employer. Investment decisions in 401(k) plans are the joint outcome of employers' selection of investment offerings, and participants' elections among the available options. While past research has not addressed this issue specifically in the trading context, a handful of studies have linked plan menu design and participant behaviors of other sorts. For instance, Benartzi and Thaler (2001) infer from experimental evidence that menu design can lead participants to naively diversify their portfolios; Elton, Gruber and Blake (2004), argue that some 401(k) investment menus prevent participants from constructing efficient portfolios; and Iyengar, Huberman and Jiang (2004) suggest that participants may suffer from "choice overload," where complex investment menus discourage participation in the plan. In what follows, we focus not only on trading patterns by investor characteristics, but also how menu design may shape trading outcomes.[9]

Descriptive Statistics

Our dataset consists of a two-year extract of 401(k) plans and participants drawn from the recordkeeping systems of Vanguard from 2003 to 2004. The same encompasses 1,530 defined contribution retirement plans and includes asset allocation and trading patterns for nearly 1.2 million active participants in those plans.[10]

Plan-level statistics. Table 1 provides key plan-level descriptive statistics: for instance, we see that the average plan has 776 active participant accounts with assets of $38.4 million. These plans offer an average of 17 investment choices. Almost all plans include one or more equity index funds; half of plans offer lifecycle funds;[11] 15% offer employer stock (also known as company stock); 93% offer one or more international options; and only 3% offer a brokerage option.[12] Nearly three-quarters of the sample plans permit participants to take a loan from their own plan assets (up to a legal maximum). The vast majority of the plans (90%) permit employee contributions; only a few are completely employer-financed.[13]

Table 1 here

Participant-level statistics. While the plan-level measures of our dataset are heavily skewed toward small firms, the 1.2 million participants in the sample are mainly found in the larger firms.[14] Some 68% of the participant accounts in our sample are found in the largest 10% of plans; 97% of participant accounts are in the top half of plans. Since our trading analysis is conducted at the participant, rather than the plan level, our universe is more characteristic of the participant behavior found at medium- and large-sized firms.[15]

Panel A of Table 2 provides summary statistics at the participant account level. It shows that the average plan participant has a 401(k) account balance of more than $86,000,[16] is 44 years old, has been on the job for eight years, and has an average household income of just over $88,000. About half the sample is identified as male and about a quarter female (another quarter of accounts lack an identifier for sex); the ratio of men to women is approximately 2:1 assuming no bias in missing data. Table 2 also indicates the distribution of imputed non-retirement household financial assets: 32% of the participants are classified low wealth, 45% as medium

wealth, and 23% as high wealth.[17] Some 37% of the participants are registered to access their account via the internet (as of January 2003).

Table 2 here

Panel B of Table 2 reports on 401(k) plan features offered and actually taken up by sample participants. It is interesting that the average participant has access to nearly 18 options in his plan, but he utilizes only 3.5 investment funds in his investment portfolio. Earlier, we saw that 15% of plans offers employer stock, but since these are the larger firms, over half (52%) of the participants have access to employer stock and one-third (32%) holds an employer stock investment. Almost all of participants have access to equity index funds (99%) and international funds (98%), but only one-half (53%) and a fifth (20%), respectively, actually invest in these choices. Another notable finding is that some 85% of participants have access to a 401(k) loan feature, but only 11% have a loan outstanding.

Trading Patterns. Of particular interest, of course, is an overview of 401(k) trading activity in our dataset. It is worth noting that a substantial portion of observed asset movement turns out to be sponsor-initiated rather than participant-initiated. Employers have responsibility for designing the fund menu offered to participants, and they may periodically add or delete fund choices in response to changing investment manager process or performance or other concerns.[18] When a new investment option is added, the sponsor will typically provide information on the new fund and will allow participants to decide whether or not to invest in it. But when a fund is to be deleted, the sponsor will typically notify participants and after a certain period will transfer any remaining holdings in the deleted fund to another fund in the plan. In the latter case, this will generate observed trading which is employer-initiated rather than employee-driven. To estimate the extent of such activity we examined asset balances by fund and plan over time; if the assets

in a given fund declined by 98% or more in a given month, we excluded all trading in the fund in that one month as "sponsor-initiated."[19]

Evidently, this sort of plan sponsor behavior accounts for a meaningful volume of gross 401(k) trading activity over the 2003-04 period. Table 3 defines a "trade" as a fund purchase and sale occurring on a given day in a single account (this is because 401(k) purchases and sales are only priced once per day).[20] Here we see that 30% of accounts had at least one trade over the period, with one-third of the trades classified as sponsor-initiated. Similarly, the mean number of trades over the two-year period is 0.76, but adjusting for sponsor-initiated trading, the average falls to 0.60. Accordingly, about 20% of all trades are therefore sponsor-related (=0.16/0.76). In the remainder of this paper, we focus attention only on participant-initiated trading activity.

Table 3 here

After these adjustments for sponsor-related trading, four-fifths of the accounts experience no participant-directed trades at all over a two-year period. This lack of activity is reflected in a variety of trading statistics. For all accounts, including traders and non-traders, the mean number of trades is 0.6 per account over two years. Portfolio turnover, defined as the average amount traded divided by the average balance,[21] is 18% over the two-year period. For traders these measures are higher: the mean number of trades for accounts with trading is 3 over two years; the mean two-year turnover is 90%) Medians are dramatically lower and underscore the skewed distribution of trading activity. For the entire sample, the median number of trades and turnover rate over two years is zero; for those trading, the median number of trades is 1 and median two-year turnover is 48%. We also define "active traders" as the subset of participants having 6+ trades over two years (representing the top 2% of accounts). For this group portfolio activity is

far greater, as the mean number of trades is 13 (9 median) and the mean portfolio turnover rate is 347% (median 162%) over the period.

A summary distribution of the number of trades across all accounts and for active traders appears in Table 4, and histograms are provided in Figures 1 and 2. What is most striking is the very low level of trading. Not only do very few people trade at all, but even those who do trade are fairly inactive. A second striking feature is the "fat tailed" phenomenon of trading, with the percentage of participants falling dramatically as the level of trading increases.

