Performance of TIAA-CREF's Recommended Portfolios

Barry R. Cobb,
Associate Professor
Department of Economics and Business
Virginia Military Institute

Alex J. Menas
2nd Lieutenant, U. S. Air Force

Abstract

TIAA-CREF provides retirement savings plans to over three million employees of educational and research institutions. This paper identifies mean-variance efficient portfolios composed of the TIAA-CREF investment options to determine the potential diversification opportunities available to participants. Additionally, the historical performance of five portfolios suggested by the TIAA-CREF Asset Allocation Evaluator is examined. This questionnaire is an online tool that allows participants to assess their risk tolerance and determine an allocation of retirement savings assets among broad investment categories. A specific retirement plan administered by TIAA-CREF that provides outside mutual funds as investment options is also investigated to appraise how accounts outside the TIAA-CREF family affect the performance of the suggested portfolios, as compared to those constructed using mean-variance optimization techniques.

TIAA-CREF manages over $400 billion in assets, primarily invested in the retirement plans of the employees of educational and research organizations. As of 2006, TIAA-CREF served 3.2 million people at over 15,000 institutions and more than 500,000 retirees were dependent on TIAA-CREF for more than $6 billion in retirement income ("TIAA-CREF Annual Report," 2006).

Although the investment options available to employees differ by institution, most TIAA-CREF plans include eight CREF variable annuity accounts, the TIAA Real Estate fund, and the TIAA Traditional annuity. The

company provides the TIAA-CREF Asset Allocation Evaluator (2008) in order to assist investors in allocating their retirement assets among these options. This tool is a six-item questionnaire that seeks to determine an investor's risk tolerance and investment philosophy. Based on an individual's responses, TIAA-CREF suggests an allocation of investment savings to the following broad asset classes: Equity, Bonds, Money Market, Real Estate, and Traditional. An investor is guided to implement one of five recommended portfolios, which are classified according to risk preference as Conservative, Moderately Conservative, Moderate, Moderately Aggressive, and Aggressive.

Based on fund performance data for the period from 1994–2002, McClatchey, Moon, VandenHul, & Griswold (2003) used a mean-variance portfolio optimization approach to investigate the diversification benefits available to investors across and within asset classes for the TIAA-CREF funds. This research concluded that diversification within the Equity class has minimal benefits. Rather than spreading assets among equity funds, an investor would be better served to select an equity fund that provides a desired level of return at the minimum possible risk, or vice versa. The addition of non-equity funds further extended the feasible frontier of investment opportunities. The authors concluded that appropriate diversification among asset classes is important to achieving an investor's goals, as a simple strategy of equal investment in all available funds produces inferior results. This study also includes a thorough review of pertinent literature related to investment allocation decisions in retirement plans.

McClatchey & VandenHul (2005) test a naïve $1/n$ portfolio allocation against a mean-variance efficient portfolio allocation. The $1/n$ portfolio places an equal amount of the investment balance in each available fund. The comparison involves calculating the variance of the $1/n$ portfolio over a 60-month historical period, then finding a mean-variance efficient portfolio with the same variance. The parameters for the optimization model are determined from the same 60-month historical period. The ending investment balance is then calculated based on the actual returns observed during the next period. Mean-variance optimization outperformed the $1/n$ allocation strategy, when tested using simulated data for the TIAA-CREF retirement accounts during 1994 through 2004.

This paper seeks to complement the research of McClatchey et al. (2003) and McClatchey & VandenHul (2005) in two ways. First, the optimal portfolios in the TIAA-CREF retirement plan will be revisited based on data obtained through April 30, 2008. Second, as the previous study found diversification across asset classes to be important, the historical performance of the five portfolios suggested by TIAA-CREF's Asset Allocation Evaluator will be evaluated versus optimal portfolios identified using the mean-variance optimization approach. The experiment will be conducted using a rolling time-period estimation approach similar to that of McClatchey & VandenHul (2005).

Optimal portfolios in the Commonwealth of Virginia Optional Retirement Plan, which includes some TIAA-CREF funds and two options outside the TIAA-CREF family will also be explored. The inclusion of these additional investment options significantly improves the performance of the recommended portfolios, although portfolios with similar risk and higher returns were obtained in a historical experiment by applying mean-variance optimization.

