University of Michigan Retirement Research Center

Working Paper
WP 2007-154

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MRRC

UM07-11

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June 2007

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Acknowledgements

This work was supported by a grant from the Social Security Administration through the Michigan Retirement Research Center (Grant # 10-P-98362-5-04). The findings and conclusions expressed are solely those of the author and do not represent the views of the Social Security Administration, any agency of the Federal government, or the Michigan Retirement Research Center.

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Abstract

Few previous studies have explored how individuals manage their defined contribution (DC) pension plan assets, even though such plans constitute an increasingly important component of retirement wealth. Using a unique new dataset on over one million active 401(k) plan participants in a wide range of plans, we assess the impact of trading on investment performance in DC plans. We find that, in aggregate, the risk-adjusted returns of traders are no different than those of nontraders. Yet certain types of trading such as periodic rebalancing are beneficial, while high-turnover trading is costly. Interestingly, those who hold only balanced or lifecycle funds, whom we call passive rebalancers, earn the highest risk-adjusted returns. These findings should interest fiduciaries responsible for designing DC pensions and regulators of the retirement saving environment.

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In the US and in other countries around the world, participant-directed defined contribution (DC) accounts are increasingly replacing professionally-managed defined benefit (DB) plans. As a result, employees must take an increasingly active role in managing their retirement assets. Yet little research has examined how active workers manage their 401(k) plan assets, and even less is known about how a critical aspect of investment decision-making, trading activity, affects DC pension performance.[1] Relying on a unique new data set of about one million active 401(k) participants in some 1,500 DC plans, this study is the first to evaluate in detail the impact of workers' trading decisions on the performance of their DC portfolios.

As observed in our related study on the propensity to trade in 401(k) plans, the dominant trading behavior in 401(k) plans is not active or even somewhat inactive trading, but rather non-trading (see Mitchell, Mottola, Utkus and Yamaguchi, 2006). Most DC plan participants do not trade at all, a small group trades infrequently, and a minority engages in quite active trading. In this study, we show that, as a group, traders outperform nontraders when returns are not risk-adjusted. But because traders assume higher portfolio risk, the difference in returns between the two broad groups disappears after adjusting for risk. Further, we also find significant differences in risk-adjusted returns among specific groups of DC plan participants based on trading activity. In particular, some types of trading are beneficial, while other types are not. Rebalancing seems to be a particular beneficial strategy on a risk-adjusted basis. Passive rebalancers, or investors

[1]Throughout this paper we use the terms 401(k) and DC plans interchangeably, though we recognize there are other types of DC plan designs—including money purchase plans, standalone or 401(k)-paired profit-sharing or Employee Stock Ownership Plans (ESOP) plans, 403(b) plans for the non-profit sector, and 457 plans for government entities.

who hold only balanced or lifecycle funds and leave trading to the fund's portfolio manager, realize excess annual returns of 84 basis points on a risk-adjusted basis. Active rebalancers, who move their 401(k) portfolio's equity allocation back to a given target on their own, earn 26 basis points in excess risk-adjusted returns. Yet by our estimates only about 10 percent of participants rebalance their 401(k) account on an active or passive basis—thus leaving some 90 percent of participants forfeiting the potential advantages of rebalancing. We also find that while some degree of trading is a return-enhancing trading strategy, very high portfolio turnover is not. Among those who trade, investors who most actively churn their accounts lose 72 basis points per year compared to traders with the lowest turnover ratios.

Our findings should be of great interest to corporate plan sponsors and policymakers charged with managing DC retirement systems. In particular, our research underscores the value of rebalancing as an essential investment approach. Currently, most DC plans do not impose automatic rebalancing as the default; rather, each participant must actively rebalance his portfolio from time to time, unless he selects a single balanced or lifecycle fund that is professionally rebalanced on his behalf. In view of the clear rewards from rebalancing as an investment strategy, plan sponsors should ask whether using an automatically rebalanced account should become the default.[2] Finally, since we find that high turnover rates in 401(k) plans harm investment performance, it would appear that discouraging active trading would produce superior risk-adjusted returns and ultimately higher retirement savings.

In what follows, we first discuss related research and then turn to a discussion of our methodology. Next we describe the data and then turn to an analysis of participant raw and risk-

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[2] In a related development, the US Department of Labor recently issued new default fund regulations for 401(k) plans under the 2006 Pension Protection Act, and these regulations encourage adoption of automatically rebalanced balanced/lifecycle funds or managed account options as plan defaults.

adjusted returns. Subsequently we report our multivariate analysis of the effect of trading patterns on portfolio behavior. A final section offers a short discussion of implications.

Related Studies

Relatively little is known about what motivates plan participants to trade in their DC pension accounts. Nevertheless, conventional neoclassical models of investor behavior imply that a rational agent should continuously rebalance his portfolio to his target allocation determined by his risk tolerance, as long as there are no transaction costs (Sharpe 1964, Merton 1973). In the real world, of course, even rational investors may rebalance their portfolios less than instantaneously when they have drifted from their target allocations, due to transaction costs. Nevertheless, such an investor still should return to his target allocation when the marginal cost of trading is less than the benefit, and he should earn relatively more than an investor who does not follow this rebalancing approach (Grossman and Stiglitz, 1980). That said, in markets which are efficient and where all agents act rationally, there should be no gains from trading at all. Returns of traders and nontraders should be identical.

By contrast, behavioral finance theorists suggest that trading may be both irrational and detrimental to performance (Barber and Odean, 2000 and 2001; Gervais and Odean, 2001). At one extreme, overconfidence may lead some investors to misestimate the gains to be realized from trading, contributing to excessive and costly portfolio turnover. Those more subject to overconfidence as a bias would thus realize lower returns than those who are less biased. At the other extreme, procrastination or inertia may lead investors to fail to trade, even though they might benefit by trading.

Participants in 401(k) plans do not usually directly pay for trading costs, so if they are rational investors they would be expected to rebalance their retirement portfolios frequently.[3] Yet research to date has found that pension participants trade rather infrequently in their DC plans: for instance, Mitchell *et al.* (2006) report that only 20 percent of participants trade in a broad set of 1,500 plans over a two-year period. The few who do trade tend to be affluent older men with long job tenure, who hold more funds in their portfolios, and who are less likely to invest in index or lifecycle funds. In their study of a single employer plan, Agnew *et al.* (2003) find that only 10 percent of their participants traded in a given year. In their study of teachers, Ameriks and Zeldes (2001) report that almost three-quarters of participants never changed their investment holdings over an entire decade.[4] Thus far, no research has examined the impact of trading on 401(k) portfolio performance in the US context, which is what we undertake below.