Table 4 and Figures 1 and 2 here

It is interesting to compare 401(k) trading patterns with trading outcomes reported in other studies. For instance, Reid and Millar (2004) estimate a mean portfolio turnover rate of 117% (with a median of 65%) for US professional equity mutual fund managers as a whole. This, of course, is far higher than our sample, since 80% of our sample executes zero trades, and of the 20% who do trade, the median annualized turnover rate during the two-year period is 24% or one-third the turnover rate of professional equity fund managers.[22] Even our most active 401(k) traders (the top 2%) have an annualized turnover rate of only 162%, equivalent to about the top half of equity fund managers in terms of turnover. Ultimately, for our sample, there is very little evidence of rebalancing or other trading activity: that is, it appears that most 401(k) plan participants are characterized by profound inertia, tending to buy and hold.

Multivariate Analysis of Trading Patterns

The purpose of the multivariate empirical analysis is to explore the role of three sets of factors as influences on 401(k) plan trading activity. First, we seek to test whether and how employee characteristics influence pension trading. For instance, we wish to determine whether,

as noted in previous studies, men tend to exhibit disproportionate portfolio churning as compared to women. Second, we hypothesize that plan features will influence trading patterns. Since the dataset includes an exceptional variety of plan designs, we should be able to disentangle the effects of plan design versus employee demographics on trading. Finally, we evaluate how plan trading patterns are related to actual investment holdings. For example, investors who hold passive index equity funds may also be those less likely to trade subsequently, as compared to people who invest in actively managed equity funds—perhaps because they tend to be believers in capital market efficiency. Conversely, people who invest in their own employer's stock may trade more if they believe they can outperform market indexes or if they have "inside" information (Mitchell and Utkus, 2004).

For the *ith* participant account in the *jth* plan, we relate four participant trading measures (summarized here as the $TRADING_{i,j}$ vector) to a set of employee demographic characteristics $(DEMO_{i,j})$, plan design features offered to plan participants (PD_j), and (in a subset of cases) measures of participants' own account holdings prior to the beginning of the trading analysis ($ACCT_{i,j}$):

$$TRADING_{i,j} = \beta_0 + \beta_1 \cdot DEMO_{i,j} + \beta_2 PD_j + \beta_3 \cdot ACCT_{i,j} + \varepsilon_{i,j} \quad .$$

So as to compare our results with prior studies, model A is estimated with demographics only, model B adds plan design factors, and model C adds account holdings.[23] The four dependent variables include: *TRADER*: a dummy (1/0) variable indicating whether the participant account included a trade or not over the 2003-04 period; *ACTIVE TRADER*: a dummy (1/) variable indicating whether the participant account included six or more trades over that same period; *NTRADES*: the total number of trades the participant had over the period; and *TURNOVER*: the participant's two-year turnover rate (analyzed for both non-traders and traders alike). Since the

first two dependent variables are (0/1) indicators, they are estimated as Probit models.[24] *NTRADES* is estimated using a negative binomial count regression.[25] The fourth dependent variable, *TURNOVER*, is estimated as a censored Tobit regression.[26] The *TRADER, NTRADES* and *TURNOVER* regressions are estimated for the entire sample of traders and non-traders; the *ACTIVE TRADER* regression, for the "active" population executing six or more trades over the two-year period.

Empirical Findings

Table 5 provides estimated marginal effects for the key and statistically significant variables of interest. [27] Coefficient estimates for all regression models appear in Appendix Tables A1-4.[28]

Across the board, the most robust finding across all model specifications is the coefficient on the participant's sex: all else constant, men are much more likely to be traders, to be active traders, to execute more trades, and to have higher portfolio turnover rates than women. For instance, the probability that a male will trade over a two-year period is 24% versus 17% for an otherwise similar female participant, a relative difference of 40%. Men are also predicted to execute 91% more trades than similar female participants, and they churn their portfolios at a rate 41-55% higher than women. It is worth noting that the interpretation of this effect also depends on how the results are framed. For example, it is also correct to conclude that 76% of men are non-traders versus 83% of women, a "non-trading" differential of only 7%. Similarly, while men are more likely to be active traders, this is a small group in practical terms. The quantitative differences in turnover rates by sex are also small. Thus while we confirm the

Barber and Odean (2001) view that "boys will be boys," perhaps the more salient observation is that most men and women do not trade in their 401(k) plans in the first place.

Table 5 here

Another important result has to do with the influence of other financial wealth on 401(k) trading (controlling on other factors, including income). Table 5 shows that higher-wealth participants are more likely to trade, to be active traders, and to execute more trades, than low-wealth participants, a conclusion that could indicate that better-off households have more experience, knowledge, or level of engagement with financial matters generally, which then spills over into the 401(k) plan arena.[29] Turnover rates are substantially higher for high net worth households.

The other employee-side factors we control on include participant age, income, and plan tenure, and these also have some relationship to trading incidence but have a smaller impact than sex and wealth. For example, at the margin, being 10 years older (versus a mean age of 44) is associated with only a 5-12% increase in the probability of trading, and a 6-14% increase in portfolio turnover. Aging, thus, is associated with higher levels of portfolio attentiveness—although again this is in the context of the vast majority of younger and older participants not trading in the first place. In addition, whether higher trading later in life is due to systematic age-based selling of equities or to other types of trading, remains to be seen. Changes in household income of one standard deviation ($60,000 in household income) and job tenure (7 years) are associated with similar single to double-digit relative differences on various trading measures, including turnover rates. Of three important demographic characteristics—age, tenure and income—tenure appears to have the stronger relative impact on all measures of trading. It has been said, in the context of 401(k) savings, that "stayers are savers" (Even and Macpherson,

2004). At the margin, our results suggest that "stayers are also traders"—again, in the context that the overwhelming majority of long-tenured participants do not trade in the first place.