Recommended Portfolios

Previous studies have identified shortcomings in the retirement asset allocations selected by investors in defined contribution savings plans, which require employees to choose how to invest their money. Agnew, Balduzzi & Sundén (2003) discovered that many investors tend to place either very small or very large proportions of their retirement savings in stocks and tend to maintain default allocations initially set by plan administrators. Choi, Laibson & Madrian (2005) concluded that investors in company-sponsored plans tend to invest large fractions of their savings in the stock of their own company. This study also found further evidence of passive investment strategies in retirement savings plans. Based on such research, the need to provide effective allocation techniques is apparent.

Moreschi (2004) states that questionnaires or risk-profilers such as the TIAA-CREF Asset Allocation Evaluator are commonly used by advisors and mutual fund companies due to the complex nature of assessing a client's risk tolerance. Droms and Strauss (2003) find that many such risk-profilers are focused more on providing a reasonable asset allocation and not on understanding an individual's true risk tolerance. A suggested asset allocation is certainly part of the outcome of the TIAA-CREF questionnaire, in addition to a short statement summarizing the investor's risk preferences.

Each of the questions in the TIAA-CREF Asset Allocation Evaluator provides the investor a brief scenario, a related question, and a list of multiple choice responses (see the Appendix for details). While some risk-profilers utilize twelve or more questions (Moreschi 2004), the TIAA-CREF assessment is comprised of just six items.

After submitting the questionnaire, an investor is provided with a suggested investment portfolio and is categorized according to one of the following risk classifications:

1. **Conservative**. "For investors who want to seek greater stability and a lower level of risk."
2. **Moderately Conservative**. "For investors who want to seek a balance between safety and growth, but are still very concerned with preserving existing accumulations."

3. **Moderate**. "For investors who want to seek a balance between safety and growth, but are still very concerned with preserving existing accumulations."
4. **Moderately Aggressive**. "For investors who want to seek a balance between safety and growth, but are still very concerned with preserving existing accumulations."
5. **Aggressive**. "For investors who are probably comfortable with a higher level of risk."

The associated portfolio allocations are shown in Table 1. Although the middle three categories in the risk spectrum have identical descriptions of investor risk preference, the suggested allocations differ. Interestingly, although TIAA-CREF maintains the Social Choice fund—which is categorized in the Multi-Asset class since its holdings include equities and bonds—none of the suggested portfolios includes this fund, perhaps because similar returns can be gained by simultaneously holding separate funds in the Equity and Bond classes. The mean and standard deviations of the monthly returns on the available investment options in each asset class are shown in Table 2, with the correlation coefficients for the returns shown in Table 3. These statistics are based on monthly returns calculated for the most recent 60 months as of April 2008.

Table 1
Percentage of Savings Invested in Each Asset Class in the Portfolios Suggested by the TIAA-CREF Asset Evaluation Allocator

Asset Class	Conservative	Moderately Conservative	Moderate	Moderately Aggressive	Aggressive
Bonds	40%	28%	20%	13%	0%
Equity	17%	38%	57%	75%	89%
Money Market	13%	9%	5%	0%	0%
Real Estate	3%	3%	3%	5%	6%
Traditional	27%	22%	15%	7%	5%

The TIAA Traditional annuity guarantees the investor a 3% return on funds, plus additional returns that may be declared on a year-by-year basis ("TIAA Traditional Annuity," 2008). The returns on assets saved in prior years may be different for each vintage year in which an investment is initially purchased. For these reasons, the 10-year historical monthly average is used for purposes of the analysis in this paper, and the returns in this fund are assumed to be uncorrelated with those in any other fund.

While the Asset Allocation Evaluator provides the allocation of retirement funds to asset classes as shown in Table 1, the investor is left to

distribute the dollars to the funds within each asset class. This task will be discussed further later in the paper.

Table 2
Mean and Standard Deviation of Monthly Returns for TIAA-CREF Funds
(May 2003 through April 2008)

Fund	Class	Mean	Standard Deviation
Bond	Bond	0.32%	1.05%
Equity Index	Equity	0.86%	2.65%
Global Equities	Equity	1.15%	2.80%
Growth	Equity	0.73%	2.96%
Inflation-Linked Bond	Bond	0.48%	1.80%
Money Market	Money Market	0.25%	0.14%
Real Estate	Real Estate	0.95%	0.48%
Social Choice	Multi-Asset	0.66%	1.59%
Stock	Equity	1.03%	2.70%
Traditional	Traditional	0.51%	N/A