A few studies evaluate household investment and trading patterns in their portfolios but do not focus on pensions (c.f. Calvet *et al.* 2006, Grinblatt and Keloharju 2000, 2001; Odean *et al.* 2006; Guiso and Jappelli 2006). In general, these authors confirm that household investors tend to underperform institutional investors. Odean (1999) and Barber and Odean (2000) also investigate trading patterns and performance but they are limited to a very special subset of investors, namely investors holding retail brokerage accounts. Their analysis shows that active stock traders realized substantially lower risk-adjusted returns compared to nontraders for two

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[3] When a participant trades, the transaction is consolidated with all other buy and sell transactions for the 401(k) fund option. The fund's portfolio manager must buy and sell securities only on the net transactions, and thus in many instances any given trade by a single participant may be offset in whole in part by opposite trades by others, resulting in zero transaction costs for all or part of the trade. Finally, any transaction costs from a net sales or purchase position are shared across all holders of the fund, and not just the participants or other investors undertaking a transaction. Thus, even in the worst case where every participant trade results in a purchase or sale of securities by the portfolio manager, virtually all of the costs are borne by other holders. Recently, there has been a move to impose redemption fees due to excessive trading, and these fees would be borne directly by participants. During our study period, they applied only to a limited number of not-widely-held fund options.

[4] Madrian and Shea (2001) also find evidence of inertia in their study on automatic enrollment.

reasons: traders must pay transaction costs which lowers returns, and traders also trade a great deal due to overconfidence. By contrast, 401(k) participants are usually offered pooled investment vehicles such as mutual funds, where transactions fees from trading are borne by all investors. In other words, DC plan traders are in effect subsidized by non-traders, which may make 401(k) trading relatively more profitable than trading in a discount brokerage account.

Empirical Strategy

Our research aim is to examine whether and how trading activity alters the investment performance of workers' DC pension accounts. To evaluate this question, we calculate raw (or non-risk-adjusted) returns, as well as risk-adjusted returns based on two models: a variant of the traditional Capital Asset Pricing Model (CAPM, Sharpe 1964), as well as a Fama-French (1982, 1993) multi-factor model.

Realized returns and risk. For each 401(k) participant account, the raw realized monthly return is the asset-weighted average of the returns realized by each of the participant's beginning-of-month positions.[5] The realized monthly return $R_{i,t}$ of a particular 401(k) participant's portfolio is defined as $R_{i,t} = \sum_{j=1}^{J} \alpha_{j,t} R_{j,t}$, where $R_{i,t}$ is the return of participant i in month t, j represents each fund in investor i's portfolio, $\alpha_{j,t}$ is the dollar weight of fund j in beginning-of-month portfolio for investor i, $R_{j,t}$ is the total return of fund j in month t, and J is the total number of held funds. We also calculate a relative return measure for each participant portfolio and a risk measure. The "Own Relative Benchmark return" is computed as the difference between what the participant actually realized and what he would have earned had he always rebalanced back to

[5] Following Barber and Odean (2000), we assume that all transactions occur at the end of a month and therefore ignore the impact of intra-month transactions.

the allocation reflected in his contribution allocation.[6] This is expressed as $R_{i,t}^{\Delta own} = R_{i,t} - R_{i,t}^{own}$ where $R^{\Delta own}{}_{i,t}$ is the own relative benchmark return of participant *i* in month *t*, $R_{i,t}$ is the total return of participant *i* in month *t*, and $R^{own}{}_{i,t}$ is the monthly return on his/her own benchmark. Finally, we calculate portfolio risk as the average monthly excess portfolio standard deviation.

Risk-adjustment methods. Following Fama-MacBeth (1972), we begin by calculating factor loadings for each of the underlying assets held by the 401(k) participants in our universe. We use the returns of the fund investments from the five-year period prior to our study – January 1998 to December 2002 – as the period for estimating these factors. There are two sets of factors calculated: one for the CAPM variant, and a second for the Fama-French model.

The investment options included in our dataset include a wide variety of domestic and international stock funds, bond funds, balanced or lifecycle funds, investment contract funds, and money market funds. For the modified CAPM model, we take this breadth of asset choices into account by regressing the excess return[7] for each of the 401(k) funds in our universe on three market indices: the value-weighted CRSP portfolio, the Lehman Brothers Aggregate Bond Index (LBA), and the Morgan Stanley Capital International (MSCI) Europe, Australia and Far East (EAFE) Index. These, respectively, represent the US equity market, the US bond market, and the international equity market. The residuals of the LBA and MSCI EAFE are regressed on the CRSP US market index, in practice, to create orthogonal factors because LBA and MSCI EAFE are highly correlated with CRSP. This regression function can be written as

[6] Each participant's own benchmark return is computed using the contribution allocation that was on record when the first contribution was recorded. Our analysis confirms that contribution allocations tend to be extremely stable over time. In only a handful of cases, a fund to which a participant had directed his initial contribution was later dropped. If such an instance, if the fund was merged into another one, we assumed that he would have selected the acquiring fund; if the fund was simply dropped, we use a fund from the same asset class, if available at the plan, or a benchmark from that asset class to compute benchmark returns.

[7] Throughout the paper, all returns—for participant portfolios and market indices—are excess returns, calculated using the return of a US Treasury Bill as the risk-free investment.

$$R_{j,t} - R_{f,t} = \beta_1 (R_{CRSP,t} - R_{f,t}) + \beta_2 R_{LBAX,t} + \beta_3 R_{MSCIX,t} + \varepsilon_{j,t} \qquad (1)$$

where $R_{j,t}$ is the total return of fund *j* in month *t*, and $R_{f,,t,}$ is the risk free return as defined above, $R_{CRSP,t}$, $R_{LBAX,t}$, and $R_{MSCIX,t}$ are returns on the CRSP value-weighted market portfolio and residuals of the LBA and MSCI EAFE indexes regressed against CRSP, respectively. β_1, β_2 and β_3 are the regression coefficients or factor loadings; $\varepsilon_{i,t}$ is the error term.

