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Red, Yellow, and Green:
A Taxonomy of 401(k) Portfolio Choices

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Abstract

One measure of financial literacy is the quality of portfolio decision-making in 401(k) plans. Applying a qualitative framework to a dataset of nearly three million 401(k) accounts, we estimate that 43% construct "green" portfolios with balanced exposure to diversified equities, while 26% construct "yellow" portfolios with possibly too-aggressive or too-conservative equity holdings. Another three in ten participants make egregious errors and have "red" portfolios—either holding zero in equities or over concentrating their account in employer stock. Using a subset of our sample, we estimate the costs of portfolio errors (and the potential gain from improved allocations) at roughly 60 to 350 basis points in expected real return per year, depending on the initial portfolio held. Low income, low wealth and female participants are more likely to experience the largest gains from better portfolios, given their tendency to hold less aggressive portfolios.

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Red, Yellow, and Green: A Taxonomy of 401(k) Portfolio Choices

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The shift over the past quarter century from professionally managed defined benefit (DB) plans to participant-directed defined contribution (DC) plans has raised questions about the quality of portfolio choices made by 401(k) plan participants. Surveys of participants suggest that many are inexperienced and have low levels of financial literacy.[1] Participants appear to make obvious portfolio errors, either concentrating their portfolio in employer stock, holding too-conservative portfolios generally, or failing to diversify their equity portfolio more broadly with small-capitalization or international stocks.[2] In response to these concerns, the 2006 Pension Protection Act (PPA) in the US envisions a new type of 401(k) plan – the autopilot or automatic 401(k) – in which more participants are automatically enrolled into qualified default investments designed by investment professionals. The PPA also encourages greater provision of investment advice to participants. Yet even if automatic plan designs or advisory services grow quickly, it remains the case that the vast majority of nearly 60 million private-sector DC plan participants have constructed their portfolios on their own, without professional help.

How well (or poorly) constructed are these portfolios? In this paper we first address this question qualitatively, by developing a taxonomy of the types of portfolios constructed by over two million Vanguard participants at year-end 2005. This classification scheme reflects to what extent 401(k) accounts conform with certain portfolio construction rules. Second, we estimate the costs of poor portfolio construction by utilizing a subset of 12,000 participants drawn from the same sample who adopted a managed account service during 2005.[3] These costs – both in terms of reduced return and inadequate diversification – are also a measure of the potential gains to be realized by shifting participants to arguably better portfolios.

At a gross level of portfolio construction, we find that over four in ten participants construct “green” portfolios representing balanced and diversified portfolio strategies, while another quarter or so build “yellow” portfolios that appear over- or under-weighted to equity holdings. The most egregious errors are made by the remaining three in ten participants: 13% fail to participate in equity markets entirely, while 17% over-invest in company stock. At a finer level of detail, we find that many participants fail to diversify in broadly available asset classes such as international or small-capitalization stocks, while other, more specialized asset classes are typically not made available by plan sponsors. Portfolio errors can be costly—anywhere from roughly 60 to 350 basis points in expected real return per year based on our quantitative analysis. As suggested by our multinomial model of the determinants of portfolio choice, it appears lower income, lower wealth and female participants are more likely to invest in a conservative manner, and so might be the largest beneficiaries of improved portfolio performance. Meanwhile, more aggressive investors, who are more often affluent male investors, may see portfolio returns fall but diversification levels rise.

For sponsors and policymakers, among the remedial mechanisms for reducing portfolio construction errors are the use of default investment funds, the introduction of managed account advisory services, and the mapping of participants to “better” fund holdings.

In what follows, we briefly review prior research and describe our data. We present the results of our portfolio construction analysis and then estimate the cost of various portfolio choices. A final section offers conclusions and implications.

Prior research

Prior research on 401(k) investment decision-making falls broadly under three themes: behavioral biases (including investment menu effects, portfolio preferences, and inertia and procrastination), portfolio trading activity, and financial literacy.[4]

Considerable research has focused on the behavioral biases that might influence 401(k) portfolio choices—particularly the influence of the fund menu on participant allocations. Benartzi and Thaler (2001) find that some participants may follow a naïve "1/n" heuristic in choosing among menu options. In contrast, Huberman and Jiang (2006) note that while a "1/n" heuristic appears not to apply to large investment menus, there is evidence of a "conditional 1/n," whereby participants allocate their contributions evenly among a subset of funds chosen from the broader menu. Both Benartzi and Thaler (2001) and Brown, Liang and Weisbenner (2006) find that share of a given asset class in the 401(k) plan's menu influences participant allocations to that class.[5] 401(k) investment menus may also give rise to "choice overload," either leading to lower participation (Iyengar, Huberman and Jiang, 2004) or to greater reliance on familiar, conservative investment choices (Iyengar and Jiang, 2006).[6]

Neoclassical utility models of portfolio choice are based on the premise that actual portfolio choices reveal underlying investor preferences. Yet experimental evidence from Benartzi and Thaler (2002) suggests that participant preferences for their current portfolio may be unstable or ambiguous and easily subject to manipulation. Thus, not only may participant choices be influenced by employer menu decisions; but conditional on a given plan menu, participant preferences may be changeable.

The role of procrastination or inertia as a decision heuristic is evident in portfolio decisions, with most automatically enrolled participants remaining in the default investment fund

over time (Madrian and Shea, 2001; Choi, Laibson, Madrian and Metrick, forthcoming). Ameriks and Zeldes (2004) find that 45% of higher-education plan participants never changed their asset allocation over a 10-year period. Inertia is apparent in studies of 401(k) trading, with little evidence of regular portfolio rebalancing. Agnew, Balduzzi and Sundén (2003) observe that only 10% of participants in one large firm traded in any given year. This is similar to trading levels found in our survey of 1.2 million active participants in over 1,500 corporate and non-profit plans (Mitchell, Mottola, Utkus and Yamaguchi, 2005). In that same sample, only 9% of participants engaged in any direct or indirect rebalancing activity, even though such activity might lead to improved portfolio results (Yamaguchi, Mitchell, Mottola and Utkus, 2006).

Finally, the research on 401(k) decision-making takes place in the context of broader questions regarding financial literacy. John Hancock (2002) finds that some 401(k) participants believe money market funds include stock investments; few understand the inverse relationship of bond prices and yields; and many find their employer stock to be a safer investment than a diversified portfolio. A 2001 national survey of 401(k) participants (Vanguard, 2002) found that 42% of participants described themselves as "novice" or "beginner" investors and a similar percentage as "little or somewhat experienced." Examining older Americans in the Health and Retirement Survey, Mitchell and Lusardi (2006) note that while many Americans understood basic percentages, they struggled with calculations of compound interest and the equal division of a lottery prize among four individuals. They also report the demographic characteristics typically associated with low levels of financial literacy include: younger age, lower income, lower levels of educational attainment, female sex and lower wealth. More broadly, Campbell (2006) observes that one of the substantive "investment mistakes" made by some American

households, particularly lower-income or lower-wealth households, is the failure to participate in the equity markets—the failure to take any equity risk whatsoever.[7]

Data

We utilized two distinct data sets in our analysis. The first dataset, called the full sample, is extracted from Vanguard's database of more than 2,000 tax-qualified defined contribution plans, nearly encompassing 2.9 million participants, as of December 31, 2005.[8] As shown in Table 1, the median participant in this dataset was 44 years old, was male, worked for his employer for 8.5 years, had a household income of $87,500, and had accumulated $23,784 in 401(k) savings at year-end 2005.[9] In addition, half were registered for online access to their retirement plan accounts.