Table 3
Correlation Coefficients on Monthly Returns for the TIAA-CREF Investment Options (Calculated From Monthly Returns Over the Period Of May 2003 Through April 2008)

	Bond	Equity Index	Global Equities	Growth	Inflation-Linked Bond	Money Market	Real Estate	Social Choice	Stock
Bond	1.00								
Equity Index	-0.14	1.00							
Global Equities	-0.11	0.94	1.00						
Growth	-0.15	0.92	0.88	1.00					
Inflation -Linked Bond	0.88	-0.20	-0.17	-0.20	1.00				
Money Market	0.12	-0.15	-0.13	-0.06	0.03	1.00			
Real Estate	0.13	-0.04	-0.06	-0.01	0.12	0.27	1.00		
Social Choice	0.14	0.95	0.89	0.88	0.07	-0.13	-0.01	1.00	
Stock	-0.13	0.99	0.98	0.92	-0.19	-0.14	-0.04	0.94	1.00

Mean-Variance Efficient Portfolios

Following McClatchey et al. (2003), a mean-variance optimization process based on the approach of Markowitz (1952) is employed to determine

optimal portfolio weightings for the TIAA-CREF funds, using monrhly historical data for the period from May 2003 through April 2008. This technique uses the mean and variance of asset returns to characterize their random behavior, in addition to the correlations between returns on each possible pair of assets to account for the tendency of asset returns to vary together, either directly or inversely. To use this method an investor establishes a required or desired rate of return, and then minimizes the variance of portfolio returns subject to a rate of return constraint. Conversely, an investor could choose a desired portfolio variance, and then maximize portfolio returns subject to this limitation on the expected riskiness of the returns.

A portfolio that has the lowest possible variance for a given required portfolio return, or alternatively the highest return at a pre-established portfolio variance, is termed mean-variance "efficient." The set of all such feasible portfolios for a given set of investments comprises the mean-variance "efficient frontier." Levy and Markowitz (1979) developed an alternative portfolio selection method that maximizes an investor's utility, which is assumed to be a function of the mean and variance of the portfolio returns. Kroll, Levy & Markowitz (1983) tested this "direct maximization" method and concluded that most portfolios maximizing a wide range of investor utility functions for varied investor risk preferences lie on or very near the mean-variance efficient frontier. Thus, one method of suggesting an effective portfolio allocation from a set of investment options is to identify the mean-variance efficient portfolios and allow an investor to choose from this set the option that best satisfies his or her risk preferences.

The inputs to the mean-variance optimization process are the monthly mean returns, standard deviations, and correlation coefficients, as presented in the last section. The problem solved by the investor is to choose weights w_i for each of n possible investments (indexed i=1,…,n) to satisfy

$$\begin{aligned} &\underset{w_1,\mathrm{K}\,,w_n}{\text{Minimize}} \quad \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \cdot Cov(R_i,R_j) \\ &\text{subject to:} \\ &\qquad \sum_{i=1}^{n} w_i \cdot \mu_i = \mu_P \\ &\qquad \sum_{i=1}^{n} w_i = 1 \qquad\qquad (1) \\ &\qquad 0 \le w_i \le 1 \quad \text{for all } i = 1,\mathrm{K}\,,n, \end{aligned}$$

where $Cov(R_i, R_j) = \rho_{ij} \cdot \sigma_i \cdot \sigma_j$ is the covariance between monthly returns on funds *i* and *j* with standard deviations σ_i and σ_i as shown in Table 2 and correlation coefficient ρ_{ij} as shown in Table 3 (when the indices match in the covariance formula, the covariance reduces to the variance of an investment's returns). The average annual returns are denoted by μ_i (as shown in Table 2) and μ_ρ is the investor's required rate of return. The objective function in the optimization problem minimizes the portfolio's variance. The first constraint ensures that the mean portfolio return is equal to the investor's required return, the second constraint ensures a full allocation of available investment dollars, and the third constraint prevents the short sale of fund shares.

