



**Department of Finance**  
Working Paper Series

---

**FIN-03-051**

---

**The Adequacy of Investment Choices Offered By 401K Plans**

*Edwin J. Elton, Martin J. Gruber and Christopher R. Blake*

**December 2003**

The 2003 NYU Stern Department of Finance Working Paper Series is generously sponsored by

**FitchRatings**

The Adequacy of Investment Choices Offered  
By 401K Plans

Edwin J. Elton\*

Martin J. Gruber\*

Christopher R. Blake\*\*

\* Nomura Professors of Finance, New York University

\*\* Professor of Finance, Fordham University

# The Adequacy of Investment Choices Offered by 401K Plans

## **Abstract**

Defined-contribution plans represent a major organizational form for investors' retirement savings. Today more than one third of all workers are enrolled in 401K plans. In a 401K plan, participants select assets from a set of choices designated by an employer. For over half of 401K-plan participants, retirement savings represent their sole financial asset. Yet to date there has been no study of the adequacy of the choices offered by 401K plans. This paper analyzes the adequacy and characteristics of the choices offered to 401K-plan participants for over 400 plans. We find that, for 62% of the plans, the types of choices offered are inadequate, and that over a 20-year period this makes a difference in terminal wealth of over 300%. We find that funds included in the plans are riskier than the general population of funds in the same categories. We study the characteristics of plans that are associated with adequate investment choices, including an analysis of the use of company stock, plan size, and the use of outside consultants. When we examine one category of investment choices, S&P 500 index funds, we find that the index funds chosen by 401K-plan administrators are on average inferior to the S&P 500 index funds selected by the aggregate of all investors.

Keywords: 401K plans, pension, spanning, portfolio, investment choices

JEL classification: G11, G12, G23, E21

A major trend in pension plans offered by companies is a movement from defined-benefit plans to defined-contribution plans. The majority of defined-contribution plans offered by companies are 401K plans. More than one third of all workers are enrolled in 401K plans, and these plans have over one trillion dollars under management. There has been some research on how investors react given the investment choices they face. For example, investors tend to allocate their funds equally over the investments they are offered. This is often referred to as the “ $1/n$  Rule” (see Benartzi and Thaler (2001) and Liang and Weisbenner (2002)). Another finding is that investors over-invest in stock of the company for which they work (see Huberman and Sengmuller (2003) and Agnew and Balduzzi (2002)).

With all the interest in how investors react given the choices they are offered, it is surprising that there have been no studies of the appropriateness of the decisions that corporations make with respect to which investment choices to offer plan participants. The investment alternatives offered are important to participants because, for over one half of plan participants, the 401K investments are their sole financial assets. Even for those participants who hold other financial assets, the 401K assets are likely to be the bulk of their financial assets, so that plan offerings are likely to restrict the portfolios they can hold.

What choices should a corporation offer to plan participants? For those participants for whom 401K investments are their sole financial assets, the corporation should offer a sufficient set of investment alternatives so that the investor could construct the same efficient frontier that he or she would obtain if there were choices from a reasonable set of alternatives. Investors who have other financial assets would not be hurt by such a strategy, so this strategy is dominant for

all investors.<sup>1</sup> In this paper we examine the adequacy of the investment alternatives offered by 401K plans utilizing mutual funds.

This paper is divided into eight sections. In the first section we discuss the data used. In the second section we discuss two ways of classifying investment choices to form alternative portfolios to compare against actual 401K plan offerings, and we explore which type of classification offers the best set of alternative choices for plan participants. In the third section we examine the minimum number and types of alternative investment choices to include in the optimal choice set of the comparison portfolios. In the fourth section we examine whether or not the mutual funds offered would suggest that 401K plan administrators consider risk in deciding which investment choices to offer. In the fifth section we explore issues of how well the fund offerings span the efficient set. In that section, we not only examine statistical tests, but we also examine economic significance (effect on participants' returns) of a failure to provide appropriate offerings. In the sixth section we examine the effect of offering company stock on plan risk and the efficient frontier. In section seven we examine whether other characteristics of the plans affect the appropriateness of the investment choices offered to plan participants. Finally, in section eight we summarize our results.

## **I. Data**

Our data were provided by Moody's Investor Services. Moody's collects data by means of a survey of pension plans offered by both for-profit and non-profit entities (collected in 2002 with information through 2001). From this data set we selected all 401K plans that employed publicly available mutual funds for participant choices. However, we did not exclude plans that

---

<sup>1</sup> If a plan is administered by an external party, the administrator may charge additional fees if the company wishes to include funds outside the external party's normal offerings. However, there are so many plan

offered, in addition to mutual funds, non-public money market funds, GICs and stable value funds and/or company stock. We were able to identify 680 401K plans for which the CRSP mutual fund database contained at least some data on each of the mutual funds offered in the plan. Of the 680 plans, 417 had at least five years of total returns data in the CRSP database for every mutual fund they offered.<sup>2</sup> For each of these plans we collected data on the mutual funds offered, historical returns for each mutual fund, and the names and characteristics of the firms offering the plans.

Table 1 shows the number of distinct investment choices offered by the 680 plans mentioned above. The median number of 401K plan offerings is eight. Approximately 12% of the 401K plans offer four or fewer investment choices, and approximately 11% offer 13 or more investment alternatives. The median number of investment offerings we report is somewhat less than that reported by Huberman and Sengmuller (2003). Huberman and Sengmuller's data sample came from 401K plans managed by Vanguard. Many plans restrict their offerings to one fund family. Vanguard is one of the largest mutual fund families in terms of number of funds offered. Thus it is not surprising, and is consistent with what we observed in our sample, that plans managed by Vanguard offer more choices than would be observed in the population.

Table 2 shows the percentage of plans that offer various types (using ICDI classifications) of investment choices to their participants. The most common investment choice (offered by 97.4% of plans) is a domestic equity fund. The next most common offering (86.8%) is an alternative such as a GIC or money market fund, where interest is intended to be the only source of return. Other common offerings fall in the following categories: domestic bond funds

---

administrators for a company to choose from that this is unlikely to have an effect on our findings.

<sup>2</sup> When later we draw general samples of mutual funds for comparison purposes, we use the same selection procedure so that comparisons are not biased.

(71.5%), domestic mixed bond and stock funds (80.6%), and international bond and/or stock funds (75.1%). The high percentage of 401K plans that offer international funds is surprising, given the much lower percentage international funds constitute of mutual funds publicly available to investors. Finally, 22.9% of the 401K plans offer company stock as an alternative for their participants.

Forty-eight of the 680 plans offered pension participants at least one specialized fund as an alternative choice; there were a total of 56 such choices. Thirty-one of these specialized funds were science and technology funds, six were real estate funds, five were telecommunications funds, four were healthcare funds, four were natural resources funds, four were utilities funds, one was an e-commerce fund and one was a financial services fund. There is no relationship between type of specialized funds offered and the type of firm offering the 401K plan. We noted that 33 of the 56 specialized funds were T. Rowe Price funds, suggesting that recommending inclusion of a specialized fund is a strategy employed to market T. Rowe Price funds to 401K plan administrators. The large number of science and technology funds offered at the date our sample was constructed suggests that some plan administrators were including the then-current “hot” sector.

## **II. Determining the Comparison Portfolios**

In order to determine if 401K plans offer their participants adequate investment choices, we need to hypothesize an adequate set of alternative investment choices. There are two approaches we can use to determine an adequate set of alternative investment choices. The first approach draws on the field of financial economics, where extensive literature exists that discusses indexes that are necessary and sufficient to capture the relevant return characteristics

for a range of investment choices. The second approach draws on the development by the financial industry of a set of classifications that the industry finds relevant for classifying investment portfolios. These classifications represent the investment industry's attempt to separate mutual funds into groups that behave similarly and define a complete set of relevant investment choices. In this section of the paper we examine both of these methods for classifying investments to see which classification provides a better set of alternative investment choices.