Table 1 here

The second dataset, called the managed account sample, is a subset of nearly 12,000 participants in the full sample who adopted a managed account service in the twelve months prior to September 2005.[10] It is this sample that we use to estimate portfolio risk and return attributes for participant portfolios. Specifically, Financial Engines, a 401(k) investment advisory firm, provides the underlying investment advisory feature of the Vanguard managed account program and was able to provide us with portfolio return and risk characteristics for the participants in this sample both before and after the adoption of the managed account service.

As shown in Table 1, the managed account sample is broadly similar to the full sample in financial terms, but there were some marked demographic differences. The managed account sample tended to be somewhat older, longer tenured, and more female, and somewhat more likely to be registered for internet access to their account. They also tended to hold less in

diversified equities overall (ten points less) and in company stock (though company stock exposure was generally small for both samples in the aggregate). They obviously also differ from other participants in their preference for advisory services.

Portfolio Construction Analysis

Our portfolio construction analysis examines the degree to which participants in the full sample conform to simple portfolio construction rules provided by portfolio advisers or experts. We examine portfolio construction both at a "gross" level, based on participants' aggregate exposure to diversified equity market and specific company-stock risk, and a "fine" level, based on their exposure to more specialized equity and fixed income holdings.

Our gross analysis focuses on diversified equities and company stock—the first because it determines the aggregate risk exposure of the participant, and the second because it represents the degree to which participants are willing to expose themselves to high levels of specific security risk correlated with their employment. In terms of exposure to diversified equities, a neoclassical utility model would suggest that any exposure to equities, from 0% to 100%, is simply a reflection of varying individual risk preferences (even though, as noted above, Campbell (2006) suggests that a 0% allocation is a likely error). Our approach here is to assume that participants may have unstable or ambiguous preferences for equity exposure, and so diversified equity allocations should be evaluated using external benchmarks based on professional judgments or expertise. Specifically we apply the following two portfolio construction rules regarding diversified equity exposure:

1. *The diversified equities rule*. We consider portfolios with between 40% and 95% equity exposure to be consistent with well-accepted standards of portfolio practice based on two independent investment methologies. In our managed account sub-sample, Financial Engines recommends overall portfolio allocations to equities ranging from 40% to 95%

of 401(k) account assets.[11] In addition, as noted on www.vanguard.com, the equity allocations for Vanguard age-based lifecycle funds range from roughly 45% to 90% for individuals in their working years.

2. *The zero-equity error rule.* As noted in Campbell (2006), , a common financial mistake for households is to hold zero percent in equities.[12] As such, we consider portfolios with no equity exposure to be problematic.

We add a third rule regarding specific risk arising from company stock. A capital markets efficiency argument would suggest that investors are not rewarded for taking specific or non-market risk, and so company stock exposure exceeding zero constitutes a portfolio error. But at the same time there is ambiguous research on the motivational aspects of investing in the stock of one's own employer. And so we have:

3. *The company stock rule.* In the post-Enron era, proposed legislation in Congress argued for a 20% limit on company stock. This is the limit also imposed by the Vanguard managed account service. It is also the rule included in mandatory disclosure to participants regarding company stock in the 2006 Pension Protection Act.[13] As such, we consider portfolios with more than 20% exposure to company stock to be problematic.

Our taxonomy applies these three rules to our 2.9 million accounts in the full sample. The results, shown in Table 2, result in five "investor segments" based on their exposure to equity market and company stock risks. We use a simple stop light color scheme to reflect the extent to which participant portfolios conform to our three rules of portfolio construction.[14] Forty-three percent of portfolios are in the Green segment, with equity allocations ranging from 40% to 95% and company stock exposure less than 20%.[15] Thirty percent are in one of two Red segments, with either zero in equities or a concentrated stock position exceeding 20%. Because of some ambiguity over whether participants with equity allocations outside our 40-95% range reflect their own well-established preferences or unsophisticated portfolio choices, we define as Yellow the one quarter of participants who either under-invest or over-invest in equities compared to our baseline rules. This investor segmentation is graphically depicted in Figure 1.

Table 2 and Figure 1 here

In terms of "fine" portfolio construction rules, it appears that participants in the aggregate fail to avail themselves of additional avenues for diversification. As shown in Table 3, most plans offer, and most participants are offered, the opportunity to diversify their holdings more broadly – including mid- and small-capitalization US stocks, international developed market stocks, and high-quality bonds. Yet less than three in ten participants appear to avail themselves of diversification benefits from these three classes.[16] Moreover, as Elton, Gruber and Blake (2006) have suggested, there is a case for even broader diversification opportunities with 401(k) plans. In our sample, specialized classes – including emerging markets, non-US bonds, real estate investment trusts, and Treasury Inflation Protected Securities (TIPS) – are not widely offered by sponsors, and accordingly not widely held by participants.

Table 3 here

Table 4 summarizes the main investment patterns for each of the five segments identified. Unsurprisingly, Red (Zero Equity) investors invest almost exclusively in stable-principal investments such as money market funds and guaranteed investment contract (GIC) funds and to only a limited extent in bonds. Yellow (Conservative Equity) investors have a high weighting to stable-principal investments as well. Both of these segments no doubt reflect either high levels of risk aversion and a preference for capital stability—or a lack of knowledge about the potential benefits, even for cautious investors, of investing in bond funds relative to shorter duration money market or GIC funds. Interestingly, two segments, Green and Yellow (Aggressive Equity), appear to have somewhat higher holdings in mid- and small-capitalization and international stocks, so not all segments are bypassing the opportunity for extended diversification. One other noteworthy finding is the high use of balanced and lifecycle funds

among the Green segment – no doubt a reflection of the growing popularity of life-cycle funds and the increasing use of such funds as default investment options in 401(k) plans.

Table 4 here

Our qualitative analysis of portfolio construction raises an additional question, Which demographic characteristics are associated with membership in a given investor segment? Table 5 provides summary demographic statistics for each of our five segments. Across the segments, there are few demographic differences, with the Red (Zero Equity) segment an exception. Investors in this segment have significantly lower plan assets, household income, non-plan financial wealth, and rates of web registration – all proxies for investor sophistication or literacy. There is also some evidence of male overconfidence, with Yellow (Aggressive Equity) and Red (Company Stock) segments somewhat more likely to be male than other segments.