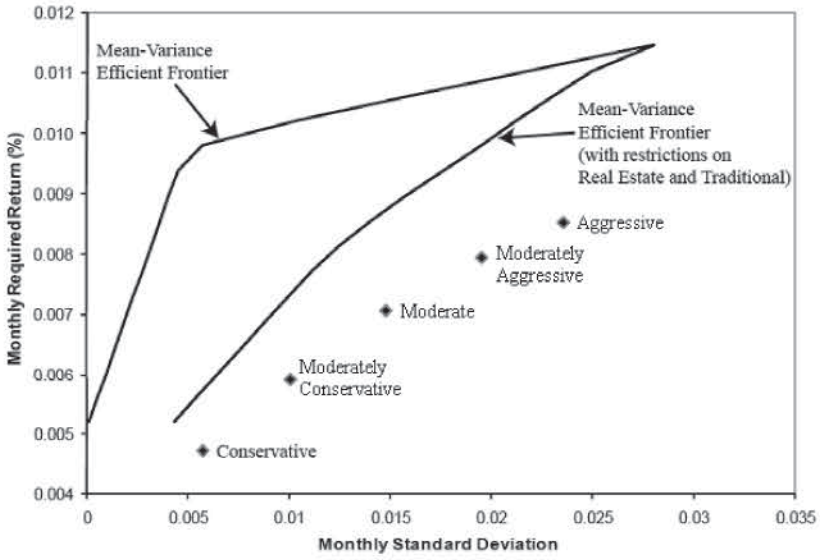
When no restrictions on minimum or maximum allocations to individual accounts are imposed, the mean-variance efficient portfolios include only the Global Equities, Real Estate and Traditional accounts. The percentage of the portfolio allocated to each is shown in Table 4. Until a required monthly return of 0.94% is reached, the optimal portfolios are comprised of increasing investments in the Real Estate fund and decreasing investments in the Traditional fund, complemented by small investments in Global Equities. For required monthly returns of greater than 0.94%, the optimal portfolios consist of decreasing investments in Real Estate and increasing investments in Global Equities. A graphical view of the mean-variance efficient frontier is shown in Figure 1.

Both the Real Estate and Traditional funds have limitations on balance transfers out of the accounts. The Real Estate fund only allows transfers out of the account once per calendar quarter and these cannot be performed using the online account management facility. According to the TIAA Real Estate Account Prospectus (2008), "Because excessive transfer activity can hurt Account performance and other participants, we may further limit how often you transfer or otherwise modify the transfer privilege" (p. 81). Also, returns in the Real Estate account may be based on assessed or estimated property values, which can over- or under-estimate actual returns that would be realized if the underlying assets were sold. If returns are over-estimated, the allocation to Real Estate may be biased upward, and vice versa. Once requested, withdrawals from the Traditional account must be made in ten annual payments ("Systematic Withdrawals and Transfers," 2005). For these reasons, some investors may look to limit investments in the Real Estate and Traditional funds. The mean-variance efficient portfolios were recalculated with additional constraints dictating that the percentage of savings in the Traditional and Real Estate accounts cannot exceed 27% and 6%, respectively. These are the maximum allocations suggested by TIAA-CREF in the five recommended portfolios, as shown in Table 1.

Table 4
Optimal Allocation Percentages for Mean-Variance Efficient Portfolios of TIAA-CREF Funds

Required Monthly Return (%)	Global Equities	Real Estate	Traditional
0.0052	0.00	0.02	0.98
0.0056	0.01	0.10	0.89
0.0060	0.01	0.19	0.80
0.0065	0.02	0.28	0.70
0.0069	0.02	0.37	0.61
0.0073	0.02	0.46	0.52
0.0077	0.03	0.55	0.42
0.0081	0.03	0.64	0.33
0.0085	0.03	0.73	0.24
0.0090	0.04	0.81	0.15
0.0094	0.05	0.90	0.05
0.0098	0.15	0.85	0.00
0.0102	0.36	0.64	0.00
0.0106	0.57	0.43	0.00
0.0110	0.78	0.22	0.00
0.0115	1.00	0.00	0.00

Figure 1
Mean-Variance Efficient Frontier of Optimal TIAA-CREF Portfolios



With the additional constraints on maximum investment in Traditional and Real Estate, the efficient frontier lies below and to the right of the original frontier, as shown in Figure 1. The optimal percentages allocated to each investment are displayed in Table 5. The limitations on Real Estate and Traditional lead to the inclusion of the Inflation-Linked Bond and Money Market funds in the best available portfolios. Clearly, the historically high returns and relatively low risk of the Real Estate fund and the guaranteed returns of the Traditional fund enhance the possibilities for TIAA-CREF participants to form relatively low-risk optimal portfolios over a wide range of required rates of return. The mean and standard deviation of the TIAA-CREF recommended portfolios are also plotted on Figure 1. Allocations to accounts within fund classes are made for the recommended portfolios so that the portfolio variance is as small as possible; however, the recommended portfolios lie below the mean-variance efficient frontier, even in the case where limitations are placed on investments in Traditional and Real Estate.