Initially, we examine classifications from research on what affects returns. For common stocks, we classified by value versus growth and by size as advocated by Fama and French (1994). Because of industry practice, we classified by size into three groups: small-cap, mid-cap and large-cap. Each of these three groups was then further divided into value and growth.<sup>3</sup> All six indexes were taken from Wilshire. We chose Wilshire indexes because there are existing tradeable funds that attempt to match them. For bonds, we used a general bond index, including governments and corporates, a mortgage-backed index, and a high-yield index. This division is supported by Blake, Elton and Gruber (1993), who found this division was sufficient to capture differences in return across bond funds. We used the Lehman U.S. Government/Credit index for the general bond index, the Lehman Fixed-Rate Mortgage-Backed Securities index for the mortgage index, and the Credit Suisse First Boston High-Yield index for the high-yield bond index. We also included the Salomon Non-U.S.-Dollar World Government Bond index for international bonds and the MSCI EAFE index for international stocks.<sup>4</sup>

---

<sup>3</sup> This division is also supported by Elton, Gruber and Blake (1999), who found that these indexes plus a bond and international index captured most of the return differences among funds.

<sup>4</sup> We also considered adding a real estate index. However, only six of our 417 sample 401K plans include a real estate fund. Therefore, we dropped real estate when we looked at sufficiency of offerings of 401K plans, so that rejection of sufficiency of any sample 401K plan's offerings would not be due to the exclusion of a real estate investment choice. However, we should note that inclusion of a real estate index did improve the efficient frontier in some periods.



Since returns on all mutual funds are computed after expenses, we deducted expenses from each of our indexes. For each of our indexes, we used the expense charge of the index fund (including exchange-traded funds) that most closely matched the index. If there were multiple index funds matching the index, we used the expense charge of the lowest cost fund. In what follows we refer to these indexes as “Research-Based” indexes, or “RB” indexes.

The second method for selecting categories of funds that might be appropriate to include in 401K plans is to use one of the public investment services’ fund classifications based on fund objectives and policies. These classifications represent the investment industry’s attempt to divide funds into groups that behave similarly and are a complete set of investment alternatives. Groups based on ICDI classifications and the percentages of plans that offer any particular group to a participant are shown in Table 2. For each ICDI investment objective group except interest-only funds and utility funds, we computed a monthly return index starting in January 1992 and ending December 2001 (10 years) by taking an equally weighted average each month of the returns on all funds in the group that existed as of January 1992. If, during the 10-year period, a fund ceased to exist or changed objectives, the fund was dropped from the index at that point in time.<sup>5</sup> In what follows we will refer to these indexes as “Objective and Policy-Based” indexes, or “OPB” indexes.

In the next section, we compute Sharpe ratios and perform intersection tests to examine which of these classifications provide better opportunities for investors.

---

<sup>5</sup> The CRSP mutual fund database is not very accurate in properly recording when a firm ceased to exist or changed objective. Elton, Gruber and Blake (2001) showed this does not add bias. The way we constructed each index assumes investors reallocate their money across the remaining funds in the group when a fund changes objectives or ceases to exist.

## **II.A. Sharpe Ratios**

Table 3 shows the Sharpe ratios for optimal portfolios when short sales are not allowed constructed from the 11 RB indexes and the 14 OPB indexes for the ten-year period 1992-2001 and the two five-year sub-periods.<sup>6</sup> In computing Sharpe ratios we used as the risk-free rate the average of the 30-day CRSP T-bill rate over the relevant period. In the two five-year sub-periods and in the 10-year period the Sharpe ratios are higher for the efficient frontier calculated using returns on the RB indexes. Furthermore, the differences in Sharpe ratios between the two sets of indexes are statistically significant in both of the five-year subperiods. (The significance tests are described in Appendix A.)

The evidence in Table 3 indicates that classifying funds along the lines suggested by the literature of financial economics may be superior to accepting commonly used objective and policy classifications such as those provided by ICDI. Next we will examine intersection tests to see what this adds to the analysis.

## **II.B. Intersection Tests**

One of the principal tests used in this paper is a test of intersection, a particular form of spanning. For example, if a set of choices were offered to holders of a 401K plan, do these choices lead to the same efficient frontier as would a more general set of options? Spanning is important because for over half the 401K participants the 401K investments are their sole financial investments. Tests of spanning are discussed in Huberman and Kandel (1987), De Santis (1994), Bekaert and Urias (1996) and DeRoos, Nijman and Werker (2001), among others. In this article we make use of the results derived in DeRoos et al (2001) for the case of short sales disallowed. At this point we will provide an intuitive explanation for the methodology used

---

both in this section and in later sections of this paper, followed by an application of the methodology to RB and OPB indexes.

### II.B.1. Methodology

The purpose of the intersection test is to examine whether, given a riskless rate, a particular set of benchmark assets is sufficient to generate the efficient frontier or whether including (long or possibly short) members of a second set of assets would improve the efficient frontier at a statistically significant level.

As DeRoos et al (2001) have shown, if the optimal (tangent) portfolio consists of  $K$  benchmark assets, then intersection is a test of the impact of restricting the intercept ( $\alpha$ ) in the following time-series model:

$$R_{it} - R_f = \alpha_i + \sum_{k=1}^K \beta_{ik} (R_{kt}^B - R_f) + \varepsilon_{it} \quad (1)$$

where

$R_{it}$  = the return on non-benchmark asset  $i$  ( $i = 1, \dots, N$ ) in month  $t$ ;

$R_f$  = the risk-free rate;

$R_{kt}^B$  = the return on benchmark asset  $k$  in month  $t$ ;

$\varepsilon_{it}$  = the error term for asset  $i$  in month  $t$ .

When short sales are allowed, intersection occurs if, for all of the  $N$  non-benchmark assets jointly, the  $\alpha_i$  are not statistically significantly different from zero, i.e., the restrictions are

$$\alpha_i = 0 \quad \forall i \quad (1a)$$

---

<sup>6</sup> Throughout this paper, the case of short sales not allowed is emphasized because a plan's participants can not short sell the mutual funds offered by the plan.

When short sales are not allowed, the right-hand side of equation (1) includes returns on only those benchmark assets that are held long in the optimal portfolio of benchmark assets.<sup>7</sup> Intersection occurs if, for all of the  $N$  non-benchmark assets jointly, the  $\alpha_i$  are not statistically significantly positive, i.e., the restrictions are

$$\alpha_i \leq 0 \quad \forall i \quad (1b)$$

The logic behind the test can be easily understood. In the case of short sales allowed if an asset had a positive (or a negative) alpha, then including the asset long (or short) would improve the efficient frontier. Without short sales, only the inclusion of an asset with a positive alpha would improve the efficient frontier.

To test whether, given a riskless rate, we have a set of benchmark assets that spans the relevant space, we simply have to test the unrestricted model (equation (1)) against the model with the restrictions on alpha. This involves employing equation (1) using the restrictions (1a) ( $\alpha_i = 0 \quad \forall i$ ) for the case where short sales are allowed and using the restrictions (1b) ( $\alpha_i \leq 0 \quad \forall i$ ) for the case where they are not allowed.

To test whether or not the restrictions hold, we use the likelihood ratio test statistic suggested by Gallant (1987) with small-sample adjustment. The likelihood ratio test is:

$$L = T \left( \ln |\tilde{\Sigma}| - \ln |\hat{\Sigma}| \right) \quad (2)$$

where  $T$  is the number of time-series observations,  $\tilde{\Sigma}$  is the estimated variance-covariance matrix of the residual errors of the  $N$  non-benchmark assets from the restricted equation, and  $\hat{\Sigma}$  is the estimated variance-covariance matrix of the residual errors of the  $N$  non-benchmark assets from the unrestricted equation.  $L$  is asymptotically distributed as chi-squared with  $q$  degrees of

---

<sup>7</sup> These benchmark assets can be easily identified by solving a quadratic programming problem.

freedom, where  $q$  is the number of parametric restrictions. For small samples such as we have cross-sectionally, Gallant recommends the use of the  $F$  distribution with degree-of-freedom corrections instead of the chi-squared distribution. The small-sample adjustment is simply to compare  $L$  to  $q \times F_x$ , where  $F_x$  is the  $F$  statistic at significance level  $x$  with  $q$  numerator degrees of freedom and  $T \times M - p$  denominator degrees of freedom, and where  $M$  is the number of equations estimated and  $p$  is the number of parameters. If  $L$  is greater than  $q \times F_x$ , then the null hypothesis that the restrictions hold is rejected.