Turning now to the impact of plan design on trading patterns, we see that perhaps the most significant factor influencing trading is the presence of company stock in the plan investment menu. While this is associated with statistically higher trading probabilities, more trades and higher turnover, the empirical magnitudes are relatively modest: for instance, in a plan lacking employer stock, the probability that a participant will trade is 19% over two years, versus 21% if company stock is offered. Of course this is a relative difference of 13%, but the absolute magnitudes are close in practical terms. Turnover is higher due to company stock as well—by about 12% in one specification. In other words, participants with access to company stock are, at the margin, more likely to churn their portfolios at a somewhat higher rate. This finding is interesting in light of our conversations with plan sponsors and recordkeepers who note that employer stock is often associated with active 401(k) trading. Our findings suggest two motivations for this higher trading: plans offering company stock may have workforce characteristics that contribute to higher trading levels generally (older, higher income, longer tenure, more male), and also employer stock appears to have its own distinct influence on trading activity independent of these characteristics.

Turning to other plan design features, we find that increasing the number of funds offered by the plan does boost the probability of having active traders, but it has contradictory effects on turnover depending on the specification. Our tentative conclusion is that the number of funds does not appear to influence aggregate trading levels. Offering of a brokerage option within the 401(k) plan has a large impact on trading activity and turnover rates, though the impact in practical terms is still small since only 3% of participants are currently offered such an option.

Also, in the case of the brokerage option, we measure trading only in the non-brokerage component of the 401(k) account. Part of this higher trading may be due to greater movement among the regular fund options in the account; another part is likely due to the movement of money from these regular fund options to the brokerage feature.[30]

As noted above, Model C findings also include controls for participants' account holdings, and it stands to reason that participants' initial account status (e.g. their equity mix, whether they are registered for internet trading) will be correlated with subsequent trading outcomes. In fact, several interesting patterns emerge. For instance, individuals who registered for internet access to their accounts are three times more likely to be traders and nine times more likely to be active traders; they also execute five times as many trades. Turnover rates also differ markedly: non-web registered participants are predicted to have a 13% turnover rate versus a 48% turnover rate for web-registered participants, a 251% relative difference. In other words, 401(k) participants who are internet users have higher turnover rates and they use the web to engage in smaller, more frequent trades. That said, there remains the unsolved question regarding causality, as to whether participants who trade more gravitate to internet trading, or whether making internet trading available itself provoke more trading.

The other results indicate that participants who initially have their money allocated across larger numbers of funds are more likely to trade. Participants who own company stock appear to have higher turnover, but holdings of company stock *per se* do not contribute to higher overall trading rates or larger numbers of trade. Overall, the employee's decision to own company stock (once it is offered) appears to have a smaller effect on trading, than does the sponsor's initial choice of company stock for the plan investment menu Those with brokerage accounts are more frequent traders and have higher turnover levels. (They are also less than 1% of all

participants and so this effect is not broadly economically meaningful.) Meanwhile, those who initially hold index or lifecycle funds are subsequently less likely to be traders and have lower turnover rates. We also note that, in this sample, participants who hold international funds actually were less likely to trade, suggesting that at least most of these participants were not attempting to engage in international arbitrage trading. Finally, those who had taken out a loan from their accounts are less likely to trade, and turnover rates in aggregate are lower too.

Comparison with prior studies. Compared to the single 401(k) plan examined by Agnew et al. (2003) during the mid-1990s, we report a surprisingly similar level of the incidence of trading despite differences in sample size and time period: 21% of our accounts had at least one trade over two years (10% annualized), versus approximately 12% of their accounts with at least one trade per year. Our mean number of trades (0.6 over two years, 0.3 annualized) is very similar to the earlier paper's mean number of trades of 0.26. Yet our portfolio turnover rates (18% over two years, 9% annualized) are half the 16% annualized for their single 401(k) plan. Not surprisingly, all 401(k) results, both ours and those of Agnew et al. (2003), pale in comparison to the 72% annualized turnover rate for the discount brokerage account holders of Barber and Odean (2001).

Like the two prior studies, we also find a pronounced effect of the participants' sex on trading, but there is still considerable cross-study variation in magnitudes. In our demographics-only models, designed to mirror the empirical models used in these prior studies, men are 40% more likely to be traders, they execute 91% more trades, and their portfolio turnover is 55% higher than for women. By comparison, Agnew et al. (2003) find a lower sex-related incidence of number of trades, with single males executing 30% more trades than single females (versus our 91%), yet a comparable rate of turnover, with male turnover 50% higher than female

turnover (versus our 55%). Barber and Odean (2001) report that "men trade 45% more than women," when measured in terms of portfolio turnover, although as noted earlier, this refers to sample means differences while the marginal effects are much smaller. It would appear, strikingly, that sex matters more for 401(k) plans than self-directed brokerage accounts, perhaps because of the self-selection inherent in brokerage account investing. Unlike the other studies, our estimated effects due to sex are meaningful despite controls for non-financial wealth. Like Agnew et al. (2003), we find that age, job tenure, and income influence trading, with the tenure effect particularly pronounced. These effects are generally smaller than for sex and other wealth.

Discussion and Conclusions

Based on our analysis of who trades in 401(k) plans, we conclude that, at least over our two-year period of analysis, participants are generally inattentive in their oversight of retirement plan assets. Four of five accounts execute no participant-driven trades, even though the stock market (as measured by the Standard & Poor's 500 Index) rose by a cumulative 43% over the study period. In other words, for the overwhelming majority of retirement savers, there is no evidence of portfolio rebalancing, shifts in risk tolerance with age, or tactical portfolio changes. It remains to be seen whether such portfolio inertia serves participants well given the investment choices they have available to them.

The few people who are traders are likely to be older affluent men, with higher incomes and longer job tenure; they use the internet to access their 401(k) plan accounts; hold more funds in their portfolios, and at the margin they invest in active equity funds while steering clear of lifecycle and equity index funds. While some of the measured differences in behavior confirm those in prior studies—the male/female difference in propensity to trade is positive, statistically

significant and, in our case, 40% in relative terms—it is crucial to emphasize the low base: fewer than one-quarter of the men trade in a two-year period versus 17% of the women. Employer plan design features such as offering company stock or a brokerage option do influence some trading outcomes including aggregate portfolio turnover rates.

Our analysis will be extended in future work in at least two directions. First, the panel we use here covers only the 2003-04 period. This was an exceptionally salubrious period for stock market investing, with US stock prices gaining more than 40%. In the future, we will expand the panel by including new periods and by reconstituting information for the 2000-02 bear market. Second, this analysis offers a cross-sectional view of the panel, modeling trading over this period from a variety of perspectives. We will take on a more detailed time-series approach as the panel expands over time.