Table 5
Optimal Allocation Percentages for Mean-Variance Efficient Portfolios With Restrictions on Traditional and Real Estate

Required (%) Monthly Return	Global Equities	Inflation-Linked Bond	Money Market	Real Estate	Traditional
0.0052	0.15	0.12	0.40	0.06	0.27
0.0056	0.19	0.15	0.33	0.06	0.27
0.0060	0.22	0.18	0.27	0.06	0.27
0.0065	0.26	0.21	0.20	0.06	0.27
0.0069	0.30	0.24	0.13	0.06	0.27
0.0073	0.34	0.28	0.05	0.06	0.27
0.0077	0.37	0.29	0.00	0.06	0.27
0.0081	0.44	0.23	0.00	0.06	0.27
0.0085	0.51	0.16	0.00	0.06	0.27
0.0090	0.57	0.10	0.00	0.06	0.27
0.0094	0.63	0.08	0.00	0.06	0.23
0.0098	0.70	0.09	0.00	0.06	0.15
0.0102	0.77	0.09	0.00	0.06	0.08
0.0106	0.83	0.10	0.00	0.06	0.01
0.0110	0.89	0.05	0.00	0.06	0.00
0.0115	1.00	0.00	0.00	0.00	0.00

Historical Comparison

The previous two sections have described portfolios recommended by the TIAA-CREF Asset Allocation Evaluator and efficient portfolios constructed using a mean-variance optimization technique. In this section, these two methods of allocating retirement savings will be tested using historical data on the TIAA-CREF investments. The recommended and optimal portfolios will be instituted assuming an investor has accumulated retirement savings of $100 thousand as of May 1, 2002 and has a remaining time horizon until retirement of six years (ending April 30, 2008).

Using the five TIAA-CREF recommended portfolios—Conservative, Moderately Conservative, Moderate, Moderately Aggressive, and Aggressive—the experiment will proceed as follows at each of the rebalancing periods leading to the investor's retirement:

1. Collect historical return data for the most recent 60 months and calculate means, variances, and correlations for fund returns. For instance, on May 1, 2002, this involves collecting data for May 1997 through April 2002 (this is the first month with 60 historical observations for all funds). In the second month (assuming monthly rebalancing is instituted), data from June 1997 through May 2002 is used to calculate fund return means, variances, and correlations, and so on.
2. The optimization problem in equation (1) is solved without the required rate of return constraint to find the portfolio with the smallest variance that meets the restrictions imposed by the recommendations in Table 1. For instance, in the case of the Equity class funds, the optimization problem chooses an allocation to the Equity Index, Global Equities, and Growth funds to minimize the variance of the portfolio; however, this allocation to the Equity class funds cannot exceed the total percentage recommended for this asset class, according to Table 1.
3. Determine the allocation of the investor's beginning investment balance to each of the funds chosen in the portfolios.
4. Calculate the investor's ending investment balance based on the actual returns observed during that period.

A mean-variance efficient portfolio is constructed to match the five risk classifications of the TIAA-CREF recommended portfolios by solving the following optimization problem:

$$\begin{aligned} &\text{Maximize} \quad \sum_{i=1}^{n} w_i \cdot \mu_i \\ &w_1, \mathrm{K}\ , w_n \\ &\text{subject to:} \\ &\qquad \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \cdot Cov(R_i, R_j) = \sigma_P^2 \\ &\qquad \sum_{i=1}^{n} w_i = 1 \qquad (2) \\ &\qquad 0 \le w_i \le 1 \quad \text{for all } i = 1, \mathrm{K}\ , n. \end{aligned}$$

The required portfolio variance σ_P^2 is determined as the variance of the TIAA-CREF recommended portfolio with the same risk classification calculated for the prior 60-month period. Thus, the experiment seeks to find a portfolio that matches the variance of the corresponding recommended portfolio, but potentially earns a higher rate of return. The experiment proceeds as follows at each of the rebalancing periods leading to the investor's retirement:

1. Collect historical return data for the most recent 60 months and calculate means, variances, and correlations for fund returns.
2. Solve the mean-variance optimization problem in equation (2) using the variance calculated for the TIAA-CREF recommended portfolio with the same risk classification over the prior 60-month period.
3. Determine the allocation of the investor's beginning investment balance to each of the funds chosen in the portfolios.
4. Calculate the investor's ending investment balance based on the actual returns observed during that period.