Table 5 here

We further examine the relationship between demographics and investor segment membership using multinomial regression analysis. Since we are most interested in comparing "good" portfolio construction with "bad," we develop a model that compares the Red (Zero Equity) and Yellow (Conservative) segments to the Green segment. We exclude the Red (Company Stock) segment because preliminary analysis showed that the likelihood of being classified in the Red (Company Stock) segment is overwhelmingly driven by whether or not a participant is offered company stock. In other words, plan design factors overwhelm demographic factors in determining membership in the Red (Company Stock) segment. The general form of each of the three equations for our multinomial model is below, where β_0 is the intercept and $\boldsymbol{X}_{i,j}$ represents a vector of participant demographic variables. The model clusters

participants at the plan-level to ensure robust standard errors and uses a generalized logit link function.

$$\Pr(Segment_{i,j}) = \beta_0 + \beta_1 \mathbf{X}_{i,j} + \varepsilon_{i,j} \qquad (1)$$

Figure 6 contains the results of the multinomial regression. The first column, labeled Red (Zero Equity), shows the relationship between various demographic characteristics and membership in the Red (Zero Equity) segment relative to the Green segment. Web-registered participants are 14% less likely than non-web registered participants to be in the Red (Zero Equity) segment compared to the Green segment—a relative decrease of nearly 60%.[17] We interpret web registration as a proxy for investor sophistication and level of account engagement—presumably those willing to register for internet access to their 401(k) account are more likely to be knowledgeable or motivated about retirement savings. As such, one way to interpret the web registration finding is that less sophisticated investors (i.e., non web-registered participants) are more likely to construct overly conservative portfolios. In addition, income and wealth are significant determinants of membership: participants with high income, high 401(k) balances, or high non-retirement wealth are less likely to be in the Red (Zero Equity) segment, while low-income participants are more likely to have zero equity portfolios. For example, low income participants are 4% more likely than moderate income participants to be in the Red (Zero Equity) segment compared to the Green segment, a relative difference of 18%.

Table 6 here

The marginal probabilities for the Yellow (Conservative) segment are similar to, but somewhat smaller than, the marginal probabilities for the Red (Zero Equity) segment—which is understandable given that both segments are comprised of participants that are under-exposed to

equities. More specifically, high wealth and web registered participants are less likely to be in this segment whereas low wealth and non-registered participants are more likely to be in this segment. In addition, as age increases so does the likelihood of being in this segment—a finding consistent with either an age-cohort effect or the glide path approach to investing (where participants decrease their risk level as they age).

Last, we turn our attention to the Yellow (Aggressive) segment, which is comprised of participants that are arguably over-aggressive in their 401(k) portfolios. Men are 7% more likely to be in this segment, a relative increase of about 23%. Furthermore, high wealth, high income, and web registered participants are also more likely to be in this segment. In other words, this segment seems to be populated with participants whose characteristics are more frequently associated with high levels of account engagement and financial literacy.

Figure 4 graphically depicts and summarizes the results of the regression analysis. In short, after adjusting for various demographic variables, the conservatively invested segments—that is, Red (No Equity) and Yellow (Conservative)—are more likely to have older, less affluent, unengaged participants whereas the more aggressively invested Yellow segment tends to have younger, more affluent, engaged participants. Since affluence and web registration are also proxies for financial literacy, there appears to be a relationship between a participant's willingness to take on risk (perhaps even too much risk) and their financial literacy.

Figure 4 here

The Cost of Portfolio Choices

For each of our five segments of investors, we are able to estimate the costs of a given type of portfolio strategy using a subset of those accounts—namely, our managed account sample described earlier. During 2005, 37 plans (out of over 1,900 in our full sample) introduced a managed account to over 242,000 participants. Nearly 12,000 participants adopted the managed account service. For many, the managed account service dramatically changed their portfolio allocation from its original position to one recommended by the advisor. Figure 2 depicts the sizeable changes that occurred using a histogram of equity exposure before and managed account implementation. By comparing portfolio risk and return attributes on a before and after basis, we can develop reasonable estimates of the potential costs of current portfolio strategies—and conversely, the potential benefits that may be realized from any improvement in those strategies.

Figure 2 here

One question is whether this much smaller sample of participants is representative of the 2.9 million participants in our full sample. Tables 7 and 8 suggest that this is broadly true. Tables 7 classifies the 12,000 managed account adopters using the same investor segment rules noted above, both before and after the managed account adoption. As a benchmark, it compares the managed account sample with our full sample, and the two samples are reasonably similar. The managed account sample has somewhat more Green investors at the outset and more Yellow (Conservative Equity) investors, with a correspondingly lower percentage of Yellow (Aggressive Equity) and Red (Company Stock) investors. In terms of actual portfolio composition, Table 8 decomposes asset holdings in each segment by various asset classes (in Panel A) and then documents the difference between the managed account sample and full sample (Panel B). In

terms of overall equity exposure, the most notable difference is that managed account Green investors have an 8% lower allocation to equities. This is principally because the managed account Green investors hold more in balanced and lifecycle funds than the full sample, while holding less in large-capitalization, or mid- and small-capitalization US stocks. There are other minor differences for Yellow (Aggressive Equity) and Yellow (Conservative Equity) investors. These tables suggest that while not identical, the two samples are broadly equivalent in terms of investment patterns. As such, we believe that the managed account sample offers a reasonable first-order approximation of portfolio characteristics for the entire sample as well.

Tables 7 and 8 here

In order to assess portfolio changes for participants in our subsample, we estimated portfolio expected returns and variances at two points in time: September 2004, prior to the introduction of the managed account service in late 2004, and December 2005, the end point of our analysis. Our analysis relies on the proprietary estimated returns (and variance-covariance matrices) for plan investment options from Financial Engines, the managed account sub-advisor.[18, 19]

Table 9 presents expected returns and Sharpe ratios[20] for each of the five segments in the managed account sample. These results estimate, in effect, the costs or inefficiencies associated with a given type of portfolio strategy chosen by the participant compared to a portfolio selected by a professional adviser. For Red (Zero Equity) participants, not surprisingly, the costs in terms of lower expected returns are dramatic: 358 basis points in expected return are foregone by these investors. Even Green portfolios experience gains in expected return of 63 basis points due to improvements in portfolio strategy.[21] Sharpe ratios (as a measure of portfolio efficiency)

improve for each investor segment; the largest gains occur for zero-equity holders and for those eliminating company stock risk.[22]

Table 9 here

As shown in Table 9, adoption of professional advice does not lead to improvements in expected real returns across the board. The most aggressive investors – Yellow (Aggressive Equity) and Red (Company Stock) – actually see expected returns fall as their portfolios are diversified away from high levels of, respectively, diversified equities and company stock specific risk. In both groups, however, expected returns per unit of risk improve.

In addition, we used an ordinary least squares difference-in-difference approach to determine which demographic segments might benefit the most – in terms of improved portfolio risk and return characteristics – if they were to adopt "greener" portfolio strategies. This regression model relates expected returns and portfolio Sharpe ratios to demographic characteristics, and the analysis is based on our smaller managed account sample. The empirical model for $E(r_{i,j,t})$, the expected returns for the *ith* participant account in the *jth* plan at time *t*, is as follows:

$$E(r_{i,j,t}) = \beta_0 + \beta_1 Treatment_{i,j,t} + \beta_2 \mathrm{Y}_{i,j,t} + \beta_3 \mathrm{Z}_{i,j,t} + \varepsilon_{i,j,t} \qquad (2)$$

We observe each participant portfolio at two points in time: prior to the managed account adoption (September 2004) and after (December 2005). Our independent variables include a within-subject *Treatment* variable (i.e., set to 1 if after adoption of the managed account and 0 before adoption) and a vector of demographic variables $\boldsymbol{Y}_{i,j,t}$. Furthermore, we interact the *Treatment* variable with the between-group demographic variables such as gender, age, and web registration in $\boldsymbol{Z}_{i,j,t.}$ Observations are clustered at the participant level to ensure robust errors.