The Fama-French multi-factor approach follows the same methodology but adds factors for firm size and book-to-market ratio:

$$R_{j,t} - R_{f,t} = \beta_1 (R_{CRSP,t} - R_{f,t}) + \beta_2 R_{LBAX,t} + \beta_3 R_{MSCIX,t} + \beta_4 R_{SMB,t} + \beta_5 R_{HMLX,t} + \varepsilon_{j,t} \qquad (2)$$

where $R_{SMB,t}$ is the Fama-French small-minus-big (SMB) index and $R_{HMLX,t}$ is the residual of Fama-French high-minus-low (HML) index regressed on SMB. We again employ the residuals of the HML factor because HML and SMB factors are highly correlated during the period.

As a result, each investment option in our universe has two sets of factor weightings based on the preceding five-year period—β_1, β_2 and β_3 for the CAPM model, and another β_1 through β_5 for the Fama-French model. We next impute each participant's exposure to these factors for the subsequent 24-month period, January 2003 to December 2004, the period over which we observe participant trading activity. The participant exposure to these factors is a weighted average of the factors for each fund held by the participant over the 24 months.[8]

In the end, for the CAPM model, each participant has a weighted exposure to three distinct factors: $B_{i,CRSP}$ is the participant's average exposure to the CRSP value-weighted US stock portfolio factor (controlling for the US equity market); $B_{i,LBAX}$ is the participant's average

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[8] Specifically $B_{i,k} = \frac{1}{24} \sum_{t=Jan,03}^{Dec,04} \sum_{j=1}^{J} \alpha_{j,t} \hat{\beta}_{j,k}$ where $B_{i,k}$ is participant *i*'s risk loading on factor *k*, $\alpha_{j,t}$ is the allocation of fund *j* in beginning-of-month portfolio in month *t*, and $\hat{\beta}_{j,k}$ is the regression coefficient of fund *j* on factor *k*.

exposure to the residual Lehman Brothers Aggregate Bond Index factor (capturing residual effects of the US bond market not already captured in the CRSP index); and $B_{i,MSCIX}$ is his average exposure to the residual MSCI EAFE International factor (capturing residual effects of non-US stocks not already captured in the CRPS index). For the Fama-French set of factors, each participant has an unique exposure to the three preceding factors, plus $B_{i,SMB,}$ capturing the effects of small versus large US stocks, and $B_{i,HMLX}$ capturing the residual effects of growth versus value stocks.

Finally, we regress the average realized excess return of each participant's portfolio on his risk exposure to each factor, and a set of behavior variables to evaluate how trading effects 401(k) investment performance. The CAPM and Fama-French regressions are as follows:

$$\overline{R}_{i,ex} = \gamma_0 + \gamma_1 B_{i,CRSP} + \gamma_2 B_{i,LBAX} + \gamma_3 B_{i,MSCIX} + \delta TRADE_i + \varepsilon_i \quad (4)$$

$$\overline{R}_{i,ex} = \gamma_0 + \gamma_1 B_{i,CRSP} + \gamma_2 B_{i,LBAX} + \gamma_3 B_{i,MSCIX} + \gamma_4 B_{i,SMB} + \gamma_5 B_{i,HMLX} + \delta TRADE_i + \varepsilon_i \quad (5)$$

where $\overline{R}_{i,ex}$ indicates participant *i*'s realized average excess return.[9] Of most interest is the vector δ on the $TRADE_i$ variable which varies across specific models, as described below.

Hypotheses

As part of our empirical approach we developed several hypotheses based on the previous literature. First, according to conventional neoclassical investment theory, in the near-frictionless world of 401(k) trading, individuals would not be hindered by transaction costs as they are in other types of investment accounts, and so might trade more frequently. But in an informationally efficient market, such trading would be for rebalancing purposes only and there

[9] Specifically $\overline{R}_{i,ex} = \frac{1}{24}\sum_{t=Jan,03}^{Dec,04} R_{i,t}$ where $R_{i,t}$ is the participant account return (defined above) for a given month..

would be no sustainable gains to be realized by trading for other reasons. As a result, from this point of view, traders and nontraders would realize similar risk-adjusted returns:

- H1: Traders will earn no more than nontraders on a risk-adjusted basis.

To test this hypothesis, we define *TRADE* as a dummy variable where *TRADE* = 1 if the participant trades in his or her account. If H1 holds, we would anticipate that coefficient of *TRADER*, δ_{trade}, should be zero.

From a behavioral perspective, prior research has also identified a tendency among investors, including 401(k) participants, to be subject to procrastination and inertia—to be inattentive in managing their portfolios. As a result, workers might overlook the potential advantages of periodically rebalancing their portfolio based to their preferred level of risk. Under this behavioral approach, the attentive investors – the rebalancers – should do better:

- H2: Rebalancers outperform nonrebalancers on a risk-adjusted basis.

Here we define a type of rebalancers known as "active rebalancers." They are investors who return to their target equity allocation when they trade. (As described later in more detail, we define active rebalancers as those who always trade so their asset allocation falls within +/-10 percent of their target allocation.) Accordingly, if *TRADE=1* when the investor is an active rebalancer and zero otherwise, this hypothesis predicts that $\delta_{trade} > 0$.

A further behavioral model is that while certain individuals may strive to rebalance their portfolios, they may still be subject to procrastination or inertia to some degree. As a result, they may fail to rebalance on a consistent, disciplined basis. Under this hypothesis, even those who are observed rebalancing may be inattentive from time to time. As a consequence, those who have their portfolios rebalanced by a more attentive agent, such as a professional money manager paid to rebalance a portfolio, should earn superior risk-adjusted returns:

- H3: Passive rebalancers peform better than active rebalancers on a risk-adjusted basis.

By passive rebalancers, we mean investors who hold only balanced or lifecycle funds in their account during the entire 24-month period – in effect, the situation where the fund's portfolio manager rebalances on the investor's behalf. If even some active rebalancers are inattentive, we would expect passive rebalancers to do better. In other words, $\delta_{pr} > \delta_{ar}$, where δ_{pr}, δ_{ar} refer to passive and active rebalancers, respectively.

A final behavioral test focuses on overconfidence. We know from our prior work that active traders are more likely to be affluent males, and other research suggests that such individuals may be overconfident generally and also overconfident with respect to portfolio trading in particular. In keeping with the theory of overconfidence, we would anticipate that higher levels of portfolio turnover lead to lower risk-adjusted returns, at least among those trading.

- H4: Traders with high turnover rates will earn less than those with low turnover.