Thus, at each rebalancing period a forward-looking investment strategy is determined based on historical data to that point, then the actual returns that would have resulted during that period and the corresponding ending investment balance are calculated. Rebalancing intervals of one, three, six, and twelve months will be investigated.

The results of the experiment assuming no restrictions are shown in Table 6. The differences in the ending balances when considering the four rebalancing intervals tested are less than or equal to $5,000, with the exception of the Moderately Conservative mean-variance efficient portfolio with the twelve-month rebalancing interval (as compared to each of the other interval lengths). Assuming this scenario can be considered an anomaly, the selection

of a rebalancing interval has a minor effect on the investor's ending wealth. For simplicity, we will limit discussion in the remainder of the paper to the one-month rebalancing interval.

For the investors with Conservative and Moderate risk preferences, the mean-variance efficient portfolios outperform the TIAA-CREF recommended portfolios, while there are only minor differences in the accumulated balances of the portfolios in the Moderately Aggressive and Aggressive categories. The Moderately Conservative TIAA-CREF recommended portfolio outperforms the mean-variance efficient portfolios.

The differences in portfolio performance in the TIAA-CREF recommended portfolios and the mean-variance efficient portfolios are most significant in the three most conservative scenarios. In the Conservative and Moderate cases, the mean-variance efficient portfolio maintained a significant portion of its assets in the Real Estate fund in a period of above-average returns for that account (2005-2007), resulting in 1.7% and 0.8% differences in average returns per annum. In the Moderately Conservative scenario, the mean-variance efficient portfolio contained a larger allocation to bonds than the recommended portfolio in 2005 and 2006. Bond returns were below average in those years, causing returns in the recommended portfolio to exceed those in the mean-variance efficient portfolio by an average of 0.9% per annum.

The balances in each of the 72 months for the Conservative, Moderately Conservative, and Moderate portfolios are shown graphically in Figure 2 for the one-month rebalancing interval. The Moderately Aggressive and Aggressive cases are excluded because of the inconsequential differences between the mean-variance efficient and recommended portfolios. The mean-variance efficient portfolios are shown with black lines, while the TIAA-CREF suggested portfolios are shown with the lighter-shaded lines. The TIAA-CREF recommended portfolios have returns that are closely tracked by their corresponding mean-variance efficient portfolios over the first 24 months. The Conservative portfolios produce the largest balances over the first 24 months, with the pair of Moderately Conservative portfolios falling between the Moderate and Conservative extremes.

If the investment allocations in the Real Estate and Traditional funds are limited to 6% and 27%, respectively, the accumulated ending balances for mean-variance efficient portfolios resemble those of the recommended portfolios. This is not surprising since some of the same restrictions are effectively imposed upon these portfolios. For this reason, these results are not presented in Table 6 and Figure 2.

Table 6
Accumulated Investment Balance After 72 Months for Investors Employing Mean-Variance Efficient Portfolios And TIAA-CREF Recommended Portfolios

	Mean-Variance Efficient Portfolios					Asset Allocation Allocator Recommended Portfolios				
Rebalancing Period (Months)	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.
1	156	138	157	155	153	141	146	150	154	154
3	155	139	156	155	154	140	145	150	154	154
6	157	136	152	155	153	141	146	150	154	154
12	161	148	153	153	152	142	148	152	153	153

Difference (Mean-Variance Efficient minus Asset Allocation Recommended)

Rebalancing Period (Months)	Cons.	Cons.	Mod. Mod.	Agg.	Mod. Agg.
1	15	-8	7	1	-1
3	15	-6	6	1	0
6	16	-10	2	1	-1
12	19	0	1	0	-1

As in the mean-variance efficient portfolios constructed using the most recent 60 months of data in the previous section, the Social Choice fund in the Multi-Asset class never enters the optimal portfolios for any of the time periods in the historical comparison.