The results of this regression are presented in Table 10. Examining the within-subject and between-group interaction terms, we see that *Male, Web Registered* and *Age* have the largest effects, and the direction is negative. Specifically, the benefit men received from managed account implementation was 59 basis points less than the benefit women received, and the benefit web registered participants received was 46 basis points less than non-web registered participants. Those ten years older received a benefit that was 19 basis points lower. However, it is important to note that the portfolio performance of all of these demographic groups improved after managed account adoption. What the interaction terms indicate is that certain demographic groups experienced a larger benefit than other demographic groups—namely, women, web registered and younger participants.

Table 10 here

One other finding worth noting in Table 10 is the strong marginal effect of high wealth. The high wealth category consists of those participants whose non-pension financial assets are in the top 20% of the distribution. Portfolio returns improved by 15 basis points for this group relative to the other 80% of households with lower or average non-pension financial wealth. What is striking from this result is that even affluent households may benefit disproportionately from professional advice.

Figure 3 presents the marginal effects for the regression. As shown, all demographic groups experienced an improvement in performance after managed account adoption, but the relative size of the improvement varied. In our example, a hypothetical managed account adopter—in this case defined as non-high-wealth, medium household income, non-web registered, female of average age, account balance, and tenure—experiences a 1.50% increase in her expected return. However, if we hold everything constant about this average participant but

change her sex to male, this hypothetical participant experiences a 0.91% increase in expected return after managed account adoption—an improvement in performance significantly greater than zero but also significantly less than that of a female participant. Similarly, if we hold everything constant but change the hypothetical participant to a high wealth participant, they experience a 1.65% increase in expected return instead of 1.50%.

Figure 3 here

Results from the same regression using *Sharpe Ratio* as the dependent variable are also shown in Table 10. The effects from this regression are generally smaller than those from the expected return regression, and in many instances they are not significant. The exception is web registration. Web-registered participants experience a significantly smaller improvement in their Sharpe ratios as a result of managed account implementation than do non- web-registered participants, which suggests that less sophisticated or engaged investors experience greater improvements in their returns per unit of risk than more sophisticated or engaged investors. The smaller effects generally suggest that while the managed account program impacted expected returns, the impact on risk-adjusted returns was much smaller. One possible explanation (evident in the descriptive statistics in Table 9) is that similar changes in Sharpe ratios are occurring at different ends of the sophistication spectrum—both aggressive and conservative Red and Yellow investors are seeing similar improvements in Sharpe ratios, diluting the demographic variation across the sample. Also, the entire sample is being moved to approximately the same Sharpe ratio—that is, 0.32.

Summary and Implications

Our analysis of participant portfolio choice indicates that over four in ten participants construct "green" portfolios based on their overall exposure to diversified equity market risk, while another quarter or so construct "yellow" portfolios with possibly too-aggressive or too-conservative equity market exposure. Another three in ten make egregious or "red" portfolio errors, either by not investing in equities at all, or by over-concentrating their portfolio in company stock. At a finer level of portfolio detail, most participants (with some exceptions) do not appear to engage in additional levels of portfolio diversification, such as holding mid- and small-capitalization US or non-US stocks, despite the widespread availability of these options. Some portfolio diversification errors are clearly related to employer plan design (e.g., the availability of company stock or the presence of specialized diversification options), though most participants in our sample have access to a wide range of asset classes.

Our estimates suggest that portfolio errors can be costly. The most costly errors are made by Red (Zero Equity) participants, those who hold no equities in their 401(k) account; the potential gain from improving their portfolios is estimated at over 350 basis points in real return per year. Yet even Green investors can improve portfolio performance by 60 basis points or more through better portfolio construction. Gains are also possible in terms of portfolio return per unit of risk as measured by Sharpe ratios. For plan sponsors evaluating a given plan, the potential gains at the plan level will of course depend on the proportion of investor segments in the plan population. For example, a plan with a large Red (Zero Equity) will experience more dramatic improvements in expected returns than, say, a population with more Green or Yellow (Aggressive Equity) investors. Similarly, a plan with many aggressively oriented participants is likely to see expected returns fall, while efficiency measures improve.

The participants most likely to experience dramatic improvements in expected returns and Sharpe ratios from better portfolio strategies are those whose characteristics are typically associated with low levels of financial literacy. These include lower income, low 401(k) balance, low non-retirement wealth and female participants. More aggressive investors, who are more often affluent men, may experience reductions in returns, but still see improvements in overall portfolio efficiency and diversification.

There are a variety of strategies that sponsors and policymakers might pursue in order to improve participant portfolios. Continued financial education is one avenue, and indeed, investor education materials are already quite common within the 401(k) marketplace. However, the drawback is that education programs appear to yield few actual changes in portfolio strategy, due to the widespread prevalence of inertia among participants. Another approach is to promote automatic enrollment of participants into well-designed default funds. This is the premise underlying the Pension Protection Act, and the Department of Labor has proposed new regulations encouraging the greater use of "qualified default investment alternatives" (QDIAs). Advice programs may also improve portfolios. They typically come with incremental costs for the advisory service, although those costs must be compared with the potential gains in portfolio expected returns and/or diversification that may occur for participants.

Another possible strategy is the notion of mapping plan participants to "better" investment allocations. Under U.S. fiduciary law, plan sponsors, as the ultimate party responsible for the investment of plan assets, are able to "map" (or shift) all plan participants into other investment funds if they so choose.[23] Such a strategy could potentially improve portfolio allocations quickly, given the tendency of most participants to rely on default choices made by

others. And by including a right to opt-out, such a strategy could address the needs of those participants who have strong preferences for their existing choices.

Addressing over-concentration of company stock is more difficult due to the fact that some companies match in company stock, and such matching contributions appear to be the principal determinant of concentrated stock holdings. One option is for sponsors to match "in cash" (i.e., into the funds the employee has selected) rather than in employer stock. A second strategy is to impose limits on concentrated holdings by employees. Advice programs like managed accounts are a third approach, as the third party advisory service takes responsibility for the liquidation of employer stock, and the employer is not responsible for encouraging the use of company shares. A final option is Benartzi and Thaler's "Sell More Tomorrow" program, in which participants are defaulted into a reverse dollar-cost averaging service which gradually liquidates their stock holdings down to a reduced level over time.[24]

One limitation of our study is that we are assessing participants' portfolios at the 401(k) plan level, but participants could be constructing portfolios at the household level. For example, we might classify a participant portfolio as Red (Zero Equity), but the participant or the participant's spouse or partner may have assets outside the plan that are completely invested in equities. In total, their household portfolio could be Green. While we acknowledge that this is a possibility, our research suggests that for many participants their 401(k) is their only meaningful investment. Nearly 50% of our participants have less than $10,000 in non-retirement assets. Furthermore, a 2006 study from the Employee Benefit Research Institute[25] found that for nearly a third of participants, their retirement savings in their employer plan represented "all or almost all" of their total retirement savings and for another 15%, their employer plan represented three-

quarters of their total retirement savings. Given that most participants have no or few assets outside their plan, we believe this problem may be limited in scope.