## **II.B.2. Results**

Since Sharpe ratios suggest that RB indexes are potentially superior to OPB indexes, we examine the following question: if we construct the efficient frontier using RB indexes, does adding OPB indexes shift the efficient frontier?

When we do not allow short sales, the answer is the same in each five-year subperiod and in the overall ten-year period. We can not reject the hypothesis that the intercepts are zero or less for the OPB Index, which implies that adding OPB Indexes does not shift the efficient frontier. In fact, in the ten-year period and both five-year subperiods, the determinants of the constrained and unconstrained variance-covariance matrices of the residuals are the same.

When short sales are allowed, adding the OPB Index causes the efficient frontier to shift and we reject the hypothesis that the intercepts are zero. However, examining the individual intercepts reveals an interesting pattern. In the ten-year period and both five-year subperiods, all intercepts from the unrestricted model are negative in the case where short sales are not allowed. This means that the efficient frontier shifts because we short-sell the OPB indexes. Since short sales are not allowed for 401K plans, none of the OPB indexes improves the choice set. The universally negative intercepts also explain why the determinants of the constrained and

unconstrained variance-covariance matrices of the residuals are the same. The constraint that the intercepts are non-positive is not binding.

The intersection tests show that none of the OPB indexes improve optimal portfolios derived from RB indexes when short sales are not allowed. In addition, the Sharpe ratio tests tend to support the conclusion that RB indexes provide a better set of alternatives. Thus, in what follows we will use the categorization suggested by financial research. This set of choices works at least as well as the set of choices that the investment community accepts as sufficient to delineate the relevant choice set for investors.

### **III. Reducing the Number of Choices**

Having determined that the categorization from financial research is no worse and probably better than commonly used objective and policy classifications, the next question to ask is whether some of the RB index classifications are redundant and, if so, what is the composition of the reduced set. We want to exclude redundant indexes from our index set, because their inclusion might result in our rejection of the adequacy of the investment choices offered by some plans purely on the basis of chance. We examine reducing the set of indexes in three ways: composition of efficient frontiers, factor analysis, and cluster analysis. We present the details of the analyses in Appendix B, and we summarize the results below.

We first examined composition of the efficient portfolio for each of 12 time periods. Some categories (e.g., mid-cap growth stocks) never entered the efficient frontier, while others (e.g., mid-cap value and small-cap value) occasionally entered and often substituted for each other.

We next performed maximum-likelihood factor analysis on the data. Using several tests for statistical significance, a five-factor solution was indicated. Rotating the five factors (using quartimax rotation) allowed us to associate economic characteristics with each of the five factors. However, two of the factors involved a positive weight on one index and a negative weight on a second index (e.g., a positive weight on the growth index and a negative weight on the value index), and, since pension funds can not short sell securities, replicating the five factors requires at least seven of our original 11 indexes.

As a final step, cluster analysis was performed on the 11 RB indexes. The results indicated 8 identifiable groups. From the analysis, three pairs of the 11 RB indexes were combined (small-cap growth with mid-cap growth, small-cap value with mid-cap value, and government/corporate bond with mortgage bond), leaving us with a final set of 8 RB indexes.

#### **IV. Diversification of 401K Plan Offerings**

In this section we examine the extent to which 401K plan administrators consider risk when they decide on which investment choices to offer plan participants. To examine this, we compare the risk of the actual 401K plan offerings to the risk of offerings from “synthetic” 401K plans constructed by using random selection of publicly available mutual funds. We have several ways to implement this random selection. The simplest, and most direct, method is to make the odds of selecting a fund from any ICDI category equal to the proportion of that category held by our sample of 401K plans. Within a category (e.g., aggressive growth) the odds of choosing any single fund are made equal. The population of funds from which we select consists of all funds that exist as of the end of 2001 and have five years of history. These are the same criteria we used when selecting 401K plans to include in our total returns sample.

This is an extremely naïve selection rule that ignores completely the correlation between ICDI categories. A slightly less naïve strategy would force all synthetic plans to hold at least one randomly selected bond fund and one randomly selected stock fund. Examining the holdings of the actual 401K plans shows that this is a strategy followed by many plans. Thus our second random-selection strategy, called “constrained random selection,” follows the same random-selection rules described above except that all synthetic plans are forced to hold at least one bond and one stock fund.

To calculate portfolio variances for both the actual 401K plans and the synthetic 401K plans, we need to formulate a rule to represent the investment weighting for a hypothetical plan participant. Given the strong evidence that plan participants equally weight their 401K plan offerings (see Benartzi and Thaler (2001) and Liang and Weisbenner (2002)), we use one divided by the number of a plan’s investment choices to represent a participant’s chosen investment weight in each of the plan’s mutual fund offerings.<sup>8</sup>

While estimates of variances and covariances differ according to the random-selection rules we use, we can compute overall synthetic plan portfolio variance for each random-selection rule using the standard formula for an equally weighted portfolio.<sup>9</sup> The portfolio variance is:

$$\overline{VarP_N} = \left(\frac{1}{N}\right) \times \overline{Var} + \left(\frac{N-1}{N}\right) \times \overline{Cov} \quad (3)$$

where  $\overline{VarP_N}$  is the average variance of a portfolio consisting of  $N$  funds drawn at random from our population of mutual funds, with equal investment in each fund selected, and  $\overline{Var}$  and  $\overline{Cov}$  are the average fund variance and the average covariance between funds, respectively, if funds

---

<sup>8</sup> We exclude from the investment choice sets company stock, GICs, stable value funds and money market funds.



are selected using either of the random selection techniques discussed earlier. (For details on how  $\overline{Var}$  and  $\overline{Cov}$  are calculated, see Appendix C.)

Table 4 presents the average values (by number of funds offered) of the variances for the actual 401K plans as well as the variances that would occur if plan sponsors selected funds at random using either of the selection rules described above.<sup>10</sup> The first thing to note from Table 4 is that, while on average the variance of return on actual 401K plans is lower than the variance would have been if plan sponsors had randomly selected a set of mutual funds, it is higher once we make the realistic assumption that the synthetic plans have at least one bond fund and one stock fund. Plans on average have a variance that is 2.29 lower than that using random selection of funds but 2.087 higher than that using constrained random selection.<sup>11</sup> Both differences are statistically significant at better than the 0.01 level. It is also interesting to note that as plans offer more investment choices (beyond three) the overall risk is reasonably flat

To gain more insight into the risk of 401K plans, we separately examined the average variance of individual funds held by all plans and the average correlations between the funds held by all 401K plans. The average individual variance of the mutual funds held by 401K is 26.76. If 401K plan sponsors selected mutual funds randomly but maintained the same percentage in each ICDI category as the aggregate of all plans, the average fund variance would have been 30.49. If instead we simply computed an average fund variance across all mutual funds, weighting each fund equally, the variance would be 31.26. Thus 401K plan administrators

---

<sup>9</sup> See Elton and Gruber (1977).

<sup>10</sup> Only one of our 417 sample 401K plans offered 17 funds; therefore we do not report average values for 17-fund plans in Table 4.

<sup>11</sup> Because average variances can not be constructed using constrained random selection for plans with only 1 fund, the reported averages and significance tests exclude the 10 401K plans in our sample that offered only 1 fund (along with the one plan that offered 17 funds) for a total of 406 funds.

select mutual funds with a lower fund variance both relative to what it would be if they randomly selected funds while maintaining the aggregate plan proportions in ICDI categories and relative to what it would be if they simply randomly selected across all available funds.