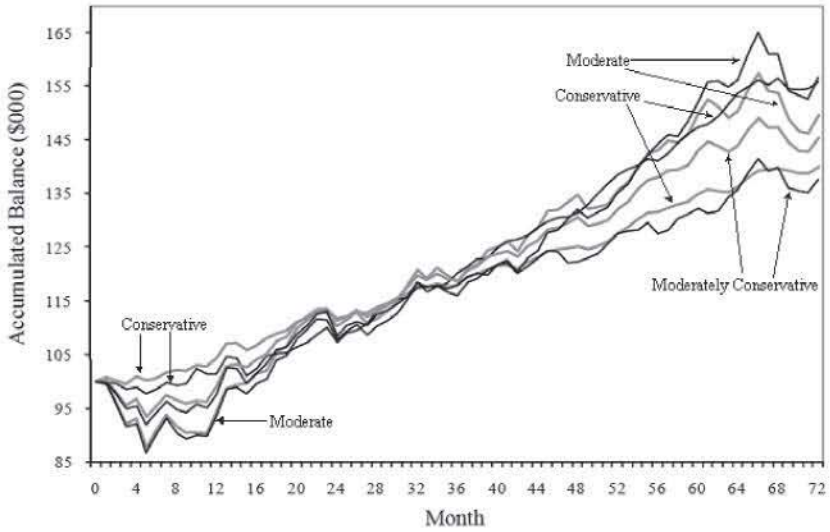
The next section describes a specific retirement plan that augments the fund offerings with two funds from outside the TIAA-CREF family and describes the effect on the optimal portfolios and account balances in a similar experiment to the one conducted previously.

Plan-Specific Options

TIAA-CREF includes investment options outside its family of accounts for participants in some retirement plans. For instance, employees of the Commonwealth of Virginia (COVA) may elect to participate in the employer-funded TIAA-CREF Optional Retirement Plan (ORP). Participants in this plan have the investment options listed in Table 2, with the exception of the Social Choice fund, which is replaced by the Vanguard Asset Allocation (VAAPX) fund. This fund is another Multi-Asset class account that has a

historical monthly return over the last 60 months of 0.84% and a standard deviation of 2.31%. This plan also offers one additional Equity class fund—the American Funds EuroPacific Growth (AEPGX) fund—which has historical returns over the last 60 months of 1.66% per month and a standard deviation of 3.15%.

Figure 2
Accumulated Investment Balance Over a 72-Month Period For Investors Employing Mean-Variance Efficient Portfolios and TIAA-CREF Recommended Portfolios (In Thousands Of Dollars)
The mean-variance efficient portfolios are shown with black lines, while the TIAA-CREF suggested portfolios are shown with the lighter-shaded lines.



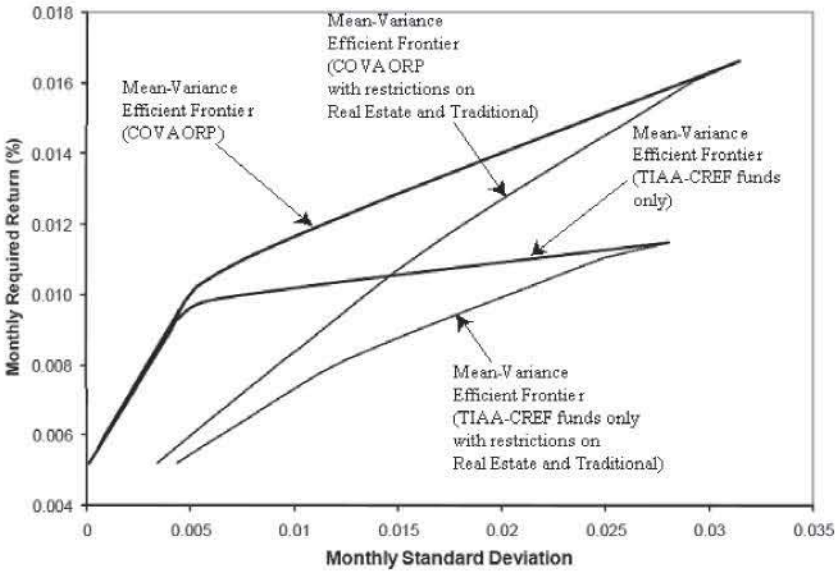
Since the monthly rate of return for AEPGX is higher than any of the TIAA-CREF funds, this investment increases the set of efficient portfolios to include a wider realm of required monthly returns. AEPGX has a lower than average correlation with the other Equity class funds, which may also offer the chance to create lower variance optimal portfolios. The mean-variance efficient frontier of portfolios determined using the COVA ORP options is shown in Figure 3. The frontier coincides with the frontier found in Figure 1 using only TIAA-CREF funds up to a monthly required rate of return of 0.94%. Above this point in the curve, the addition of AEPGX in the COVA ORP opens additional efficient investment opportunities at higher required monthly rates of return. The efficient frontier determined by applying the 27%