In conclusion, we offer thoughts on the implications of our results for sponsors, fund managers, and policymakers. One interpretation is that the portfolio inertia identified here suggests that participants may require additional help managing their portfolios. Automatic rebalancing services, lifecycle funds, and managed accounts can be useful in ensuring that sensible portfolio management takes place on a disciplined schedule—whether in 401(k) plans, public sector DC pensions, or even in a reformed Social Security system with private accounts. But any these programs necessarily will raise aggregate turnover rates, given that for most participants, current turnover rates are already zero.

Another consideration is that any assessment of trading at the plan level must account for the critical influence of plan design as well as workforce demographics. Certain employee populations (older, more male participants, longer-tenured, etc.) will be likely to trade more simply because of their demographic characteristics. Trading levels are also higher under

specific plan design circumstances, notably when the employer's stock is offered, or when a 401(k) brokerage option is provided (currently offered to only a small number of participants). Finally, employee preferences for certain assets (e.g., index funds versus brokerage accounts) and account features (web registration) will also influence trading outcomes. Our analysis also shows that it is typically the demographic and account holdings, rather than plan design *per se*, that appear to have the strongest effects on trading. A final point to emphasize is that only a small group of participants is ever involved in active trading. This set of active traders raises transaction costs for all participants, and their activities may be disruptive to portfolio managers. Accordingly, those seeking to reduce active trading in 401(k) plans may seek to target remedial policies on this specific sub-set of investors.

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Table 1. Plan-Level Statistics for Analysis of 401(k) Plan Trading Behavior

	Variable name	**Mean Value**
Plan size		
Number of active participant accounts	NUM_PRT	776
Plan assets ($ millions)	PLAN_ASSETS	$38.4
Plan assets (ln)	LNPLAN_ASSETS	17.5
Plan design features offered		
Number of funds	NFUNDS	16.6
Index equity funds	EQUITY_IND_FLG	98.8%
Lifecycle funds	LC_FND_FLG	48.8%
Company stock	CS_FLG	15.0%
International funds	INTER_FLG	93.1%
Brokerage option	VBO_FLG	3.1%
Loan	LOAN_FLG	74.3%
Employee contributions	EECONTRIB	91.8%

Note:
Number of 401(k) plans in sample= 1,530

Table 2. Participant (Account-Level) Statistics for Analysis of 401(k) Plan Trading Behavior

Panel A. Participant Characteristics

	Variable name	Mean
Demographics		
Age	AGE	43.5
Household income	HH_INC	$ 88,003
Household income (ln)	LNHH_INC	11.4
Plan tenure (years)	TENURE	8.0
Sex		
Male	MALE	48.0%
Female	FEMALE	26.2%
Missing	MALEMS	25.8%
Non-retirement financial wealth		
Low wealth	POOR	32%
Middle wealth	MIDDLE	45%
High wealth	RICH	23%
401(k) Account Features		
Account balance	BLN_PRT	$ 86,363
Web registered	WEB	37%
Equity allocation		66.2%

Panel B. Plan Features Offered versus Features Held (Account-Level)

	Variable name	Mean		Variable name	Mean
Plan features offered			**Account holdings** (12/02)		
Number of funds	NFUNDS	17.7	Number of funds	NFUNDS_HELD	3.5
Index equity funds	INDEX	99%	Index equity funds	INDEX_HELD	53%
Lifecycle funds	LC	47%	Lifecycle funds	LC_HELD	12%
Company stock	CS	52%	Company stock	CS_HELD	32%
International funds	INTL	98%	International funds	INTL_HELD	20%
Brokerage option	BROK	5%	Brokerage option	BROK_HELD	0.1%
Loan	LOAN	85%	Loan	LOAN_HELD	11%
Employee contributions	EECONTRIB	94%	Employee contributions	EECONTRIB	88%

Note:
Number of plan participants = 1,186,554
See text for definition of financial wealth.

Table 3. Summary of Two-Year Trading Statistics (1/2003-12/2004)

Mean (median) trading patterns	Accounts with any trading	% of Accounts with Trading	For all accounts* NTRADES	For all accounts* TURNOVER	For traders only* NTRADES	For traders only* TURNOVER	For active traders only* NTRADES	For active traders only* TURNOVER
All trading activity	367,283	30.1%	0.76 (0.00)	23.7% (0.00%)	2.44 (1.00)	76.5% (42.0%)	12.68 (9.00)	340.0% (160.4%)
Less: sponsor-initiated	(123,885)	-9.6%						
Participant trading	243,398	20.5%	0.60 (0.00)	18.4% (0.00%)	2.92 (1.00)	89.7% (47.7%)	12.86 (9.00)	346.9% (162.4%)

* *Note:* Traders are those having 1 or more trades over the two-year period; active traders are those with six or more trades over two years. NTRADES are the number of trades in a two-year period for traders and non-traders. TURNOVER is the percent portfolio turnover rate for both traders and non-traders.

Note:
Number of plan participants = 1,186,554

Table 4. Distribution of Key Trading Measures (1/2003-12/2004)

Panel A. Distribution of Number of Trades

NTRADES	Percent	Number of accounts
0	79.5%	943,156
1	10.9%	129,504
2-5	7.4%	87,864
6-50	2.2%	25,585
Over 50	0.04%	445
	100.00%	1,186,554

Panel B. Distribution of Participant Turnover

TURNOVER	Percent	Number of accounts
0%	79.5%	943,192
0-50%	10.6%	125,775
50-100%	5.3%	63,006
100-200%	3.1%	36,783
200%-500%	1.1%	12,933
Over 500%	0.4%	4,865
	99.6%	1,186,554

Note:
Number of plan participants = 1,186,554

Table 5. Summary of Predicted Marginal Effects (1/03-12/04)