The other element that affects portfolio variance is correlation. The average pairwise correlation among funds selected by 401K plans is 0.60, while for random selection, maintaining ICDI proportions, it is 0.55. The difference is statistically different at the 1% level. Thus plan administrators select funds that are more highly correlated than the average correlation between pairs of funds.

Overall, plan administrators offer plan participants mutual funds with less variance than randomly selected funds, but funds that are more highly correlated. Managers appear to pay more attention to a fund's variance than to the correlation of the fund with other plan choices when selecting funds. For plan participants using the  $1/n$  Rule, this results in lower variance than pure random selection. However, it results in a much higher variance than random selection if all random portfolios are constrained to include at least one bond and one stock fund.<sup>12</sup>

## **V. Adequacy of Plan Offerings**

In looking at the adequacy of plan offerings, we have to look beyond the risk attributes discussed above, since return as well as risk affects the efficient frontier. In this section we use spanning tests to see if plans offer participants adequate investment choices.

Earlier we argued that an investor could be satisfied with a choice from among eight research-based indexes. The question is whether the choices offered by 401K plans span the

---

<sup>12</sup> The random selection leads to more small funds being selected than 401K plans actually hold. If we control for this by eliminating funds less than \$50 million in size, the variance of randomly selected funds is reduced to 29.592 if we maintain the same percentage in each ICDI category as funds selected, or 30.726 using equal probability of selection for all funds.

space delineated by the eight RB indexes; if they do not, then optimal investment choices are not being offered. Since plan participants can not short sell assets in their 401K plans, we use the intersection test described earlier for the case where short sales are not allowed. The results of the intersection tests are shown in Table 5.<sup>13</sup> Plans holding four or fewer funds rarely offer a set of funds that span the eight RB indexes. For these plans there are more RB indexes than fund offerings. However, it is possible that a small set of funds spans the larger set of RB indexes, either because some of the RB indexes are not desirable investments or because some of the funds are combinations of two or more of the RB indexes. However, this does not happen for funds offering a small set of investment choices. For plans holding seven or more funds, we find that about 54% of the plans offer investment choices that span the relevant space investors are interested in.<sup>14</sup> Of course, the glass is also half empty in that 46% of the plans leave investors unsatisfied. Finally, it is not until plans offer 14 or more investment choices (4.2% of all plans) that virtually all plans offer investment choices that span the space investors should be interested in.

Of the 406 plans, only 38% span the space obtainable from the eight RB indexes.<sup>15</sup> While some 401K plans offer participants a rich enough selection of investment choices to satisfy their needs, clearly a number of 401K plans do not do so.<sup>16</sup>

---

<sup>13</sup> The results in Table 5 exclude the same 11 plans excluded in Table 4, leaving a total of 406 plans.

<sup>14</sup> The sample of 417 plans was constructed to include only those 401K plans where all offerings had five years of history. The distribution of the number of offerings with that restriction differs from the distribution of the number of offerings by 401K plans in general. If we apply the distribution of “yes” and “no” shown in Table 5 to the distribution of investment choices shown in Table 1 and assume that all plans with 17 or more investment choices span, the percentage rises to 58%.

<sup>15</sup> For the reasons discussed in the prior footnote, we apply the distribution of “yes” and “no” shown in Table 5 to the distribution of investment choices shown in Table 1, counting each plan offering one investment choice as a “no” and each plan offering 17 or more investment choices as a “yes.” Applying these rules, the percentage of plans that span is 40%.

Before leaving this section, it is worthwhile examining the loss in return to 401K plan holders due to plans not spanning the relevant space. For the 406 plans in our sample to have the same Sharpe ratio as a portfolio comprised of the 8 RB indexes, the average return on the plans would have to increase by 1.81% per year. For the 249 plans that do not span the space, average return would have to increase by 3.16% per year to match the Sharpe ratio on the 8 RB indexes. The 3.16% increase in return is equal to 42% of the return on the 8-RB-index portfolio. Thus, investors in 401K plans are sacrificing significant return because plan administrators are offering an incomplete set of investment alternatives.<sup>17</sup>

It is interesting to note why these differences in return occurred. The bulk of the differences in Sharpe ratios occurred because the plans had much more risk than a portfolio comprised of the 8 RB indexes. The problem lies not in plans selecting individual mutual funds that perform badly, but rather in plans offering too few investment choices, choices with high risk, and choices that are too highly correlated.

Our sample does not allow us to do a detailed analysis of the appropriateness of the choice of individual funds in each category of funds offered in the plans. There is not enough data after our sample ends (2001) to do a meaningful analysis of subsequent performance, and, if we used returns prior to 2001 for analysis, we would have serious selection bias. However there is one type of fund for which we can analyze the reasonableness of the plan administrators' choices: S&P 500 index funds. As Elton, Gruber and Busse (2003) have shown for this type of

---

<sup>16</sup> As a further check on plans spanning, we considered whether plans spanned the space of the simplest set of choices we could think of: a broad stock market index (the Wilshire 5000 index), a bond market index (the Lehman U.S. Government/Credit index), and an international index (the MSCI EAFE index). We adjusted the returns of the 3 indexes to reflect normal management fees (just as we did for the 8 RB indexes). With this limited set of 3 indexes, more plans offered choices that spanned the indexes' space. However, 42 of the 406 plans still did not span, and over half of those plans offered 6 or more choices.

<sup>17</sup> These differences are much larger than any possible differences due to expense ratios. See Elton, Gruber and Blake (1996) for estimates of expense ratios.

fund, future relative performance can be predicted with a high degree of accuracy by using the funds' expense ratios. Since S&P 500 index funds all hold virtually the same stocks in the same proportions, differences in performance are almost identical to differences in expense ratios. We ranked the S&P 500 index funds in the Elton, Gruber and Busse sample by expense ratios and divided them into low annual expense ratios (0.06% to 0.36%) and high annual expense ratios (0.37% to 1.36%). Of the money invested in their sample's S&P 500 index funds by all investors in 2001, 11.16% is invested in high-expense funds. In our sample of 417 401K plans, 180 plans offered S&P 500 index funds. 21.55% of the S&P 500 index funds offered to participants by the plan administrators are in the high-expense category. This is considerably more than would be invested if the plan administrators' investment pattern were the same as the aggregate of all investors. Thus, for S&P 500 index funds, plan administrators as a group make poorer choices than the average investor.

## **VI. Company Stock**

The analysis to this point has ignored company stock as an asset in 401K plan offerings. In this section we explore the impact of including a firm's own stock as one of the investment choices in the 401K plan. We examine the impact of including company stock on the plan risk, Sharpe ratio, and likelihood of spanning.

On average, companies offering company stock as an investment choice offer the same number of mutual fund choices as those that do not offer stock; therefore, companies offering company stock do not offer plan participants fewer fund choices as a mechanism to encourage participants to hold more company stock.

To examine the effect of company stock on overall risk, we took all plans that offered company stock as an investment choice for which stock returns existed over our five-year period. For these plans we computed the variance using data for the last five years of an equally weighted portfolio of all offerings, with and without the company stock. For the companies offering company stock, when the company stock was included, the variance of the portfolio of 401K offerings using the  $1/n$  Rule went up by 3.17. Of the 55 plans for which we have data, 36 have a higher variance when company stock is included in the portfolio. The 3.17 increase in variance associated with including company stock is a percentage increase of about 19%, and using a one-tailed pairwise  $t$ -test, this increase is statistically significant at the 1% level ( $t = 3.6$ ).

Although the inclusion of company stock leads to risk increasing, Sharpe ratios might also increase. To examine this we examined the Sharpe ratios for optimal portfolios with no short sales. When company stock was not allowed to enter the optimal portfolio, the average Sharpe ratio was 0.240. When company stock was allowed to enter, the Sharpe ratio increased slightly to 0.255. Remember that including more securities in the population will in general increase the Sharpe ratio. If we control for this by comparing the increase from including company stock with the increase from including a randomly selected mutual fund, the difference is close to zero and is neither statistically significant nor economically significant. This is true despite the fact that company stock enters the optimal portfolio in 26 out of 55 cases.