Accordingly, the final variation of the model defines the *TRADE* variable as the investor's turnover ratio conditional on having traded. Then we test $\delta_{turnover} < 0$. If traders are overconfident, returns would be lower for the highest turnover quintile.

Data and Descriptive Statistics

To test these hypotheses we use a dataset of administrative records on 401(k) plan participants provided by Vanguard, covering 1,483 retirement plans offered by a wide range of employers. No previous study has had access to the diversity of plans and richness of data on over a million active participants, including participant investment holdings, trading patterns, contributions, and demographic characteristics.[10] The trading data are available for the 24 month period, January 2003 through December 2004.[11]

Descriptive statistics for the entire sample appear in Table 1, along with summary information comparing traders and nontraders. Panel A shows that the median participant's account balance is about $42,000, but traders have significantly higher balances than nontraders. Overall, the average equity exposure is 64 percent, and here traders do not differ from nontraders. Traders reallocate their balances about three times over the two-year period; the mean portfolio turnover rate over the same period is 92 percent. Panel B indicates that the participants' average age is 44, about half are men, mean plan tenure is 8 years, and average household income is about $87,000. Our prior study on 401(k) trading pattern showed that traders tend to be longer tenured, more affluent, males, as compared to nontraders.[12]

Table 1 here

Trading patterns are summarized in Table 2, where we see that just over one-fifth of participants traded during the period. Overall, some 17 percent are active traders and only three percent are active rebalancers. (As a percentage of all traders, 15 percent are active rebalancers, and 85 percent are active traders.)

Table 2 here

We define an *active rebalancer* as a participant whose sole trading during the observation period always returns him to within +/- 10 percentage points of his target equity/fixed income

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[10] See Mitchell et al. (2006) for more discussion of the data. Active participants as those who made a contribution to their plan during the sample period. Also participants who invest in privately-held company stock funds are excluded.
[11] Our database also included historic fund return information, as described in more detail in Appendix I.
[12] We were able to obtain data generated by the IXI Corporation on non-retirement wealth and assign these to participants by zip code. These are categorical variables collapsed here into three groups: Poor (wealth<$7,280), Medium ($7,280 to $61,289), and Rich (>$61,289).

ratio. Empirically, the target is set at each employee's own equity percentage associated with his (first observed) plan contribution. To illustrate, suppose that A's first observed contribution to his 401(k) account was a 50/50 equity/fixed income allocation. He would be classified as an active rebalancer if he was a trader and all of his trading maintained the equity/fixed income ratio within this +/- 10 percent band. All other types of traders are defined as *active traders*.

Nontraders can be further subdivided as well. The Table shows that close to six percent of all participants are *passive rebalancers*—participants who never traded on their own and invested their entire account balance in one or more balanced or lifecycle funds over the entire 24-month period.[13] In effect, the holdings of passive rebalancers are rebalanced regularly by the fund's (or funds') portfolio manager, with no trading activity by the participant. A notable fact is that total rebalancing, by our definition, accounts for less than 10% of participants: 3.1% are active rebalancers, while 5.5% are passive rebalancers. *Other nontraders*, a group comprising 74 percent of participants, are those participants who never made a trade and who did not invest exclusively in balanced or lifecycle funds.

Performance Results

Table 3 presents realized return and risk measures, along with excess or relative returns compared to the participant's own benchmark. Columns 1 and 2 show that trading seems to have a positive impact on investment performance in the 401(k) environment, using "raw" or non-risk-adjusted data. Thus Panel A compares raw returns for traders versus nontraders, and the difference indicates that traders significantly outperform nontraders by 4 basis points per month

[13] Nearly 90% of passive rebalancers hold only one fund, but a few hold more than one balanced and/or lifecycle fund (possibly because they switched their contributions to a new fund but maintained balances in an old fund); accordingly the mean number of funds held by passive rebalancers is 1.1.

or an annualized 55 basis points (difference 1-2). But as column 3 shows, traders hold more volatile portfolios and these differences are statistically significant.[14] Columns 4 and 5 compute how well the two groups actually did, compared to what they would have earned had they always held their Own Benchmark. The findings prove that actual returns compared to those from the Own Benchmark do not differ significantly between traders and nontraders (consistent with Grossman and Stiglitz, 1980). Table 3 also shows that relative returns for traders exceed those of nontraders (columns 6-7) when measured against either their own-benchmark by about five basis points per month or an annualized 60 basis points per year (difference 1-2).

Table 3 here

To press the comparisons further, we next disaggregate traders by type, to see whether participants who rebalance their portfolios do better than others. Column 1 of Panel B reports unadjusted returns, where active rebalancers outperform nontraders by 15 basis points per month (line 1), while passive rebalancers underperform nontraders by 11 basis points per month (line 2). This is a substantial advantage on an annualized basis (Column 2). Yet there are important differences within trading subgroups. Thus active rebalancers' portfolios are riskier and passive rebalancers less risky (Column 3, Diff 1-4). In all, Columns 4-5 show that active rebalancers do better than nontraders, given their own benchmarks, but passive rebalancers underperform nontraders (these results do not yet correct for risk differences). Relative realized returns over the benchmark appear in Columns 6-7, where we see that both rebalancer groups (the passives and the actives) do not achieve significantly higher excess relative returns, but other traders do.

[14] Some 15% of the sample holds only fixed income funds in their 401(k) portfolios. Volatility and excess returns are low for this asset subgroup.

This is not surprising because the rebalancer groups always maintain its then-current risk profile and keeps a relatively constant asset allocation.[15]

Panel C of Table 3 groups the sample into quintiles according to portfolio turnover, where Quintile 1 contains traders with the lowest turnover rates, and Quintile 5 includes traders with the highest turnover rates. [16] On a realized-return basis, low-turnover traders (Quintile 1) outperform higher-turnover traders (Columns 1-2). Low-turnover traders in Quintile 1 have somewhat higher standard deviations (Column 3). Columns 4-5 indicate that performance falls with turnover. Finally, excess returns using the Own Benchmark do not differ across quintiles.