Overall it seems that participant portfolios are quite heterogeneous, and efforts to improve portfolio allocations by sponsors will depend on the specific segments that predominate in a given plan. Any gains in expected real returns from improvements in portfolio strategy are likely to be largest among populations typically associated with low levels of financial literacy, especially female, low-income or low-wealth participants. Meanwhile, even aggressive, more affluent male investors may benefit from greater portfolio efficiency and diversification.

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Table 1. Sample Characteristics

	Full Sample	Managed Account Sample
N	2,857,089	11,729
Demographics		
Median age	44.0	50.0
Percent male	64%	48%
Median job tenure	8.5	13.2
Median household income	$ 87,500	$ 95,951
Percent high wealth*	21%	20%
Percent web registered	49%	56%
Investment		
Median plan assets	$ 23,784	$ 38,572
Percent equity exposure	67%	57%
Percent company stock exposure	11%	7%

Note: Data as of December 2005 except for the *Investment* data for the managed account sample, which is as of September 2004.
* Data from the IXI company were used to impute nonretirement plan household financial wealth at the ZIP+4 level. High wealth participants are defined as participants with over $50,000 in non-retirement household wealth (the top 20%).

Table 2. Participant Portfolio Construction -- Gross Level

Panel A. Equity Exposure by Company Stock Exposure

	Company Stock Exposure					
	1) Zero	2) 1 to 19	3) 20 to 39	4) 40 to 99	5) 100	All
Equity Exposure						
1) Zero	D 13.4					13.4
2) 1 to 39	B 5.2	1.7	0.8			7.7
3) 40 to 94	A 37.5	5.7	E 3.7	3.9		50.7
4) 95 to 99	C 3.3	1.0	0.6	1.6		6.6
5) 100	13.7	1.3	1.1	1.4	4.2	21.7
All	73.1	9.6	6.1	6.9	4.2	100.0

Panel B. Portfolio Classification

Investor Segment	**Percent**
A. Green	43.1%
B. Yellow (conservative equity)	6.9%
C. Yellow (aggressive equity)	19.3%
D. Red (zero equity)	13.4%
E. Red (company stock)	17.2%

Note: Based on full sample.

Table 3. Type of Investment Options Used

Category	Percent of Plans Offering	Percent of Participants Offered	Percent of Partcipants Offered and Using
Large Cap US equities	99%	98%	65%
Money Market/GIC	98%	98%	44%
Balanced / lifecycle	97%	95%	43%
High quality bond	97%	95%	26%
International equities	95%	96%	25%
Small/Midcap US equities	93%	96%	29%
REITs	21%	15%	8%
Speciality/Sector	19%	13%	12%
High-yield bonds	16%	15%	8%
TIPS	16%	20%	4%
Emerging markets	13%	15%	6%
Company stock	12%	46%	58%
World bonds	0%	2%	1%

Note: Based on full sample.

Table 4. Participant Asset Allocations by Investor Segment

Percent of assets

Category	Red (Zero Equity)	Yellow (Conservative Equity)	Green	Yellow (Aggressive Equity)	Red (Company Stock)
Large Cap	0%	8%	36%	68%	16%
Balanced	0%	16%	34%	1%	6%
Small & Mid Cap	0%	1%	7%	16%	4%
Money Market/GIC	92%	55%	7%	0%	8%
Bond	7%	14%	7%	0%	3%
International	0%	1%	5%	9%	2%
Company Stock	0%	2%	1%	1%	61%
Other	1%	2%	2%	4%	0%
TOTAL	100%	100%	100%	100%	100%
Percent Equity Exposure	*0%*	*21%*	*73%*	*99%*	*87%*

Note: Based on full sample.

Table 5. Demographics by Investor Segment

Variable	Green	Yellow (Conservative Equity)	Yellow (Aggressive Equity)	Red (Zero Equity)	Red (Company Stock)
Median age	44.0	49.0	43.0	44.0	46.0
Percent Male	61%	62%	67%	59%	70%
Median tenure	7.8	12.5	8.6	7.3	10.4
Percent Web Registered	52%	47%	56%	25%	53%
Median plan assets	$ 25,630	$ 32,089	$ 32,701	$ 6,700	$ 26,281
Median household income	$ 87,500	$ 62,500	$ 87,500	$ 62,500	$ 87,500
Percent High Wealth	22%	18%	28%	15%	18%

Note: Based on full sample.

Table 6. Demographics and Investor Segment

Percentage change in probability of being in segment relative to Green segment

	Red (Zero Equity)		Yellow (Conservative)		Yellow (Aggressive)	
N	377,049		195,823		536,756	
Percent in segment	24%		14%		31%	
Percent in Green (i.e., reference) segment[1]	76%		86%		69%	
Variable	**Marginal Probability**	**Relative Marginal Probability[2]**	**Marginal Probability**	**Relative Marginal Probability**	**Marginal Probability**	**Relative Marginal Probability**
Age (10)	1.11%	4.70% **	2.02%	14.62% **	-1.91%	-6.16% **
Male	0.71%	2.99%	0.03%	0.25%	7.34%	23.73% **
Assets (10K)	-0.78%	-3.30% **	-0.01%	-0.06%	-0.10%	-0.32% **
Tenure	0.31%	1.29% **	0.25%	1.77% **	0.11%	0.37% **
High wealth	-2.62%	-11.05% **	-2.48%	-17.93% **	5.89%	19.04% **
Household income low	4.15%	17.51% **	1.90%	13.75% **	-2.72%	-8.80% **
Household income high	-1.36%	-5.73% **	-1.41%	-10.16% **	2.96%	9.55% **
Web Registered	-13.72%	-57.91% **	-1.38%	-9.96% **	2.42%	7.82% **

** Significant at .01 level

Note: Based on full sample. Logistic regression with clustering at the plan level to ensure robust standard errors.