The most important test of the impact of company stock is the spanning test. Does including company stock increase the number of 401K plans that have offerings that span the space of our eight RB indexes? The data show that whether company stock is included in the choice set or not, there is no change in the number or identity of the plans for which spanning takes place.

In summary, the inclusion of company stock causes an increase in risk. However, this is more than offset by an increase in return, resulting in a very slight improvement in the Sharpe ratio. However, the increase in the Sharpe ratio is about the same as it would be if we randomly included an additional mutual fund rather than the common stock. The inclusion of company stock doesn't change the set of plans that span the space of the RB indexes. Considering the 401K plan as the participant's sole financial asset, the inclusion of company stock in a plan seems to neither improve nor harm the investor making intelligent 401K plan choices. However, since a plan participant's labor income may be highly correlated with the performance of the company stock, a portfolio including labor income, 401K mutual funds and the company stock may be significantly more risky than a portfolio excluding the company stock.

## **VII. Plan Characteristics**

In this section of the paper we examine the relationship between plan characteristics and performance. Before we turn to performance *per se*, we want to examine one characteristic of plans that seems to have a major impact on how management behaves and which serves as a parameter that might affect performance.

In Table 6 we divide all plans by the size of assets invested in each plan into 10 deciles.<sup>18</sup> The average size of the plan in each decile is shown in the second column. There is a wide variation in plan size, with the average plan in the tenth decile over 300 times as large as the average plan in the first decile. The first question we examine is whether plans with more assets under management offer participants more investment choices. As shown in Table 6, there is a clear and statistically significant relationship (at the 1% level) between plan size and the number

---

of investment choices offered. Since from our spanning tests we know that more investment choices are generally better for investors, this suggests that large plans *ceteris paribus* offer an advantage to the 401K participants.

Are companies that manage large plans more sophisticated than companies that manage small plans? In particular, are companies with large 401K plans more likely to hire outside consultants and use sophisticated strategies such as utilizing futures and options, hedging strategies and quantitative methods? As shown in Table 6, a higher percentage of larger plans hire outside consultants and engage in more sophisticated investment strategies. The relationship of both with size is statistically significant at the 1% level in both cases.

We next examine the relationship between size and whether a plan votes proxies in the companies it owns. Proxy voting can be interpreted as either another measure of sophistication or as a measure of social consciousness. We find at best a weak positive relationship, one that is not statistically significant.

Finally, we examine the relationship between the size of plan assets and the probability of a company including its own stock in its 401K plan. Not surprisingly, large plans show a stronger tendency to include company stock in the plan than do small plans, and this relationship is significant at the 1% level.

Next we examine whether the use of outside consultants or sophisticated strategies improves the position of plan participants. To do so we examine their impact on number of plan investment choices, optimal Sharpe ratios and spanning.

It is clear from Table 6 that there is an association between average plan size and both the employment of outside consultants and the use of sophisticated investment tools. It is also clear

---

<sup>18</sup> We were unable to obtain plan size data for 28 of the 417 tracked funds; the size deciles were formed using the remaining 389 plans.



that larger sized plans have more investment choices. Therefore, if we want to discover whether employing outside consultants or using sophisticated strategies leads to more investment choices *per se* we need to control for plan size. We divided all plans into two groups based on whether or not they employed outside consultants and two groups based on whether or not they used sophisticated strategies. For each plan in the group we calculated the difference between the number of investment choices the plan actually offered and the number of investment choices we would expect given the plan's size. We then computed the average difference for the group employing outside consultants (or sophisticated strategies) and the group that did not. The significance of this difference was then tested using a standard *t*-test. Although the sign was as expected, the relationship between the number of investment choices and the use of outside consultants or sophisticated strategies was not statistically significant at meaningful levels of significance.

The other issues we would like to examine are whether employing outside consultants or sophisticated strategies leads to better Sharpe ratios or a greater likelihood of the investment choices offered spanning the investment space. From portfolio theory we know that the greater the number of investment choices offered *ceteris paribus*, the higher the average Sharpe ratio and the more likely the offerings will span the space. Thus, to examine this question we need to control for number of investment choices. We divided the plans into two groups based on whether or not they employed consultants, and two groups based on whether they used sophisticated strategies. Within each group, given the number of investment choices offered, we computed the differences in actual Sharpe ratios and expected Sharpe ratios as well as differences in actual proportions that span and expected proportions that span. We then compared these differences between the group that employed outside consultants and the group

that did not and the differences between the group that employed sophisticated strategies and the group that did not. For each case, the difference, while in the expected direction, was not statistically significant. Thus there is at best weak evidence that plans that use outside consultants or sophisticated strategies offer more investment choices, have higher Sharpe ratios, or better span the space.

## **VIII. Conclusion**

In this paper we examine the reasonableness of the investment choices offered by 401K plans. In order to analyze this we need to determine a group of investment vehicles that plan participants would find attractive. We consider two alternatives: designing a portfolio that represents each of the standard classifications used by the financial industry and designing a portfolio that represents each classification suggested by the literature of financial economics. Employing factor analysis, cluster analysis, Sharpe ratios and spanning tests, we conclude that eight portfolios based on the literature of financial economics representing large-cap growth, small- and medium-cap growth, large-cap value, small- and medium-cap value, government/corporate/mortgage-backed debt, international equity, non-U.S. world bond and high-yield debt successfully span the space described by the larger set of indexes employed by the financial community. These eight indexes (called RB indexes for research-based indexes) are used as benchmarks in the latter part of the paper.

The second part of the paper examines the investment choices offered by 401K plans. We first examine risk. We find that 401K plans have slightly less risk than randomly selecting funds where the percentage of funds that is randomly selected from any ICDI classification is the same as the aggregate of all plans. However, if a plan sponsor used a common-sense rule of insisting

that the plan include at least one stock and one bond fund, then plan risk from random selection would be smaller than the actual risk of the 401K plans. Although the individual funds selected by 401K plans have lower variance than randomly selected funds, the correlation between them is higher.

However, risk is only part of the story of what happens to overall performance. How adequate are plan offerings? Here we use spanning tests to see if the plan offerings span the space offered by the eight RB indexes. Only 38% of 417 plans span the space defined by the eight RB indexes. This means that, for 62% of the plans, the plan participants would be better off with additional investment choices. In fact, if these plans spanned the 8 RB indexes, participants' average return would improve by 3.2% per year, which is 42% of the return on an 8-index portfolio with the same level of risk. While significant on a 1-year basis, over a 20-year period (a reasonable investment horizon for a plan participant), the cost of not offering sufficient choices makes a difference in terminal wealth of over 300%. Since, for more than one half of plan participants, a 401K plan represents the participant's sole financial asset, the consequences are serious.

We then examine plan characteristics to see if they can add insight into the adequacy of plan investment choices. We first examine plan size. There is a strong correlation between the number of investment choices a plan offers and size. This is a strong indication that participants in larger plans are better off than participants in smaller plans. In addition, larger plans are more likely to use outside consultants and to include more sophisticated strategies in the plan. This raises the question of whether the use of consultants or sophisticated strategies improves results for investors. We find that, controlling for plan size, the use of outside consultants or sophisticated investment strategies increases with the number of investment choices, increases

the optimum Sharpe ratio and increases the probability of spanning. However, none of these increases are statistically significant. Thus we have at best weak evidence that the use of consultants or sophisticated strategies leads to better results.

There is one category of investments, S&P 500 index funds, for which we can evaluate the individual funds selected by 401K-plan administrators. We find that the index funds offered by 401K plans do not perform as well as the index funds chosen by the aggregate of all investors.

Finally, we examine the effect of offering company stock as an investment choice. We find that plans that offer company stock on average provide the same number of mutual fund choices as plans that do not offer company stock. The inclusion of company stock in a plan increases the variance of the plan and also leads to a slight increase in the Sharpe ratio. There is no increase in the number of plans that span the relevant space. The overall evidence is that including company stock does not have a major positive or negative effect on the desirability of a 401K plan for participants.