These results, as they are unadjusted for risk, seem to show that traders outperform nontraders, and active rebalancers do better than passive rebalancers. But risk-adjusted returns in Table 4 lead to quite different conclusions.[17] For instance, Panel A includes the dichotomous *TRADE* variable which takes a value of 1 if the participant is a trader (0 else): after controlling for risk, the trade advantage is greatly attenuated. Specifically, in the CAPM formulation (Column 1), traders have only an excess risk-adjusted return of 2 basis points per month, while the Fama-French approach (Column 3) finds no significant impact. In other words, based on the more robust risk-adjustment approach of Fama-French, trading has no impact on risk-adjusted returns. Thus, H1, based on the neoclassical view that traders and nontraders should realized similar risk-adjusted returns, is not rejected.

Table 4 here

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[15] This statement is consistent with investors having a constant relatively risk averse utility function, as illustrated in the classic financial economics literature (c.f. Sharpe 1964).
[16] Turnover is computed for each participant by dividing the dollar value of assets traded from 1/03 to 12/04 by the participant's average assets balance at the beginning and end of the sample period.
[17] For both the CAPM and Fama-French multi-factor regressions, all standard errors are robust across plans and all functions are estimated by Ordinary Least Squares. We use Rogers' (1993) approach for clustered samples to compute robust standard errors; see Appendix 2.

A more granular trader definition is offered in Panels B and C, where participants are classified according to whether they are active rebalancers, active traders (but not rebalancers), passive rebalancers, or nontraders. Here the reference category is nontraders. In Column 1, we see that active rebalancers outperform other nontraders by 6 basis points per month or 72 basis points on an annualized basis. Meanwhile, passive rebalancers outperform other nontraders by 8 basis points per month or 108 basis points on an annualized basis in the CAPM specification. Similar though slightly smaller results are evident in Column 3 using the Fama-French model. Active rebalancers outperform other nontraders by 2 basis points per month or 26 basis points per year, while passive rebalancers outperform by 7 basis points per month or 84 basis points per year. In both formulations, active traders do no better than nontraders, and rebalancers outperform all other types of trading. We cannot reject H2—the notion that some investors are inattentive and fail to rebalance at all, leading rebalancers to realize superior risk-adjusted returns. We also find that passive rebalancers do relatively better, consistent with H3. In other words, even active rebalances are perhaps less attentive than they should be, and as a result, those whose portfolios are rebalanced by a third party realize superior risk-adjusted returns.

Earlier we noted that those who engage in higher turnover in their 401(k) accounts have lower returns unadjusted for risk. Table 5 compares risk-adjusted performance for two turnover measures. Panel A breaks the sample into five quintiles from lowest to highest turnover while Panel B presents the results of a polynomial model that tests for a curvilinear relationship between turnover and risk-adjusted performance. In both models, those with higher turnover earn less. For instance, in Column 3, traders in the highest turnover group (Quintile 5) underperform the lowest turnover group by 6 basis points per month or 72 basis points on an annualized basis.

Table 5 here

To test whether the turnover relationship is linear, Panel B uses the turnover rate as a continuous variable along with its square and cube. Again, both models yield similar results: the overall turnover effect is negative and higher 401(k) portfolio turnover means lower risk-adjusted returns. Yet the positive coefficient for turnover squared suggests that some amount of turnover helps improve performance. In other words, those engaged in modest turnover earn higher risk-adjusted returns than those who fail to trade at all. But the negative coefficient on turnover cubed shows that at high levels of trading performance declines. In other words, some turnover enhances returns, but high turnover is costly. Our hypothesis H4 regarding overconfidence is largely confirmed—overconfidence as measured by excessive trading is costly—but some trading remains beneficial.

Evidently, workers who rebalance their accounts do better from a risk-adjusted performance standpoint. In particular, active rebalancers do best, yet they are a rare breed, accounting for only a handful of participants. To better understand who they are, we present a Probit model in Table 6 where active rebalancers are coded as 1 and all other traders are the reference group. Explanatory factors include demographic characteristics, plan design variables, and investment holdings. The results show that active rebalancers are slightly younger, somewhat less affluent, and more likely to be women, compared to other traders. Some plan design variables are also related to the prevalence of active rebalancers: for instance, when more funds are offered in the 401(k) menu, the likelihood of being an active rebalancer decreases. This suggests that larger plan menus tend to encourage trading beyond traditional rebalancing. We also see that web-registered participants with online access to their accounts are less likely to be active rebalancers, and more likely to be a more-active trader. Traders who invest in index funds are more likely to be active rebalancers, perhaps because they are attracted to the buy-and-hold approach of index funds. In addition, trading restrictions imposed by index funds may discourage other types of traders from using index funds.

Table 6 here

Discussion and Implications

Over the last half-century, US company pensions have shifted from a system dominated by defined benefit (DB) plans to one dominated by defined contribution plans, usually of the 401(k) variety; it is estimated that 43 million private-sector employees currently manage $3.7 trillion in their DC pension accounts. A similar trend is evident around the world. Accordingly, it is of keen interest to investigate how trading in 401(k) plans affects DC pension portfolio performance. We conclude that those who trade in their accounts seem to earn higher returns before adjusting for risk, but traders fail to outperform after risk adjustment. Also, we find that passive rebalancers perform best (on a risk-adjusted basis): these are investors who hold only balanced or lifecycle funds where their portfolio manager rebalances on their behalf. A passive rebalancer can earn substantially more – over 80 basis points per year – compared to traders and other nontraders.

Further, we conclude that some types of trading are productive while others are not. That is, active rebalancers who always steer their equity allocation back to a target allocation earn 26 basis points more per year than non-rebalancing traders. Since only about 10 percent of participants take advantage of rebalancing strategies in their 401(k) accounts, either passive or active, this means that some 90 percent leave “money on the table.” Last, active churning of 401(k) accounts is detrimental: participants in the highest turnover quintile lose, on average, more than 70 basis points per year on an annualized basis, compared to those in the lowest turnover quintile. A little turnover may be beneficial as the case of rebalancing suggests. But a great deal of turnover is costly.

Our findings should be of great interest in the current environment where plan sponsors and policymakers seek to improve the performance of DC pension plans. Currently, most DC plans do not induce automatic rebalancing; rather, participants must actively decide whether to rebalance their own portfolios periodically, or opt to invest in professionally-rebalanced funds. In view of the rewards from passive rebalancing as an investment strategy, our research underscores the value of offering a rebalancing fund or service as an investment default, such as a balanced or life cycle fund, or a managed account. Employers and recordkeepers overseeing 401(k) plans may also want to consider whether automatic rebalancing of 401(k) accounts should be the default design.