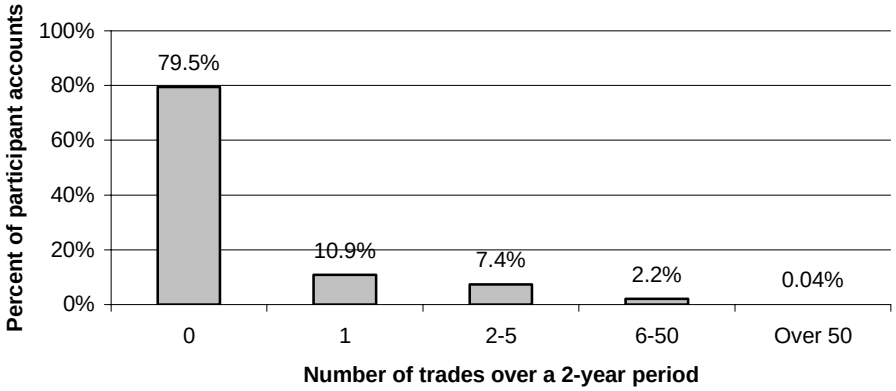
		TRADER			ACTIVE TRADER			NTRADES			TURNOVER		
DEMOGRAPHICS		A	B	C	A	B	C	A	B	C	A	B	C
Sex	Male	23.6%	23.4%	19.4%	2.6%	2.7%	1.3%	0.694	0.685	0.448	33.3%	33.3%	26.1%
	Female	16.9%	16.8%	14.7%	1.1%	1.1%	0.5%	0.363	0.362	0.275	21.5%	21.6%	18.5%
	% change	40%	40%	32%	149%	147%	146%	91%	89%	63%	55%	54%	41%
Wealth	High wealth	25.0%	24.6%	20.1%	2.5%	2.5%	1.1%	0.678	0.660	0.437	34.1%	33.7%	26.2%
	Low wealth	16.7%	16.7%	15.2%	1.5%	1.5%	0.8%	0.427	0.427	0.326	22.4%	22.6%	19.9%
	% change	50%	47%	32%	71%	62%	33%	59%	55%	34%	52%	49%	32%
Age	10 years older	21.3%	21.4%	19.5%	2.1%	2.2%	1.2%	0.587	0.590	0.437	29.4%	29.7%	25.9%
	Predicted Mean	20.4%	20.2%	17.4%	1.9%	2.0%	1.0%	0.536	0.530	0.375	27.6%	27.6%	22.8%
	% change	5%	6%	12%	13%	15%	30%	10%	11%	17%	6%	8%	14%
Income	$60K increase	22.2%	22.0%	18.2%	2.1%	2.2%	1.0%	0.590	0.583	0.393	30.3%	30.2%	24.0%
	Predicted Mean	20.4%	20.2%	17.4%	1.9%	2.0%	1.0%	0.536	0.530	0.375	27.6%	27.6%	22.8%
	% change	9%	9%	5%	12%	11%	4%	10%	10%	5%	10%	10%	5%
Tenure	7 year increase	23.3%	23.0%	19.1%	2.5%	2.5%	1.2%	0.663	0.645	0.433	32.2%	32.0%	25.4%
	Predicted Mean	20.4%	20.2%	17.4%	1.9%	2.0%	1.0%	0.536	0.530	0.375	27.6%	27.6%	22.8%
	% change	14%	14%	10%	32%	27%	22%	24%	22%	15%	17%	16%	11%
PLAN DESIGN													
Co stock	Offered		21.4%			2.2%			0.588			29.1%	23.1%
	Not offered		19.0%			1.7%			0.473			26.0%	22.5%
	% change		13%			29%			24%			12%	3%
No. funds	10 add'l funds					2.5%						29.6%	21.5%
offered	Predicted Mean					2.0%						27.6%	22.8%
	% change					28%						7%	-6%
Brokerage	Offered		25.9%			2.9%			0.759			35.3%	27.0%
	Not offered		20.0%			1.9%			0.521			27.3%	22.6%
	% change		29%			52%			46%			29%	19%
EE cont.	Allowed											28.2%	23.3%
	ER only											19.4%	16.5%
	% change											46%	41%
Loan	Offered											27.0%	22.3%
	Not offered											30.9%	25.7%
	% change											-12%	-13%

Table 5 (cont'd). Summary of Predicted Marginal Effects

		TRADER			ACTIVE TRADER			NTRADES			TURNOVER		
		A	B	C	A	B	C	A	B	C	A	B	C
ACCOUNT HOLDINGS													
Web	Registered			32.1%			3.7%			1.001			48.1%
	Not registered			11.1%			0.4%			0.209			13.7%
	% change			189%			825%			379%			251%
No. funds used	5 add'l funds			27.4%			2.5%			0.666			31.0%
	Predicted Mean			17.4%			1.0%			0.375			22.8%
	% change			58%			155%			78%			36%
Company stock	Held												24.7%
	Not held												22.0%
	% change												12%
Brokerage	Held			46.7%			6.9%			1.176			52.4%
	Not held			17.3%			1.0%			0.375			22.8%
	% change			169%			616%			214%			130%
Index	Held			16.4%			0.8%			0.336			20.9%
	Not held			18.2%			1.2%			0.421			24.7%
	% change			-10%			-38%			-20%			-15%
Int'l	Held			15.7%			0.7%			0.317			20.5%
	Not held			17.8%			1.1%			0.392			23.4%
	% change			-12%			-36%			-19%			-12%
Lifecycle	Held			15.7%			0.7%			0.310			20.1%
	Not held			17.7%			1.0%			0.387			23.3%
	% change			-11%			-35%			-20%			-14%
Loan	Held			15.2%									20.9%
	Not held			17.6%									22.9%
	% change			-14%									-9%