## Appendix A

As shown in Lo (2002) and extended by Lo in direct correspondence, the difference in two Sharpe ratios can be tested by computing a variance of the difference, where the difference is defined as

$$g(\boldsymbol{\theta}) \equiv \frac{\mu_{RB} - R_F}{\sqrt{\sigma_{RB}^2}} - \frac{\mu_{OPB} - R_F}{\sqrt{\sigma_{OPB}^2}} \quad (\text{A1})$$

and where  $\boldsymbol{\theta}$  is a vector containing

- (1)  $\mu_{RB}$ , the mean return of the RB portfolio;
- (2)  $\mu_{OPB}$ , the mean return of the OPB portfolio;
- (3)  $\sigma_{RB}^2$ , the variance of the RB of the portfolio;
- (4)  $\sigma_{OPB}^2$ , the variance of OPB portfolio.

As Lo (2002) shows, an estimate of the variance of the difference between the two Sharpe ratios can be computed as:

$$\hat{V}_g = \frac{\partial g(\hat{\boldsymbol{\theta}})}{\partial \hat{\boldsymbol{\theta}}} \hat{\boldsymbol{\Sigma}} \frac{\partial g(\hat{\boldsymbol{\theta}})}{\partial \hat{\boldsymbol{\theta}}'} \quad (\text{A2})$$

where

$\hat{\boldsymbol{\theta}}$  contains the sample estimates of the parameters in  $\boldsymbol{\theta}$ ;

$\hat{\boldsymbol{\Sigma}}$  is the estimated  $4 \times 4$  variance-covariance matrix of  $\hat{\boldsymbol{\theta}}$  using the Newey-West (1987) procedure;

$\frac{\partial g(\hat{\boldsymbol{\theta}})}{\partial \hat{\boldsymbol{\theta}}}$  is the  $1 \times 4$  gradient vector of  $g(\hat{\boldsymbol{\theta}})$ :  $\left[ \frac{1}{\hat{\sigma}_{RB}} \quad \frac{-1}{\hat{\sigma}_{OPB}} \quad \frac{-(\hat{\mu}_{RB} - R_F)}{2\hat{\sigma}_{RB}^3} \quad \frac{\hat{\mu}_{OPB} - R_F}{2\hat{\sigma}_{OPB}^3} \right]$ .

## **Appendix B**

In this appendix, we discuss in detail the analyses we used to reduce our 11 RB indexes to a set of 8 indexes.

### **B.1 Inclusion in Efficient Frontiers**

One way to examine whether an index is redundant is to see if it enters the efficient set at any point in time. To examine this we used 15 years of monthly data ending December 2001. For each of 12 overlapping three-year periods we computed an efficient frontier when short sales were not allowed. Over the 12 overlapping three-year periods, only two asset categories were never included, international stock and mid-cap growth stocks. Some other categories like small-cap value and mid-cap value occasionally came into the optimal portfolio and often substituted for each other in the optimal portfolio. This is preliminary evidence that we may be able to eliminate or combine some categories.

### **B.2 Factor Analysis**

In this section we use factor analysis to determine the minimum number of indexes that can capture the information in our 11 indexes and to give guidance as to what these indexes may be. We then employ cluster analysis to examine which indexes are redundant.

Factor analysis is a technique that is frequently used to reduce the dimensionality of a set of data. In this case we employ factor analysis to find a smaller set of our 11 RB indexes that captures all of the information contained in the original set of indexes. We employ statistical tests of the number of appropriate factors, and examine the economic rationale behind the mathematical results.

### **B.2.a. Generating an Appropriate Factor Structure**

We start by performing a maximum-likelihood factor analysis on the 11 RB indexes for both the full 15 years of our sample and the last five years of our sample. We performed the factor analysis sequentially assuming two-factor, three-factor, etc., up to eight factors.

Three statistical criteria that have been widely used to aid in selecting the appropriate number of factors are: examining eigenvalues, a chi-square test using Bartlett's correction, and Schwarz's Bayesian criterion (see Harmon (1976)). The simplest criterion is to examine the eigenvalues of the factored correlation matrix and to keep all factors with an eigenvalue greater than one. For the 15-year period this suggests that we have a five-factor solution, while it suggests four factors for the five-year period. The second method, Bartlett's chi square criterion, rejects the need for more factors after six have been extracted in the 15-year-period and after five have been extracted in the five-year period. Finally, Schwarz's Bayesian criterion indicates that five factors should be extracted in both the five- and 15-year periods. The preponderance of the statistical evidence suggests a five-factor solution.

### **B.2.b. Explaining the Factor Structure**

It would be extremely useful if we could identify the factors extracted in terms of the security traits each represents. Not only would this help us identify the role these factors play in subsequent analysis; it would give us added confidence that we have uncovered economic influences as opposed to capturing random statistical noise. In order to have the factors more easily interpretable, we performed an orthogonal rotation of the factors using the quartimax method for simplifying structure. We examined only orthogonal rotations, for there are

advantages in portfolio allocation and risk estimation in having an orthogonal set of indexes. Quartimax rotation is an orthogonal rotation of the original factor solution such that each variable has large factor loading with a small set of the rotated factors and small loading with the rest.

In Table B1 we present the results of the quartimax rotation of the five-factor solution for our 15-year sample. Each of the five factors has a reasonably straightforward interpretation. For example, in the first factor all of the stock indexes with the exception of international stocks have high loadings, while bond indexes, with the exception of high yield bonds, have extremely low loadings. High-yield bonds and international stocks have intermediate loadings. This first rotated factor can be clearly identified as a domestic stock factor. The two intermediate loadings can be explained by the fact that high-yield bonds have stock-like characteristics and international stocks, while different from domestic stocks, have some movement in common with domestic stocks.

The second factor is clearly a domestic bond factor, while the third is an international factor with both international bonds and stocks heavily loaded on it. The fourth and fifth factors represent partitioning of domestic stocks into growth versus value and large versus small. However, the division is not clean. Factor four has a lower loading on large growth than it would if factor four was purely growth minus value. Thus factor four is growth minus value with a bias against large growth stocks. Likewise, factor five is large minus small with a bias towards small growth stocks.

We also performed a quartimax rotation for the five-year period, and the results were similar to those presented in Table 4. Quartimax rotations were also examined for four- and six-factor solutions over both the 15-year and 5-year periods, and the interpretation of the factors



was much less clear than the interpretation for the five-factor solution. This gave us added confidence in our choice of five factors.

Factor analysis suggests that we need five indexes to approximate the original 11 indexes in our data. However, this is based on the factors (indexes) containing short sales. Examining the factor loadings shown in Table B1 indicates that if short sales were forbidden, at least two more factors would be needed. These factors would represent large stocks and small stocks rather than their difference, and value stocks and growth stocks rather than their differences. Based on this analysis, if short sales of indexes are not allowed, we should expect to find that at least seven indexes are needed to capture the security traits contained in our original eleven indexes.

### **B.3. Cluster Analysis**

We now turn to cluster analysis to get further insight into how we can combine our eleven indexes into a smaller set that captures the relevant information contained in the larger set of indexes.

Cluster analysis is a series of routines that group elements, in this case indexes, into groups based on how far apart they are in some space. There are several different ways distance can be measured, and there are several different techniques that can be used for forming groups. In this study we used three different distance measures and two clustering routines. The first distance measure we used was difference in return space. Using returns as a distance measure, cluster routines calculate the distance between two funds as the square root of the average squared difference in monthly returns. The second distance measure normalizes the data so that distance is measured in units of standard deviation. The third distance measure uses the

correlation between two funds or two groups as the measure of distance. Given alternative distance measures, there remains the problem of how to proceed to combine firms.

We used two clustering algorithms to do this: the centroid method and Ward's method. In the centroid method, after two funds are combined, distance is calculated as if the two funds become a single fund composed of an equally weighted average of the two funds. In the Ward technique, distances are still calculated with respect to each of the funds within the group.