[1] N for the Green segment is 1,211,871

[2] This figure is the marginal probability divided by the *Percent in segment.*

Table 7. Investor Segments Pre- and Post-Adoption of Managed Account

Percent of participants

		Managed Account Sample		
Investor segment	**Full sample**	**Before Adoption**	***Difference with Full Sample***	**After Adoption**
A. Red (zero equity)	13%	15%	*1%*	0%
B. Yellow (conservative equity)	7%	11%	*4%*	1%
C. Green	43%	50%	*7%*	94%
D. Yellow (aggressive equity)	19%	13%	*-6%*	3%
E. Red (company stock)	17%	11%	*-6%*	2%
Total	100%	100%	*0%*	100%

Table 8. Detailed Allocations for the Managed Account Sample

Panel A. Overall Allocations

Percent of assets

Category	Red (Zero Equity)	Yellow (Conservative Equity)	Green	Yellow (Aggressive Equity)	Red (Company Stock)
Large Cap	0%	10%	29%	76%	21%
Balanced	0%	14%	49%	1%	6%
Small & Mid Cap	0%	1%	2%	7%	2%
Money Market/GIC	87%	47%	7%	0%	7%
Bond	13%	25%	6%	0%	7%
International	0%	1%	3%	8%	2%
Company Stock	0%	1%	1%	1%	55%
Other	0%	1%	3%	8%	0%
TOTAL	100%	100%	100%	100%	100%
Percent Equity Exposure	*0%*	*22%*	*65%*	*99%*	*84%*

Panel B. Differences with Full Sample (see Table 4)

Percent of assets

Category	Red (Zero Equity)	Yellow (Conservative Equity)	Green	Yellow (Aggressive Equity)	Red (Company Stock)
Large Cap	0%	2%	-7%	7%	5%
Balanced	0%	-2%	15%	0%	0%
Small & Mid Cap	0%	0%	-5%	-10%	-2%
Money Market/GIC	-5%	-8%	0%	0%	-2%
Bond	6%	10%	-1%	0%	4%
International	0%	0%	-2%	-1%	0%
Company Stock	0%	-1%	0%	0%	-5%
Other	0%	-1%	0%	4%	0%
TOTAL					
Percent Equity Exposure	*0%*	*1%*	*-8%*	*0%*	*-3%*

Table 9. Portfolio Return and Risk Characteristics by Investor Segment

Panel A ***Expected Real Returns After Fund Expenses (1)***

Segment	Before Managed Account	After Managed Account	Methodology Adjustment (2)	Change in Expected Return	*Percent Change*
Red (Zero Equity)	1.76%	5.41%	-0.07%	3.58%	*203%*
Yellow (Conservative Equity)	3.02%	5.70%	-0.10%	2.58%	*85%*
Green	5.09%	5.87%	-0.15%	0.63%	*12%*
Yellow (Aggressive Equity)	6.63%	6.00%	-0.19%	-0.82%	*-12%*
Red (Company Stock)	7.68%	6.14%	-0.21%	-1.75%	*-23%*
Total	4.86%	5.83%	-0.15%	0.82%	*17%*

Panel B ***Sharpe Ratios***

Segment	Before Managed Account	After Managed Account	Methodology Adjustment (2)	Change in Sharpe Ratio	*Percent Change in Sharpe Ratio*
Red (Zero Equity)	0.111	0.316	-0.0064	0.198	*179%*
Yellow (Conservative Equity)	0.250	0.318	-0.0025	0.066	*26%*
Green	0.304	0.319	-0.0043	0.011	*4%*
Yellow (Aggressive Equity)	0.289	0.318	-0.0049	0.024	*8%*
Red (Company Stock)	0.233	0.313	-0.0081	0.072	*31%*
Total	0.256	0.318	-0.0049	0.057	*22%*

Projected returns are based upon Financial Engines' forecasting methodology, which projects the likelihood of various investment outcomes that are hypothetical in nature. The expected returns do not reflect actual results and are not guarantees of future results.

Note: Based on managed account sample.

(1) Expected returns are after fund expenses but before the separate fee charged by the managed account service.

(2) These adjustments reflect changes over time in the sub-adviser's expected returns and/or covariance matrix. See text.

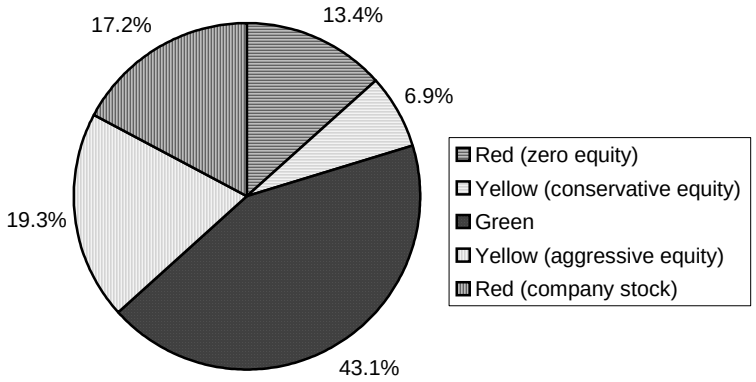
Table 10. Demographics and Portfolio Performance

	Dependent Variable: Expected Real Return		Dependent Variable: Sharpe ratio	
	Mean Before=.0486 After=.0583 Difference=.0090		Mean Before=.256 After=.318 Difference=.062	
Main Effects	*Estimates*		*Estimates*	
Intercept	0.0479	**	0.2639	**
Treatment	0.0299	**	0.0535	**
Age (10)	-0.0023	**	-0.0014	
Male	0.0073	**	0.0010	
Balance ($10K)	0.0002	**	0.0010	**
Tenure	0.0003	**	-0.0010	**
High wealth	-0.0020	**	0.0010	
Household income low	0.0003		-0.0016	
Household income high	0.0010	*	0.0024	
Web registered	0.0051	**	0.0121	**
Interaction Terms				
Treatment*Age (10)	-0.0019	**	0.0018	
Treatment*Male	-0.0059	**	-0.0017	
Treatment*Balance ($10K)	-0.0002	**	-0.0009	**
Treatment*Tenure	-0.0003	**	0.0009	**
Treatment*High wealth	0.0015	**	-0.0011	
Treatment*Household income low	-0.0004		0.0016	
Treatment*Household income high	-0.0007		-0.0022	
Treatment*Web registered	-0.0046	**	-0.0123	**
Clustering at Participant-level	Yes		Yes	
Observations	20,590		20,590	
# of Participants	10,295		10,295	
R Squared	20%		27%	

Notes:
Based on managed account sample.
Signficant at .05 (**) or .10 (*) level.
Clustering at the participant level to ensure robust standard errors.
Results do not account for the "methdology adjustment" described in footnote 21.