Furthermore, policies designed to discourage active trading in 401(k) plans would likely produce superior risk-adjusted returns, and ultimately higher retirement saving since high turnover rates harm investment performance. Round-trip restrictions and early redemption fees are two examples of policies that have been recently introduced in the US to deter excessive market-timing trading by investors. These or similar policies would appear to improve returns and reduce transaction costs for all participants since, in the commingled investment offerings of most DC plans, transactions costs are borne by all holders, not just the traders.

Future research could address several unanswered questions. First, this paper classifies participants as rebalancers based on investment patterns and trading behavior. In future work, it would be valuable to survey participants to enhance our understanding of investor motivation. Second, this paper confirms the widespread reality of inertia among investors: only 20 percent of plan participants traded over our period, only 3 percent actively rebalanced their accounts, and only 6 percent passively rebalanced by investing in balanced funds. Survey research might also assess whether participant inertia is driven by financial illiteracy or a conscious decision not to act. Third, we examine participant portfolios over a two-year period favorable to equity investing. In future work, we will include additional years to see whether our results generalize to different market conditions. Fourth, ongoing research is evaluating whether changes in investment menus offered to 401(k) participants might influence trading patterns in the long run.[18] A last intriguing question is whether there are other potential explanations, besides rebalancing, for why passive rebalancers do better than active rebalancers and active traders. We have already empirically ruled out the explanation that passive rebalancers generate superior returns by investing disproportionately in low-cost index funds.[19] However, evaluating alternative explanations for this better risk-adjusted performance remains an important area for future research.

[18] Elton *et al.* (2006) find that plan participants alter their allocations in response to investment menu changes.
[19] Many of the balanced funds in our study are index-based, so they tend to have lower expenses than actively managed funds. By definition, passive rebalancers are more likely than other participants to invest in these lower-priced funds, so it is possible that the superior performance of passive rebalancers is due to the fact that they simply choose funds with low expense ratios. To test for this possibility, we reran the regressions and added a new variable that we defined as the percent of a participant's portfolio invested in index funds. In all instances, this new variable was non-significant and had no impact on the coefficients in the equations -- suggesting that the superior performance of passive rebalancers is not due to their tendency to invest in lower-priced funds.

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Appendix 1: Fund Return Data

The Vanguard return database is constructed for the 737 distinct investment options held by our participants in their 401(k) plans, as well as a variety of market benchmarks. The 401(k) assets included publicly available mutual funds, company stocks, commingled funds, as well as privately managed separate accounts. In total, our returns database encompassed seven years – five years prior to our study and the two years for our trading analysis. Monthly total returns from January 2003 to December 2004 were used to calculate the actual portfolio returns realized by our over one million active participants, as well as a variety of risk measures. These returns are discussed in the text. Monthly asset returns for the prior five years, January 1998 to December 2002, are used in estimating risk-adjusted returns using both CAPM and Fama-French risk-adjustment models.

Appendix 2: Robust Estimation of Standard Errors in the Clustering Case

As sketched in Agnew et al. (2003), Rogers' (1993) general formula for the covariance matrix with heteroskedasticity and clustering in a panel data formulation takes the following form:

$$V\left(\sum_{i=1}^{N} u_i^{'} u_i\right)V$$

where i is the cluster, V is the negative inverse of the Hessian of the log-likelihood, and u_i is the vector of contributions of cluster i with T_i observations to the scores of the likelihood expressed as:

$$u_i = \sum_{t=1}^{T_i} \frac{\partial LnL_{i,t}}{\partial \delta} ,$$

where $L_{i,t}$ is the likelihood of the t-th observation for individual i and δ is the parameter vector.

As our sample has a multi-level structure but is not panel in design, we rewrite the estimated robust variance-covariance matrix as:

$$\left(\sum_{p=1}^{P}\ \sum_{i=1}^{N_p} z_{i,p} z_{i,p}^{'}\right)^{-1} \sum_{p=1}^{P}\left(\sum_{i=1}^{N_p} \hat{\varepsilon}_{i,p} z_{i,p}\right)\left(\sum_{i=1}^{N_p} \hat{\varepsilon}_{i,p} z_{i,p}^{'}\right)\left(\sum_{p=1}^{P}\ \sum_{i=1}^{N_p} z_{i,p} z_{i,p}^{'}\right)^{-1} ,$$

where p refers to the plan or cluster, i refers to the participant, $Z_{i,p}$ is the vector of observations on the independent variables, and $\hat{\varepsilon}_{i,p}$ is the residual of the regression.

In practice, SAS provides this estimator in Proc Surveyreg for linear regression with least-squares estimation, and Proc Surveylogistic for nonlinear maximum-likelihood.

Table 1. Socio-demographic Characteristics of 401(k) Plan Participants

	Whole Sample		Traders		Nontraders	
	Mean (1)	Median (2)	Mean (3)	Median (4)	Mean (5)	Median (6)
Panel A: Account Characteristics						
Balance ($)	83,248	42,255	133,635	74,739	70,460	36,471
Equity Allocation of Balance	0.643	0.753	0.630	0.737	0.647	0.758
Trading Propensity	0.202		NA			
Number of Trades	0.582	0.000	2.876	1.000	NA	
Turnover Ratio	0.186	0.000	0.917	0.497		
Panel B: Participant Characteristics						
Age (years)	43.536	44.000	44.982	46.000	43.169	43.000
Male (male=1)	0.465		0.550		0.444	
Plan Tenure (years)	7.940	6.081	9.353	7.669	7.582	5.665
Household Income	87,184	86,319	97,084	86,319	84,671	86,319
IXI_Rich (yes=1)	0.226		0.291		0.209	
IXI_Medium (yes=1)	0.448		0.456		0.446	
IXI_Poor (yes=1)	0.326		0.253		0.345	

Note: Balance as of 01/03. A trade is defined as any fund allocation change on a given day. A trader is a participant who ever executed at leat one trade from 01/03 to 12/04. Trading propensity refers to the percent of participants who traded over the period. Data on non-pension wealth are provided by the IXI corporation and matched by ZIP code. IXI_Rich refers to non-pension wealth>$61,289, IXI_Medium refers to $7,208-61,289, and IXI_Poor refers to <$7,280.