In each period examined (the 15-year period 1987-2001 and its three five-year sub-periods) and for each clustering algorithm, the first three sets of indexes that combined were mid-cap growth with small-cap growth (correlation 0.98), mid-cap value with small-cap value (correlation 0.97), and government bond with mortgage bond (correlation 0.91). While these correlation numbers are for the fifteen-year sample, five-year correlations are similar. The next two indexes to enter a group were large-cap growth and large-cap value. Across all periods and all clustering algorithms, two different patterns emerged. About half the time large-cap growth and large-cap value first combined, followed by the small-cap and mid-cap growth combining with small-cap and mid-cap value (size grouping). These size groupings then combined into one overall domestic equity grouping. The other times the pattern was large-cap growth first combining with the group small-cap and mid-cap growth and large-cap value combining with the group small-cap and mid-cap value (value-growth groups), and then these two groups combining into one overall domestic equity grouping at a later stage. World bond always joined the combined government-corporate/mortgage bond group, and world equity always joined the domestic equity group. In almost all circumstances high-yield bond joined the equity grouping. The order with which high-yield bond and world equity joined domestic equity varied across

samples and the clustering algorithm used, with world equity usually the first. The last combination was always bonds and stocks.

Their high correlation, their consistently combining in the first three steps in the process, and the results from the factor analysis all provide strong evidence that we should combine three pairs of indexes: small-cap growth with mid-cap growth, small-cap value with mid-cap value, and government-corporate with mortgage bonds. Since the ordering of other clustering differs across time periods and/or methodologies, we will proceed using the eight RB indexes that remain after making these three combinations. As a final check, we repeated all of our tests in section II comparing RB and OPB indexes using the eight RB indexes described above rather than the eleven RB indexes. While there were small changes in the numbers, all of the results were essentially unchanged except that one Sharpe ratio test was no longer significant.

## Appendix C

In this appendix, we derive formulas for computing the average overall variance and covariance when we know the average variance and covariance within each subgroup and the average covariance between each pair of subgroups. Given estimates of the average variance for each ICDI classification, then the average variance for the population, weighted proportional to the holdings of our 417 sample 401K plans, is

$$\overline{Var} = \sum_g \left( \frac{T_g}{\sum_g T_g} \times \overline{Var}_g \right) \quad (C1)$$

where

(1)  $T_g$  is the total number of funds in ICDI group  $g$  held by the 401K plans ( $g = 1, \dots, 14$ );

(2)  $\overline{Var}_g$  is the average variance of funds in group  $g$ .

Given estimates of the average covariance within and between ICDI groups, the average population covariance, if funds are selected using the weighted selection discussed in the text, is

$$\overline{Cov} = \left( \frac{1}{X} \right) \times \left[ \sum_{g=1}^G \frac{T_g(T_g - 1)}{2} \times \overline{Cov}_g + \sum_{g=1}^G \sum_{\substack{k=1 \\ k \neq g}}^G T_g T_k \times \overline{Cov}_{gk} \right] \quad (C2)$$

where

$$X = \sum_{g=1}^G \frac{T_g(T_g - 1)}{2} + \sum_{g=1}^G \sum_{\substack{k=1 \\ k \neq g}}^G T_g T_k$$

and

(1)  $\overline{Cov}_g$  is the average covariance between funds in ICDI group  $g$ ;

- (2)  $\overline{Cov_{gk}}$  is the average covariance between funds in ICDI group  $g$  and funds in ICDI group  $k$ .

The average variance and average covariance for constrained random selection is done as follows. The average variance and average covariance are computed as described above for the set, which is a random stock fund and a random bond fund, and for a second set, which is random selection for the whole population. The overall variance is computed using the standard formula for a combination of two sets where the covariance between the sets is computed as

$$\overline{Cov_{BS,Pop}} = \frac{1}{2} \sum_{g \in B} \frac{T_g}{\sum_{g \in B} T_g} \left[ \frac{T_g}{\sum_{j=1}^G T_j} \times \overline{Cov_g} + \sum_{\substack{k=1 \\ k \neq g}}^G \frac{T_k}{\sum_{j=1}^G T_j} \times \overline{Cov_{gk}} \right] + \frac{1}{2} \sum_{g \in S} \frac{T_g}{\sum_{g \in S} T_g} \left[ \frac{T_g}{\sum_{j=1}^G T_j} \times \overline{Cov_g} + \sum_{\substack{k=1 \\ k \neq g}}^G \frac{T_k}{\sum_{j=1}^G T_j} \times \overline{Cov_{gk}} \right] \quad (C3)$$

where  $B$  is the set of ICDI domestic bond fund groups and  $S$  is the set of ICDI domestic stock fund groups.

## References

- Agnew, Julie and Pierluigi Balduzzi, 2002, What do we do with our pension money? Recent evidence from 401K plans. Unpublished manuscript, Boston College.
- Bekaert, Geert and Michael S. Urias, 1996, Diversification, integration, and emerging market closed-end funds. *Journal of Finance* 51, 835-870.
- Benartzi, Shlomo and Richard Thaler, 2001, Naïve diversification strategies in retirement saving plans, *American Economic Review* 91(1), 78-98.
- Blake, Christopher R., Edwin J. Elton and Martin J. Gruber, 1993, The performance of bond mutual funds. *Journal of Business*.
- De Roon, Nijman and Werker, 2001, Testing for mean variance spanning with short sales constraints and transaction costs: the case of emerging markets. *Journal of Finance* 56(2), 721-742.
- De Santis, Giorgio, 1994, Asset pricing and portfolio diversification: Evidence from emerging financial markets. Working paper, University of Southern California.
- Elton, Edwin J. and Martin J. Gruber, 1970, Homogeneous groups and the testing of economic hypothesis. *Journal of Financial and Quantitative Analysis*.
- Elton, Edwin J. and Martin J. Gruber, 1977, Risk reduction and portfolio size: an analytical solution. *Journal of Business* 50, 415-434.
- Elton, Edwin J., Martin J. Gruber and Christopher R. Blake, 1996, The Persistence of Risk-Adjusted Mutual Fund performance. *Journal of Business* 69(2), 133-157.
- Elton, Edwin J., Martin J. Gruber and Christopher R. Blake, 1999, Common factors in fund returns. *European Financial Review* 3(1), 1-23.
- Elton, Edwin J., Martin J. Gruber and Christopher R. Blake, 2001, A first look at the accuracy of the CRSP mutual fund database and a comparison of the CRSP and Morningstar mutual fund databases. *Journal of Finance* 56(6).
- Elton, Edwin J., Martin J. Gruber and Jeffrey A. Busse, 2003, Are investors rational? Choices among index funds. Forthcoming, *Journal of Finance*.
- Fama, Eugene and Ken French, 1994, Book-to-market in earnings and returns, *Journal of Finance*.
- Gallant, A. Ronald, 1987, *Nonlinear Statistical Models*, John Wiley and Sons, New York.

Harman, Harry, 1976, *Modern factor analysis*. University of Chicago Press, Chicago, IL.

Huberman, Gur and Shmuel Kandel, 1987, Mean-variance spanning, *Journal of Finance* 42, 873-888.

Huberman, Gur and Sengmuller, 2003, Company stock in 401K plans. Unpublished manuscript, Columbia University.

Liang, Nellie and Scott Weisbenner, 2002, Investor behavior and the purchase of company stock in 401K plan design. Unpublished manuscript, University of Illinois.

Lo, Andrew, 2002, The statistics of Sharpe ratios, *Financial Analysts Journal* 58, 36-50.

Newey, W. and K. West, 1987, A simple positive definite heteroscedasticity and autocorrelation consistent covariance matrix, *Econometrica* 55, 703-705.

Roll, Richard, 1977. A critique of the asset pricing theory's tests, *Journal of Financial Economics* 4, 129-176.