Figure 1. Investor Segments

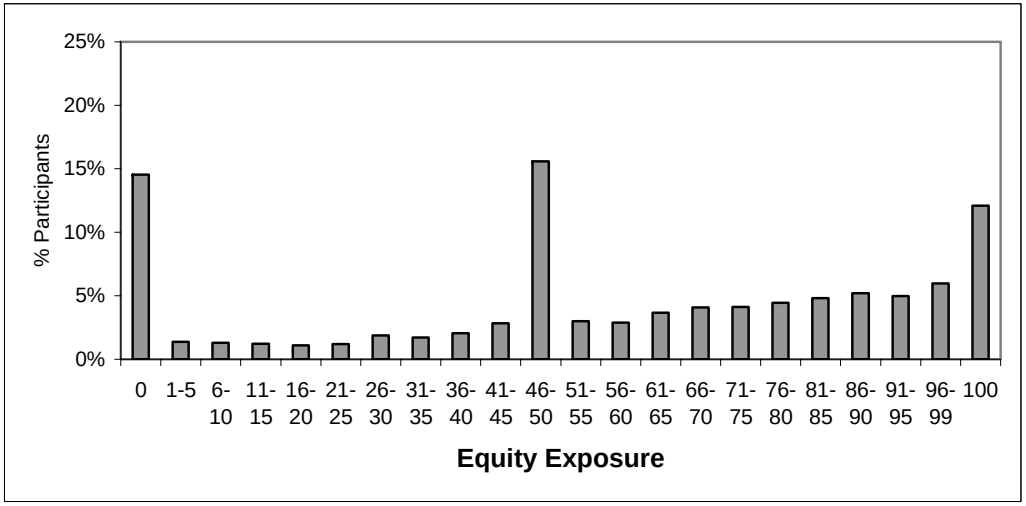
Percent of participants in each segment



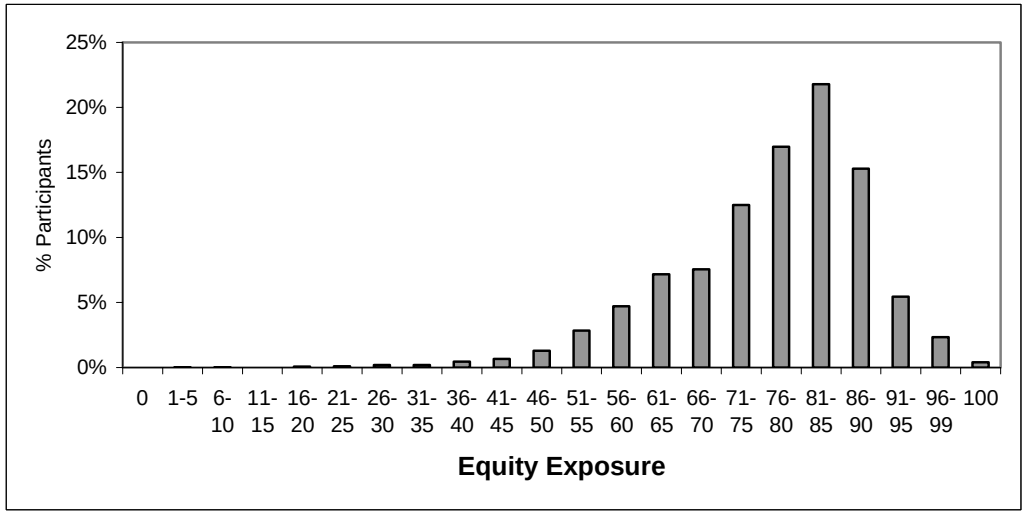
Note: Based on full sample.

Figure 2. Impact of Managed Account on Equity Exposure

Before managed account adoption



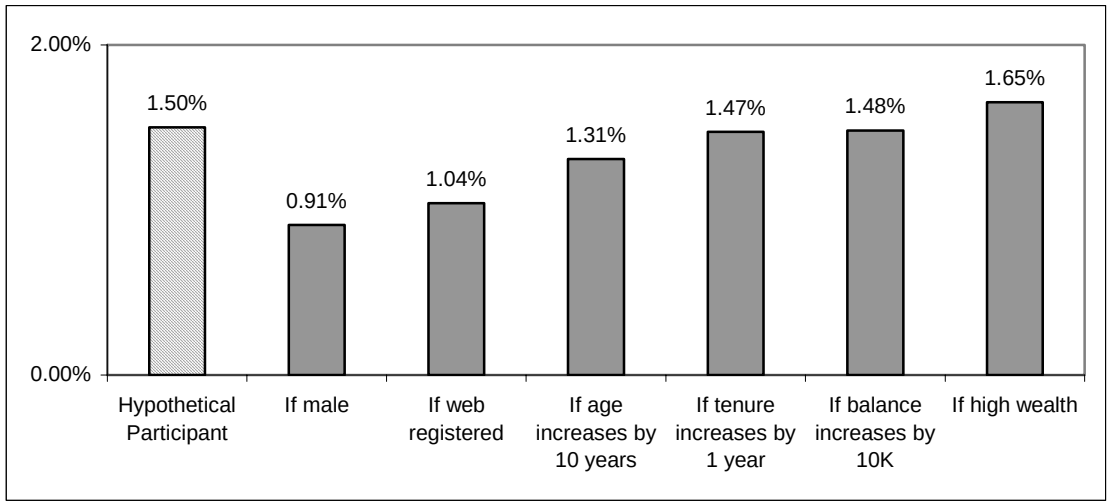
After managed account adoption



Note: Based on managed account sample.

Figure 3. Relationship Between Demographics and Portfolio Improvement

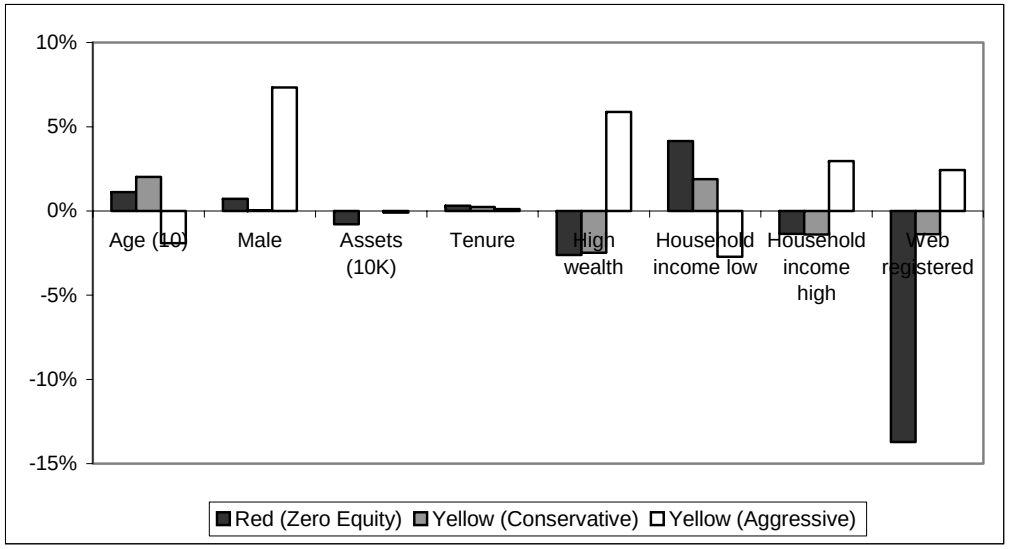
Change in expected return pre/post managed account implementation



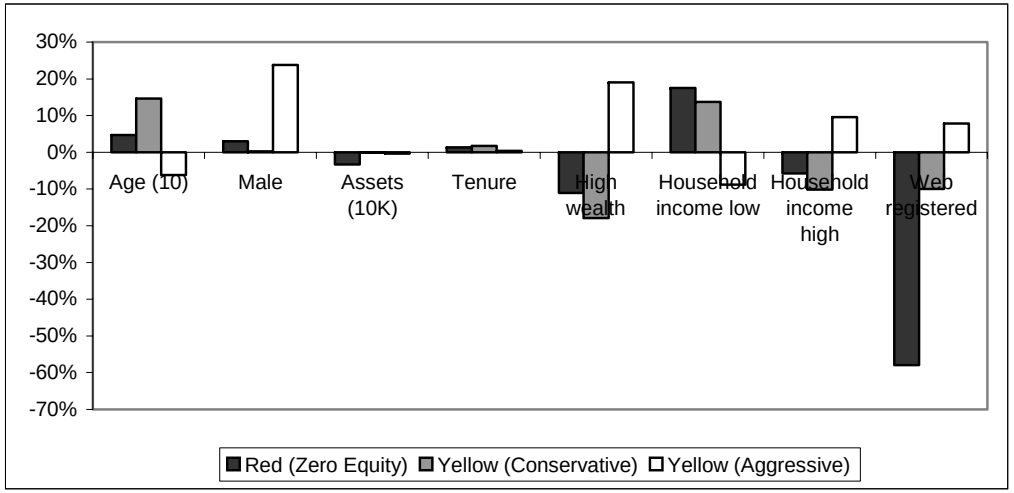
Note: Based on managed account sample. Due to the interaction terms in our model, the hypothetical participant effect of 1.50% is a conditional effect for low wealth, medium household income, non-web registered, females of average age, account balance, and tenure. The unconditional effect is .97%