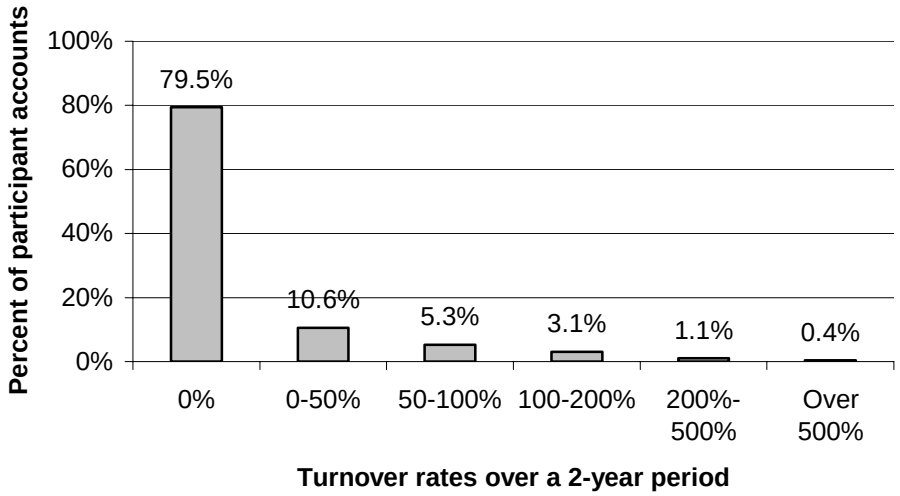
Note:
Number of plan participants = 1,186,554
Column A = demographics only; B = demographics and plan design; C = demographics, plan design and 12/02 account holdings

Figure 1. Distribution of Number of Trades (1/03-12/04)



Note:
Number of plan participants = 1,186,554

Figure 2. Distribution of Portfolio Turnover (1/03-12/04)



Note:
Number of plan participants = 1,186,554

Appendix Table A1. Multivariate Analysis of the Probability of Trading: Regression Coefficients

Probit model specification
(A) -- Demographics only
(B) -- Demographics and plan design features offered
(C) -- Demographics, plan design and account holdings on Dec. 2002

	Mean	**TRADER (mean: 20.5%)**		
Demographics		**(A)**	**(B)**	**(C)**
AGE	43.5	0.003 ***	0.004 ***	0.008 ***
TENURE	8.0	0.014 ***	0.014 ***	0.009 ***
MALE	47.5%	0.242 ***	0.239 ***	0.187 ***
HH_INC (ln)	88.0	0.118 ***	0.116 ***	0.065 ***
MIDDLE	45%	0.163 ***	0.157 ***	0.099 ***
RICH	23%	0.291 ***	0.279 ***	0.188 ***
Plan design features offered				
NFUNDS	17.7		0.009	-0.004
$NFUNDS^2$	495.1		0.000	0.000
INDEX	99%		-1.079 *	-1.15 *
INTL	98%		0.186 **	0.182 **
CS	52%		0.086 **	0.018
BROK	5%		0.194 ***	0.135 *
LC	47%		-0.027	0.023
LOAN	85%		-0.091 *	-0.089
EECONTRIB	94%		0.247	0.201
PLANASSETS	414,818		0.004	-0.011
Account holdings (Dec 2002)				
WEB	37%			0.756 ***
NFUNDS_HELD	3.5			0.068 ***
INDEX_HELD	53%			-0.063 ***
INTL_HELD	20%			-0.091 ***
CS_HELD	32%			0.060 *
BROK_HELD	0%			0.730 ***
LC_HELD	12%			-0.091 ***
LOAN_HELD	11%			-0.083 ***
Observations		1,186,554	1,186,554	1,186,554
-log(L)		581,429	577,103	532,166
Pseudo R-squared		3.4%	4.2%	11.6%
Chi-square			8,652 ***	89,874 ***

All models are Probits.
***: significant at the 1% confidence level
**: significant at the 5% confidence level
*: significant at the 10% confidence level
Sector variables and missing dummy variables included but not reported.

Appendix Table A2. Multivariate Analysis of the Probability of Being an Active Trader: Regression Coefficients

Probit model specification
(A) -- Demographics only
(B) -- Demographics and plan design features offered
(C) -- Demographics, plan design and account holdings on Dec. 2002

	Mean	**ACTIVE TRADER (mean: 2.2%)**		
Demographics		**(A)**	**(B)**	**(C)**
AGE	43.5	0.005 ***	0.006 ***	0.010 ***
TENURE	8.0	0.017 ***	0.015 ***	0.011 ***
MALE	47.5%	0.368 ***	0.367 ***	0.331 ***
HH_INC (ln)	88.0	0.089 ***	0.085 ***	0.027 ***
MIDDLE	45%	0.122 ***	0.113 ***	0.053 ***
RICH	23%	0.219 ***	0.198 ***	0.105 ***
Plan design features offered				
NFUNDS	17.7		0.013 **	-0.001
$NFUNDS^2$	495.1		0.000	0.000
INDEX	99%		-0.13	-0.15
INTL	98%		-0.008	0.002
CS	52%		0.105 ***	0.051
BROK	5%		0.178 **	0.138 *
LC	47%		-0.028	0.042
LOAN	85%		-0.069	-0.101
EECONTRIB	94%		0.180	0.147
PLANASSETS	414,818		0.021	0.005
Account holdings (Dec 2002)				
WEB	37%			0.890 ***
NFUNDS_HELD	3.5			0.075 ***
INDEX_HELD	53%			-0.179 ***
INTL_HELD	20%			-0.165 ***
CS_HELD	32%			0.026
BROK_HELD	0%			0.725 ***
LC_HELD	12%			-0.180 ***
LOAN_HELD	11%			0.009
Observations		1,186,554	1,186,554	1,186,554
-log(L)		118,962	117,942	105,206
Pseudo R-squared		5.0%	5.8%	15.9%
Chi-square			2,040 ***	25,473 ***

All models are Probits.
***: significant at the 1% confidence level
**: significant at the 5% confidence level
*: significant at the 10% confidence level
Sector variables and missing dummy variables included but not reported.