Table 2. Distribution of Accounts by Trader Type

Account Type	Percent (%)	Balance Equity Allocation
Total	100.0	0.643
Traders	20.2	0.630
Active Rebalancers	3.1	0.721
Active Traders	17.2	0.613
Non-traders	79.8	0.647
Passive Rebalancers	5.5	0.565
Other Nontraders	74.2	0.653

Note: See Table 1. Active rebalancers are participants who rebalance their fixed-income/equity ratio to their targeted fraction, which defined as the fixed-income/equity ratio of their first contribution. Active traders are traders who are not active rebalancers. Passive rebalancers are participants who hold only balanced funds throughout the sample period anc did not trade. Other nontraders are the remaining of nontraders.

Table 3. Realized 401(k) Account Returns

			Raw Return (Non-risk adjusted)		Standard Deviation	Own Benchmark Return		Excess Returns over Own Benchmark	
			Monthly	Annualized		Monthly	Annualized	Monthly	Annualized
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Traders vs. Non-traders									
Traders	(1)		0.0133	[0.1718]	0.0241	0.0127	[0.1635]	0.0006	[0.0072]
Non-traders	(2)		0.0129	[0.1663]	0.0222	0.0128	[0.1649]	0.0001	[0.0012]
Difference	(1)-(2)		0.0004	[0.0055]	0.0019	*-0.0010*	*[-0.0012]*	0.0005	[0.0060]
Panel B: Disaggregated Trading Categories									
Traders	Active rebalancers	(1)	0.0145	[0.1886]	0.0251	0.0146	[0.1900]	*-0.0001*	*[-0.0012]*
	Active traders	(2)	0.0131	[0.1690]	0.0239	0.0124	[0.1594]	0.0007	[0.0084]
Non-traders	Passive rebalancers	(3)	0.0119	[0.1525]	0.0193	0.0119	[0.1525]	*0.0000*	*[0.0000]*
	Other non-traders	(4)	0.0130	[0.1677]	0.0224	0.0128	[0.1649]	0.0002	[0.0024]
Difference		(1)-(4)	0.0015	[0.0209]	0.0027	0.0018	[0.0218]	-0.0003	[-0.0012]
		(1)-(2)	0.0014	[0.0195]	0.0012	0.0022	[0.0267]	-0.0008	[-0.0024]
Panel C: Turnover Ratio Quintiles									
Q1		(1)	0.0146	[0.1900]	0.0249	0.014	[0.1816]	0.0006	[0.0072]
Q2		(2)	0.0140	[0.1816]	0.0242	0.0135	[0.1746]	0.0006	[0.0072]
Q3		(3)	0.0132	[0.1704]	0.0234	0.0126	[0.1621]	0.0006	[0.0072]
Q4		(4)	0.0120	[0.1539]	0.0229	0.0113	[0.1444]	0.0007	[0.0084]
Q5		(5)	0.0127	[0.1635]	0.0251	0.0123	[0.1580]	0.0004	[0.0048]
Difference		(1)-(3)	0.0014	[0.0196]	0.0015	0.0014	[0.0195]	*0.0000*	*[0.0000]*
		(1)-(4)	0.0026	[0.0361]	0.0020	0.0027	[0.0329]	*-0.0001*	*[-0.0012]*
		(1)-(5)	0.0019	[0.0265]	-0.0001	0.0017	[0.0206]	*0.0002*	*[0.0024]*

Note: All returns are nominal returns. Overall average monthly raw return is 0.01298. Shadow area indicates statistics are not significant at the 5% level. Raw return is the average of monthly dollar-weighted returns (01/03 - 12/04). Own-benchmark return is the return that an investor would have earned had he always rebalanced to his desired contribution allocation. Numbers in square brackets are annualized returns. Q1, Q2, Q3, Q4, Q5 refer to turnover ratio of (0-16.9%],(16.9%-36.8%],(36.8%-65.5%],(65.5%-109.6%] and 109.6%+ , respectively.

Table 4. Determinants of 401(k) Risk-Adjusted Returns
(OLS models with robust standard errors)

		CAPM+Trading			Fama-French Multi-Factor+Trading		
		Coefficient		t-value	Coefficient		t-value
		(1)		(2)	(3)		(4)
Panel A: Traders vs. Nontraders							
Intercept		0.0037	***	8.12	0.0019	***	7.06
CRSP_VW		0.0133	***	24.19	0.0143	***	39.66
LBAX		-0.0013		-1.27	0.0007		1.17
MSCIX		0.0101	***	4.04	0.0053	***	3.09
HMLX					0.0108	***	11.62
SMB					0.0059	***	4.37
Traders		0.0002	*	1.71	-0.0001		-1.11
Non-traders (reference group)							
N		1,015,557			1,015,557		
R^2		70.9%			86.1%		
Panel B: Active Traders vs. Nontraders							
Intercept		0.0037	***	8.12	0.0019	***	7.07
CRSP_VW		0.0133	***	24.18	0.0143	***	39.65
LBAX		-0.0013		-1.27	0.0007		1.17
MSCIX		0.0101	***	4.04	0.0053	***	3.09
HMLX					0.0108	***	11.62
SMB					0.0059	***	4.38
Traders	Active Rebalancer	0.0005	***	5.01	0.0002	**	2.41
	Active Trader	0.0001		0.94	-0.0001		-1.55
Nontraders (reference group)							
N		1,015,557			1,015,557		
R^2		71.0%			86.1%		
Panel C: Active Traders vs. Other Nontraders							
Intercept		0.0036	***	8.11	0.0018	***	7.29
CRSP_VW		0.0133	***	24.32	0.0143	***	40.05
LBAX		-0.0014		-1.32	0.0006		0.95
MSCIX		0.0100	***	3.96	0.0052	***	2.99
HMLX					0.0109	***	11.72
SMB					0.0059	***	4.32
Traders	Active Rebalancer	0.0006	***	5.42	0.0002	***	3.02
	Active Trader	0.0001		1.57	-0.0001		-1.05
Non-traders	Passive Rebalance	0.0008	**	2.19	0.0007	**	2.36
	Other Nontrader (reference group)						
N		1,015,557			1,015,557		
R^2		71.0%			86.2%		

Note: See Table 2. ***,**,* indicate statistically significant at 1%,5%,10% level, respectively. CRSP_VW is the excess return of the value-weighted CRSP market portfolio; LBAX is the residual of the Lehman Brothers Aggregate Bond Index excess return regressed on CRSP_VW: MSCI is the residual of MSCI EAFE international equity index excess return regressed on CRSP_VW; HMLX is the residual of Fama-French HML factor regressed on SMB factor; SMB is the Fama-French Small minus Big factor.