Figure 4. Relationship Between Demographics and Investor Segment Membership

Panel A. Marginal Probabilities



Panel B. Relative Marginal Probabilities



Endnotes

[1] See Hancock (2002) and Vanguard (2002).
[2] Vanguard (2006a) includes summary statistics on participant allocation patterns. See also Munnell and Sundén (2004).
[3] A managed account service is a third party, professional advisory service authorized for 401(k) plans by the US Department of Labor in its 2001 "SunAmerica" advisory opinion. By signing up for the managed account, the participant cedes all investment control to the third party advisor, which reallocates the participant's plan balance to conform to the advisor's investment recommendations. The advisory is also responsible for ongoing management and rebalancing of the portfolio.
[4] Though not strictly relevant to our current effort, the broader theoretical debate over whether investors should hold age-contingent equity allocations (see Viceira, 2001, and Cocco, Gomes and Maenhout, 2005) has been mirrored in 401(k) plan research, with conflicting findings. Ameriks and Zeldes (2004) find very little age-based variation in their TIAA-CREF data set drawn from the higher-education community. Yet in a study of one large corporate-sector plan, Agnew, Balduzzi and Sundén (2003) find that equity allocations decline regularly with age.
[5] Brown *et al.* (2006) also find that over time, sponsors have typically added higher-cost active funds to plans. As a result, participant costs have increased over time, and returns have fallen.
[6] In related work, focusing on the design decisions by employers, Elton, Gruber, and Blake (2006) found that 401(k) menus varied in terms of the asset classes offered to participants.
[7] See also Calvet, Campbell and Sodini (2006) for related work on Swedish households.
[8] The 2,000 plans are from 1,600 sponsoring organizations. Up to one-third of the participants are not actively contributing, typically because they have changed jobs and left their 401(k) savings in the plan of their prior employer.
[9] The mean participant in this dataset was 44 years old, worked for his employer for 12 years, had a household income of $99,000, and accumulated $68,000 in retirement savings.
[10] These participants are drawn from 19 sponsoring organizations and 37 plans with 242,412 unique participant accounts.
[11] In total, 95% of participant portfolios fell in this range after managed account implementation. See Vanguard (2006b) for full details about adoption of the managed account service.
[12] Our first-order approximation of the Campbell rule is, of course, that it is a mistake to hold zero percent in equities in one's 401(k) account, as equity options in 401(k) plans are in pooled vehicles with no transaction costs, and there are no minimum account investment amounts, unlike equities held in brokerage or mutual fund accounts.
[13] The PPA requires that plans offering company stock notify participants of their "right to diversify." The Internal Revenue Service builds on this provision with Notice 2006-1-7—which states that "if you invest more than 20% of your retirement savings in any one company or industry, your savings may not be properly diversified."
[14] Our color classification scheme shouldn't be misconstrued as concluding that, for example, all "green" portfolios are optimally diversified. The classification scheme simply represents the adherence of participant portfolios to the four portfolio construction rules outlined earlier. Of course, other types of rules will result in different outcomes.
[15] Company stock classification superseded equity exposure classification, so, for example, a participant with between 40 and 95% equity exposure but over 20% company stock exposure would be classified as Red (Company Stock). In addition, company stock exposure is a percentage of the participant's entire portfolio—not just the equity portion of their portfolio. So, a participant with $100 in Total Stock Market Index, $100 in Total Bond Market Index, and $100 in company stock would have a company stock exposure of 33%.
[16] Some other participants may have exposure to these asset classes via the balanced or lifecycle fund category. But the aggregate level of exposure is low.
[17] The relative marginal probability is determined by dividing the marginal probability by the probability of segment membership relative to the Green segment (labeled "Percent in segment" in Table 6).
[18] Portfolio expected real returns for the *i*th participant account at time *t* are simply the weighted average of expected real returns for the *k* assets in the plan: $E(r_i) = \sum_{k=1}^{N} \omega_{k,t} E(r_k)$. Portfolio variances based on the variance-covariance matrix $\hat{\Sigma}$ are: $\hat{\Sigma}_i = \omega'_{i,k,t} \hat{\Sigma} \omega_{i,k,t}$. The returns are real returns—expected returns after projected inflation. Returns are also net of fund expenses. However, the cost of the managed account service has not been

deducted from any of the returns reported in this paper. Importantly, the projected returns are based upon Financial Engines' forecasting methodology, which projects the likelihood of various investment outcomes that are hypothetical in nature. The expected returns do not reflect actual results and are not guarantees of future results.

[19] The change in participant portfolios was calculated by comparing portfolios at two points in time—September 2004 and December 2005. The expected returns/covariance matrices used in this paper were provided by Financial Engines for two points in time (i.e., July 2004 and October 2005). Time 1 characteristics were calculated using the participant's holdings from September 2004 and the expected return/covariance matrix from July 2004 and the Time 2 portfolio characteristics were calculated using the participant's holdings from December 2005 and the expected return/covariance matrix from October 2005.

[20] Each *i*th account's Sharpe ratio is its excess return over the risk-free rate divided its portfolio standard deviation, $r_i - r_f / \sigma_i$.

[21] This estimate is likely to be an upper bound of gains for Green investors in our full sample, as Green managed account participants had 8% less in equities than our full sample.

[22] One concern with our analytical approach is that we are using assumptions developed by the sub-advisor to evaluate portfolios constructed by that same sub-advisor. However, our review of Financial Engines' expected returns for major asset classes suggests that they are broadly consistent with long-term historic patterns of returns. As a result, we believe our findings are not biased by overly optimistic assumptions about future stock returns or overly pessimistic assumptions about future fixed income returns. That said, a second issue is that Financial Engines does revise its return and correlation assumptions over time, and over the period of our study, their forward-looking returns became slightly more optimistic. For example, their expected return for a broad US stock market index fund rose 13 basis points over our analysis period. We make what we call "methodology adjustments" to compensate for this effect. See Vanguard (2006) for additional details.

[23] Sponsors may forfeit so-called 404(c) fiduciary protection in doing so. But they may choose to map the plan if, as plan fiduciaries, they judge such a move to be in the best interests of plan participants. There is anecdotal evidence that some sponsors have undertaken such mappings, usually providing participants with the right to "opt out" of such changes and retain their existing holdings.

[24] See Benartzi, Thaler, Utkus and Sunstein (forthcoming).

[25] Helman, Copeland and VanDerhei (2006).