Appendix Table A3. Multivariate Analysis of the Number of Trades: Regression Coefficients for Traders and Non-Traders

Negative binomial model specification
(A) -- Demographics only
(B) -- Demographics and plan design features offered
(C) -- Demographics, plan design and account holdings on Dec. 2002

	Mean	**NTRADES (mean: 0.6)**		
Demographics		**(A)**	**(B)**	**(C)**
AGE	43.5	0.009 ***	0.011 ***	0.015 ***
TENURE	8.0	0.031 ***	0.028 ***	0.020 ***
MALE	47.5%	0.648 ***	0.637 ***	0.488 ***
HH_INC (ln)	88.0	0.185 ***	0.182 ***	0.091 ***
MIDDLE	45%	0.273 ***	0.262 ***	0.159 ***
RICH	23%	0.462 ***	0.436 ***	0.293 ***
Plan design features offered				
NFUNDS	17.7		0.019	-0.006
$NFUNDS^2$	495.1		0.000	0.000
INDEX	99%		-0.88 **	-1.19 ***
INTL	98%		0.264 *	0.243 **
CS	52%		0.217 ***	0.098
BROK	5%		0.376 ***	0.237 *
LC	47%		-0.014	0.090
LOAN	85%		-0.165	-0.187 **
EECONTRIB	94%		0.489 *	0.410
PLANASSETS	414,818		0.021	-0.001
Account holdings (Dec 2002)				
WEB	37%			1.567 ***
NFUNDS_HELD	3.5			0.115 ***
INDEX_HELD	53%			-0.218 ***
INTL_HELD	20%			-0.215 ***
CS_HELD	32%			0.084
BROK_HELD	0%			0.918 ***
LC_HELD	12%			-0.269 ***
LOAN_HELD	11%			-0.018
Observations		1,186,554	1,186,554	1,186,554
-log(L)		198,002	194,814	145,927
Pseudo R-squared		9.1%	10.5%	33.0%
Chi-square			6,376 ***	97,773 ***

All models are negative binomial regressions.
***: significant at the 1% confidence level
**: significant at the 5% confidence level
*: significant at the 10% confidence level
Sector variables and missing dummy variables included but not reported.

Appendix Table A4. Multivariate Analysis of Portfolio Turnover : Regression Coefficients for Traders and Non-Traders

Censored Tobit specification
(A) -- Demographics only
(B) -- Demographics and plan design features offered
(C) -- Demographics, plan design and account holdings on Dec. 2002

	Mean	**TURNOVER (mean: 18.4%)**		
Demographics		**(A)**	**(B)**	**(C)**
AGE	43.5	0.010 ***	0.012 ***	0.020 ***
TENURE	8.0	0.035 ***	0.034 ***	0.023 ***
MALE	47.5%	0.687 ***	0.681 ***	0.514 ***
HH_INC (ln)	88.0	0.283 ***	0.279 ***	0.151 ***
MIDDLE	45%	0.393 ***	0.374 ***	0.233 ***
RICH	23%	0.668 ***	0.634 ***	0.409 ***
Plan design features offered				
NFUNDS	17.7		0.017 ***	-0.011 ***
$NFUNDS^2$	495.1		0.000 ***	0.000 ***
INDEX	99%		-2.512 ***	-2.651 ***
INTL	98%		0.480 ***	0.471 ***
CS	52%		0.182 ***	0.040 ***
BROK	5%		0.417 ***	0.269 ***
LC	47%		-0.012	0.113 ***
LOAN	85%		-0.210 ***	-0.214 ***
EECONTRIB	94%		0.574 ***	0.502 ***
PLANASSETS	414,818		0.025 ***	-0.013 ***
Account holdings (Dec 2002)				
WEB	37%			1.931 ***
NFUNDS_HELD	3.5			0.095 ***
INDEX_HELD	53%			-0.233 ***
INTL_HELD	20%			-0.205 ***
CS_HELD	32%			0.155 ***
BROK_HELD	0%			1.106 ***
LC_HELD	12%			-0.281 ***
LOAN_HELD	11%			-0.103 ***
Observations		1,186,554	1,186,554	1,186,554
-log(L)		916,762	913,795	880,451
Pseudo R^2		1.7%	2.1%	5.6%
Likelihood ratio test[1]			5,933 ***	66,689 ***

All models are censored Tobit regressions.
***: significant at the 1% confidence level
**: significant at the 5% confidence level
*: significant at the 10% confidence level
1: Likelihood test is to compare the models: B with A, C with B.
Sector variables and missing dummy variables included but not reported.

Endnotes

[1] Mitchell, Utkus, and Yang (2005) provide a review.

[2] In the US there are three times as many workers participating in DC plans today compared to defined benefit (DB) plans and DB assets (at $2.2 trillion) are now less than DC assets (Vanguard, 2004).

[3] Ameriks and Zeldes (2004) provide an excellent summary of the debate. They also conclude that there is no evidence of age-based trading away from equities.

[4] For example, most of the participants in our dataset received an initial investor questionnaire that, if completed, recommended a target asset allocation based on the investor's time horizon, risk tolerance and other factors such as job security. Rebalancing was also recommended as an annual strategy. More generally, Bodie, Kane and Marcus (2002) discuss how investors' risk tolerance and ability to recover from losses declines with age, implying a shift toward conservative assets over time. The Certified Financial Planner (CFP; Tacchino and Littell, 1999) and the Certified Financial Analyst curricula (CFA; Bronson, Scanlan and Squires, forthcoming; and Maginn *et al.* forthcoming) emphasize the importance of life stage and time horizon in investors' ability to take risk. Writers who link age to equity exposure include Brennan (2002) and Evensky (1997).

[5] Active traders in their study posted an average annual return of 11.4% versus the average annual return of 16.4% for all households and a average annual return of 17.9% for the market.

[6] This figure is our calculation from reported regression results.

[7] Barber, Lee, Liu and Odean (2004) also find that in a study of market trading from Taiwan, trading is a zero-sum game, with profits gained by institutional investors exactly equal to losses incurred by individuals.

[8] According to the joint Employee Benefit Research Institute/Investment Company Institute (EBRI/ICI) data base of defined contribution plan participants (Holden and VanDerhei, 2004), participants held 67% of their assets in equities as of December 2003, the month prior to the beginning of our sample period.

[9] Mitchell, Utkus, and Yang (2005) describe how plan features influence savings behavior.

[10] This file is taken from a larger dataset of more than 2,000 plans and 2.5 million participant accounts. Our selection criteria identified those individuals who were active participants in their 401(k) plans over the 24-month window, and who were in plans in continuous existence over the same period.

[11] Lifecycle funds are investment options designed to provide "one stop" portfolio diversification in a single fund. They are typically offered as a series within a plan. Static allocation funds offer a range of funds based on risk characteristics (e.g., conservative, moderate, aggressive), while target maturity funds are based on an expected retirement date (the 2005 fund, the 2015 fund, the 2025 fund, etc.), with equity allocations higher for longer-dated funds, and automatic reductions in equity exposure over time.