Table 5. Determinants of 401(k) Risk-Adjusted Returns for Traders Only
(OLS models with robust standard errors)

	CAPM+Trading		Fama-French Multi-Factor+Trading	
	Coefficient	t-value	Coefficient	t-value
	(1)	(2)	(3)	(4)
Panel A: Traders by Turnover Ratio 1				
Intercept	0.0045 ***	7.32	0.0019 ***	7.09
CRSP_VW	0.0130 ***	21.88	0.0144 ***	41.58
LBAX	-0.0015	-1.40	0.0005	0.90
MSCIX	0.0117 ***	3.73	0.0060 ***	3.41
HMLX			0.0117 ***	12.91
SMB			0.0048 ***	3.55
Q1 (Reference group)				
Q2	-0.0003 ***	-2.99	-0.0002 ***	-4.67
Q3	-0.0006 ***	-3.62	-0.0003 ***	-5.49
Q4	-0.0011 ***	-4.53	-0.0006 ***	-6.12
Q5	-0.0010 ***	-3.71	-0.0006 ***	-4.38
N	205,557		205,557	
R^2	66.1%		81.6%	
Panel B: Traders by Turnover Ratio 2				
Intercept	0.0039 ***	7.36	0.0016 ***	5.70
CRSP_VW	0.0131 ***	22.15	0.0145 ***	41.52
LBAX	-0.0015	-1.41	0.0005	0.91
MSCIX	0.0117 ***	3.69	0.0059 ***	3.38
HMLX			0.0118 ***	12.84
SMB			0.0047 ***	3.45
Turnover/1000	-0.1000 **	-2.39	-0.0927 ***	-4.02
Turnover_sq/100000	0.3967 ***	2.87	0.2700 ***	4.47
Turnover_cube/100000	-0.0021 ***	-2.74	-0.0014 ***	-4.50
N	205,557		205,557	
R^2	65.7%		81.4%	

Note: See Table 4 for details.

Table 6. Characteristics of Active Rebalancers
(Probit models with robust standard errors)

			Dependent Variable: Active Rebalancer Dummy (Mean=15%)					
			Model A Demographics Only		Model B +Plan Design		Model C +Prior Holding	
	Mean	Unit	Regression Coefficient	Marginal Effect	Regression Coefficient	Marginal Effect	Regression Coefficient	Marginal Effect
Constant and Demographics								
Intercept	1.00		-0.5478 ***		-1.0874 ***		-1.3171 ***	
AGE	44.98	Year	-0.0079 ***	-0.0177	-0.0087 ***	-0.0194	-0.0079 ***	-0.0173
PLAN TENURE	9.35	Year	0.0019	0.0027	0.0021 *	0.0030	-0.0004	-0.0005
MALE	0.55	Male=1	-0.0829 ***	-0.0199	-0.0852 ***	-0.0204	-0.0774 ***	-0.0181
HH_INC	97.08	$K	-0.0062	-0.0007	-0.0076	-0.0009	-0.0168 ***	-0.0018
MEDIUM	0.46	Medium=1	-0.0051	-0.0012	0.0029	0.0007	-0.0165 *	-0.0038
RICH	0.29	Rich=1	-0.0188	-0.0044	-0.0068	-0.0016	-0.0367 ***	-0.0084
Plan Design								
NFUNDS	17.73				-0.0064 *	-0.0102	-0.0092 ***	-0.0102
NFUNDSQ	494.93				0.0001		0.0001 **	
INDEX_OFFER	0.98	Yes=1			0.7831 ***	0.1183	0.7111 ***	0.1086
INTER_OFFER	0.98	Yes=1			0.0672	0.0152	0.0262	0.0059
CS_OFFER	0.51	Yes=1			0.0172	0.0040	-0.0320	-0.0073
VBO_OFFER	0.08	Yes=1			-0.0029	-0.0007	-0.0252	-0.0057
LC_OFFER	0.45	Yes=1			0.0085	0.0020	-0.0268	-0.0061
LOAN_OFFER	0.84	Yes=1			-0.0798 *	-0.0192	-0.0748 **	-0.0175
EE	0.95	Yes=1			0.1961 ***	0.0418	0.1475 ***	0.0313
PLANBLN	466.50	$M			-0.0162 ***	-0.0004	-0.0074	-0.0002
Prior Holding								
WEB	0.64	Yes=1					-0.1161 ***	-0.0269
NFUNDS_HELD	3.95						0.0439 ***	0.0559
INDEX_HELD	0.59	Yes=1					0.1599 ***	0.0391
INTER_HELD	0.24	Yes=1					0.1034 ***	0.0244
CS_HELD	0.33	Yes=1					0.0495 *	0.0077
VBO_HELD	0.01	Yes=1					-0.4762 ***	-0.0857
LC_HELD	0.11	Yes=1					0.1806 ***	0.0403
LOAN_HELD	0.10	Yes=1					0.0056	-0.0014
BLN	133.64	$K					0.0117 **	0.0010
Obs					205,557			
-log(L)			87,340		86,948		85,263	
Pseudo-R^2			0.48%		0.93%		2.85%	

Note: See Table 2. Plan design variables are as of 01/2003. The marginal effects of AGE, PLAN TENURE, HH_INC, NFUNDS, PLANBLA NFUNDS_HELD and BLN respectively refer to the change of probability of being Active Rebalancer when an investor's age increases 10 years, plan tenure increases 6 years, household income increases 6K, number of funds increases 10, plan balance increases 50M dollars number of funds held increases 5 and balance increases 6K dollars, respectively. The marginal effects of MALE, MEDIUM, RICH refer to t probability of being Active Rebalancers as male, in medium or rich group of non-pension wealth compared with reference group of female, and poor group. Marginal effects of INDEX_OFFER, INTER_OFFER, CS_OFFER, VBO_OFFER, LC_OFFER, LOAN_OFFER, EE refer th probability of being active trader in a plan that offers indexed equity funds, international funds, company stock, brokerage option, life-cycle funds, loan and is employee contributory compared with in a plan that does not offer these investment options and is not employee contributory. The marginal effects of WEB, INDEX_HELD, INTER_HELD,CS_HELD,VBO_HELD,LC_HELD,LOAN_HELD refers the change probability of being Active Rebalancer when a participant has a registered internet account, holds indexed equity funds, international funds company stock, brokerage option, life-cycle funds, and loan compared with when he does not hold these investment options.