**Table 1**

**Percentages of 680 401K Plans Offering Different Numbers of Investment Choices  
(Number of choices and percentages include mutual funds, stable value funds, GICs and company stock.)**

<u>Number of Investment Choices</u>	<u>Percentage of Plans</u>
1	2.21%
2	2.35%
3	3.09%
4	4.85%
5	8.97%
6	12.06%
7	12.06%
8	13.82%
9	11.76%
10	9.85%
11	5.59%
12	2.21%
13	2.50%
14	1.91%
15	1.18%
16	1.03%
17 or more	4.56%



Table 2

Types of Investment Choices Offered in 680 401K Plans

Category	ICDI Classification	Percentage of Plans Offering Investment Choice	
Interest Only	Money Market Fund	57.35%	
	Stable Value Fund	24.85%	
	GIC	14.71%	
	At Least One Interest-Only Fund	86.76%	
Domestic Equity	Aggressive Growth Fund	55.44%	
	Growth and Income Fund; Equity Index	80.00%	
	Long-Term Growth Fund	82.94%	
	Sector Fund	6.47%	
	Total Return Fund; Equity Value Fund	21.62%	
	Utilities Fund	0.59%	
	At Least One Domestic Equity Fund	97.35%	
	Domestic Bonds	Quality Bond Fund	54.85%
		High-Yield Bond Fund	4.71%
		Government Mortgage Fund	12.79%
Government Securities Fund		12.35%	
At Least One Domestic Bond Fund		71.47%	
Domestic Mixed	Balanced Fund	73.68%	
	Income Fund	23.68%	
	At Least One Domestic Mixed Fund	80.59%	
International	Global Bond Fund	9.12%	
	Global Equity Fund	18.97%	
	International Equity Fund	62.94%	
	At Least One International Fund	75.15%	
Company Stock	Company Stock	22.94%	

Table 3

**Sharpe Ratios and Differences of Sharpe Ratios from Optimal Tangent Portfolios  
(Using Monthly Total Returns and Arithmetic Averages of 30-Day T-Bill Rate; Short Sales Not Allowed)**

Period	Sharpe Ratios		Differences in Sharpe Ratios 1 minus 2
	1 11 RB Indexes <sup>a</sup>	2 14 OPB Indexes <sup>b</sup>	
1/92 - 12/01 (10 Years)	0.2976	0.2214	0.0762
1/92 - 12/96 (5 Years)	0.6495	0.5412	0.1084 *
1/97 - 12/01 (5 Years)	0.3073	0.2259	0.0814 *

Notes:

<sup>a</sup>Tangent portfolios formed using total returns of indexes adjusted for expenses; 11 RB indexes are research-based indexes including 6 domestic equity indexes, 1 international equity index, 3 domestic fixed-income indexes, and 1 international fixed-income index.

<sup>b</sup>Tangent portfolios formed using total returns of 14 equally weighted portfolios of mutual funds grouped by investment objectives and policies using ICDI classification.

\*Significant at the one-percent level using Newey-West adjusted standard errors; see Appendix B in the text for details.

**Table 4****Average Variances**

The column labeled "Plan Funds" contains average variances assuming equal investment in each fund offered by a plan; the column labeled "Random Selection" contains average variances assuming equal investment in funds randomly selected from all funds in given ICDI categories in the CRSP mutual fund database, using as a probability of selection in each ICDI category the proportion in that category held by the aggregate of all plans; the column labeled "constrained random selection" contains average variances using the same random selection as that for the previous column, but with the constraint that the first 2 funds selected are a bond fund and a stock fund.

Number of Investment Choices in Plan <sup>a</sup>	Plan Funds	Random Selection	Constrained Random Selection
2	20.51	23.36	10.89
3	16.27	20.98	13.04
4	15.29	19.79	13.97
5	16.01	19.08	14.49
6	15.63	18.61	14.82
7	17.61	18.27	15.04
8	16.99	18.01	15.21
9	17.79	17.81	15.33
10	17.29	17.65	15.43
11	16.84	17.53	15.51
12	17.98	17.42	15.57
13	13.79	17.33	15.62
14	15.54	17.25	15.67
15	14.80	17.18	15.71
16	16.15	17.12	15.74

Note:

<sup>a</sup>Excluding company stock, money market funds, GICs and stable value funds.

Table 5

**Sufficiency of Plan Investment Choices in Spanning 8 RB Indexes<sup>a</sup>  
(Short Sales Not Allowed)**

Number of Investment Choices in Plan <sup>b</sup>	Sufficient?	
	No	Yes
2	17	1
3	32	5
4	46	11
5	28	25
6	42	16
7	24	20
8	18	21
9	23	22
10	6	8
11	4	7
12	7	4
13	1	1
14	1	3
15	0	7
16	0	6
Total	249	157

Notes:

<sup>a</sup>RB indexes are research-based indexes including 4 domestic equity indexes, 1 international equity index, 2 domestic fixed-income indexes, and 1 international fixed-income index.

<sup>b</sup>Excluding company stock, money market funds, GICs and stable value funds.

Table 6

Plan Characteristics Grouped by Plan Asset Size Deciles

Plan Asset Size Decile	Avg. Plan Asset Size (Thousands)	Avg. Number of Investment Choices <sup>a</sup>	Percentage of Plans that Use Sophisticated Strategies <sup>b</sup>	Percentage of Plans Offering Company Stock as Investment Choice <sup>b</sup>	Percentage of Plans that Vote Proxy <sup>b</sup>	Percentage of Plans that Hire Outside Consultants <sup>b</sup>
1	\$2,124.579	4.42	13.16%	7.89%	13.16%	2.63%
2	\$6,045.974	5.21	7.69%	7.69%	7.69%	5.13%
3	\$10,857.308	6.21	10.26%	5.13%	15.38%	5.13%
4	\$16,882.821	5.23	7.69%	20.51%	2.56%	12.82%
5	\$24,754.590	6.08	12.82%	20.51%	7.69%	5.13%
6	\$37,363.923	7.28	10.26%	17.95%	12.82%	23.08%
7	\$57,851.154	6.72	17.95%	12.82%	7.69%	28.21%
8	\$88,923.718	7.82	20.51%	38.46%	23.08%	7.69%
9	\$173,890.667	7.85	28.21%	41.03%	15.38%	28.21%
10	\$780,277.821	8.18	46.15%	46.15%	17.95%	20.51%

Spearman

Rank Corr. <sup>b</sup>	1.00 *	0.95 *	0.77 *	0.84 *	0.49	0.77 *
-------------------------	--------	--------	--------	--------	------	--------

Notes:

<sup>a</sup>Excluding company stock, money market funds, GICs and stable value funds.

<sup>b</sup>Spearman rank correlation of decile column with given column; \* = significant at 1% level.

<sup>c</sup>Percentages based on number of plans in size decile.

**Table B1****Factor Loadings on 11 Indexes  
(Using Five-Factor Quartimax Rotation)**

<u>Type of Index</u>	<u>Factor 1</u>	<u>Factor 2</u>	<u>Factor 3</u>	<u>Factor 4</u>	<u>Factor 5</u>
Large-cap Growth Stock	0.8704	0.0751	0.0445	0.0744	0.3628
Large-cap Value Stock	0.8912	0.1157	-0.0201	-0.3682	0.1408
Mid-cap Growth Stock	0.9214	-0.0380	0.0259	0.3285	0.1083
Mid-cap Value Stock	0.9183	-0.0521	-0.0554	-0.3261	-0.1478
Small-cap Growth Stock	0.9083	-0.0655	0.0003	0.4105	0.0252
Small-cap Value Stock	0.9335	0.0010	-0.0984	-0.1855	-0.2907
International Stock	0.5766	-0.0624	0.4687	-0.0258	0.1205
U.S. Bond	0.1099	0.9553	0.1029	-0.0085	-0.0167
Mortgage-Backed	0.1526	0.9332	0.0534	-0.0078	0.0193
High Yield Bond	0.5737	0.1993	-0.0624	0.0782	-0.2120
World Bond	-0.0565	0.1899	0.9796	0.0134	-0.0294