[12] In a 401(k) brokerage option, participants may transfer all or a portion of their account assets (depending on plan rules) to a brokerage account within the plan. They may invest in mutual funds, exchange traded funds, individual stocks and bonds or other securities (again depending on the restrictions imposed by the plan). They incur retail-level brokerage commissions for their investment transactions.

[13] We use the term "401(k) plan" interchangeable with "defined contribution plan," recognizing that there are other types of employee-contributory plans, such as 403(b) plans for non-profits, as well as employer-only contributory plans, including standalone profit-sharing and money purchase plans. Omitted are standalone Employee Stock Ownership Plans (ESOPs) since by law they are mainly invested in employer stock.

[14] This is true for the 401(k) world more generally—cf. Mitchell et al. (2005).

[15] We use the terms "participant" and "participant account" interchangeably here, though in practice 4% of the participants in our sample have accounts with different plans.

[16] This average balance is much higher than balances reported by other sources (for instance, Vanguard reported an average 2002 year-end balance of just over $45,000 for all its plans). The reason is that our sample includes only active contributors continuously participating in their employers' plans over the two-year period of interest; hence it excludes small accounts of job changers and inactive participants.

[17] Data from the IXI company are used to impute non-retirement household financial wealth at the ZIP+4 level. The data, which are categorical in nature, are collapsed into three groupings as follows: poor (wealth < $7,280), middle class (wealth between $7,280 and $61,289), and rich (wealth >$ 61,289).

[18] Sponsors may terminate money managers not only due to concerns about performance but also due to changes in the manager's investment objectives, style, investment process, staffing or organization. On the fiduciary front, some sponsors in our sample period terminated certain third-party money managers who had failed to adequately control market timing within their funds.

[19] This is likely a lower-bound estimate of sponsor-initiated trading, since participants may have several months' notice of plans for fund deletions, and some may trade after the actual mapping of funds.

[20] Participants can also alter their "contribution allocations" or way in which future contributions are to be invested, but this is not our focus in the current paper.

[21] In practice, we first calculate the dollar amount for each trade as the average of (positive) purchase and sale amounts; next we sum up this dollar amount of all trades as the total trade amount; then we divide the total trade amount the average of the beginning and ending balance for the two-year period.

[22] We recognize that comparing plan participants to fund managers is to a large extent an apples-to-oranges comparison. Participants are not full-time money managers. Moreover, the average 401(k) investor holds a balanced portfolio of both equity and fixed income securities, and hence he or she manages a less risky portfolio than the average US equity fund manager.

[23] All regression models also include industry controls. The three largest sectors include manufacturing with 31% of the sample; business, professional and non-profit services account with 22%; and finance, real estate and insurance at 10%.

[24] For instance the equation for model C is $E\left(TRADING_{i,j}=1 \mid DEMO, PD, ACCT\right)=$

$=\Pr\left(TRADING_{i,j}=1 \mid DEMO, PD, ACCT\right)=\Phi(\beta_1 DEMO_{i,j}+\beta_2 PD_k+\beta_3 ACCT_{i,j})$ where Φ is the cumulative distribution function of standard normal distribution.

[25] The negative binomial model is a Poisson model whose parameter is drawn from a Gamma distribution; the closed-form expression of the distribution is expressed as:

$\Pr\left(NTRADES'_{i,j}=NTRADES_{i,j} \mid DEMO_{i,j}, PD_j, ACCT_{i,j}\right)$

$=\dfrac{\Gamma(\theta+NTRADES_{i,k})}{\Gamma(NTRADES_{i,j}+1)\Gamma(\theta)}\left(\dfrac{1}{1+\alpha}\right)^{\theta}\left(\dfrac{\alpha}{1+\alpha}\right)^{NTRADES_{i,j}}$ where Γ is a Gamma function with parameters θ and u, $\alpha=\dfrac{\lambda_{i,j}}{\theta}$, $E\left(NTRADES_{i,j} \mid DEMO_{i,j}, PD_j, ACCT_{i,j}\right)=\theta\alpha=\lambda_{i,j}$, and

$Var\left(NTRADES_{i,j} \mid DEMO_{i,j}, PD_j, ACCT_{i,j}\right)=\theta\alpha(1+\alpha)=\lambda_{i,j}\left(1+\dfrac{1}{\theta}\lambda_{i,j}\right)$.

[26] The first three models use error correction to adjust for plan-level heteroskedasticity. For the TURNOVER model, a two-stage Heckman selection model does not produce a statistically significant coefficient on the inverse Mills ratio for the second-stage regression. A censored Tobit model with error correction fails to converge, probably due to the enormous size of the dataset.

[27] Marginal effects for continuous variables use either one standard deviation change in the dependent variable (e.g. 7 more years of tenure, $60,000 more household income) or an intuitively appealing change in the unit of analysis (e.g. 10 more years of age). To evaluate changes in the account holdings, we set the corresponding plan design variables to 1 (e.g. to assess the impact of more company stock holdings, we set the 'company stock offered' variable to 1). We exclude from Table 5 two statistically significant plan design variables, the offering of index funds and international funds, since virtually all participants are offered such options, and few plan sponsors are likely to eliminate them. Hence the variation in our data is likely due to some idiosyncratic behavior associated with handful of plans lacking these choices.

[28] As shown in the Appendix Tables, it is worth noting at the outset that goodness-of-fit measures improve dramatically as the specifications are made more elaborate. For example, in the TRADER equation, the pseudo-R^2 of the demographics-only model (A) is 3.4% which rises to 11.6% for model C. Similarly the pseudo-R^2 for NTRADES increases from 9.1% (model A) to 33% (for model C). The TURNOVER model has the lowest R^2, ranging from 1.7% to 5.6%.

[29] Bernheim (1998) noted a spillover effect in the other direction: workplace education programs promoted not only 401(k) saving but also non-plan saving in the household.

[30] The brokerage account can be thought of as a "sidecar." Participant and employer contributions are first made to the regular investment options offered by the plan; participants wanting to make a brokerage trade must then transfer these assets from the regular fund options to the brokerage, which counts for a portion of the trading volume.