and 6% restrictions to investments in Traditional and Real Estate, respectively, is also shown in Figure 3, along with the same frontier found using only TIAA-CREF funds. The mean-variance efficient allocations to each fund in the unrestricted case are shown in Table 7, with the optimal allocations in the restricted case shown in Table 8. When restrictions are placed on the amount invested in Traditional and Real Estate, the Inflation-Linked Bond and Money Market funds enter the mean-variance efficient portfolios.

Table 7
Optimal Allocation Percentages for Mean-Variance Efficient Portfolios in The COVA ORP Determined Using the Mean-Variance Portfolio Optimization Technique

Required Monthly Return (%)	Real Estate	Traditional	AEPGX
0.0052	0.10	0.90	0.00
0.0056	0.11	0.89	0.00
0.0060	0.18	0.81	0.01
0.0065	0.26	0.72	0.02
0.0069	0.34	0.64	0.02
0.0073	0.42	0.55	0.03
0.0077	0.50	0.47	0.03
0.0081	0.58	0.38	0.04
0.0085	0.66	0.30	0.04
0.0090	0.74	0.21	0.05
0.0094	0.83	0.11	0.06
0.0098	0.91	0.03	0.06
0.0102	0.90	0.00	0.10
0.0106	0.84	0.00	0.16
0.0110	0.78	0.00	0.22
0.0115	0.72	0.00	0.28
0.0119	0.67	0.00	0.33
0.0123	0.61	0.00	0.39
0.0127	0.55	0.00	0.45
0.0131	0.49	0.00	0.51
0.0135	0.43	0.00	0.57
0.0140	0.37	0.00	0.63
0.0144	0.32	0.00	0.68
0.0148	0.26	0.00	0.74
0.0152	0.20	0.00	0.80
0.0156	0.14	0.00	0.86
0.0160	0.08	0.00	0.92
0.0165	0.02	0.00	0.98
0.0169	0.00	0.00	1.00

Figure 3
Mean-Variance Efficient Frontier Of Optimal Portfolios in the COVA ORP Plan, Graphed With Mean-Variance Efficient Portfolios Comprised of TIAA-CREF Funds Only



Performing the historical experiment used in the prior section with data for the same period on all funds available in the COVA ORP yields interesting results. The experiment follows the same process. At each of the rebalancing intervals, historical data is used to calculate statistics on returns over the prior 60 months. Next, TIAA-CREF recommended portfolios are determined by selecting the allocations that minimize portfolio variance, subject to the restrictions on total allocations to each asset class specified in Table 1. For the suggested portfolios, AEPGX is included in the Equity class. The VAAPX fund is a Multi-Asset fund, so it is not included in any recommended portfolios since TIAA-CREF does not include this asset class in any of its suggestions. The variance of each of the TIAA-CREF recommended portfolios is determined in each period of the 72-month time horizon using data over the previous 60 months. Subsequently, a mean-variance efficient portfolio is determined for each risk classification using equation (2).

Accumulated account balances for the investor that begins May 2002 with $100 thousand are shown in Table 9 for the mean-variance efficient and suggested portfolios. The recommended portfolios limit investments in Real Estate and Bond funds, and in the Moderately Aggressive and Aggressive scenarios, investments are redirected to the equity accounts.

Table 8
Optimal Allocation Percentages for Mean-Variance Efficient Portfolios in the COVA ORP Determined Using the Mean-Variance Portfolio Optimization Technique, With Limitations On Investments in the Traditional And Real Estate Accounts

Required Monthly Return (%)	Inflation-Linked Bond	Money Market	Real Estate	Traditional	AEPGX
0.0052	0.06	0.51	0.06	0.27	0.10
0.0056	0.07	0.47	0.06	0.27	0.13
0.0060	0.09	0.42	0.06	0.27	0.16
0.0065	0.10	0.38	0.06	0.27	0.19
0.0069	0.12	0.34	0.06	0.27	0.21
0.0073	0.14	0.30	0.06	0.27	0.23
0.0077	0.15	0.25	0.06	0.27	0.27
0.0081	0.17	0.21	0.06	0.27	0.29
0.0085	0.18	0.17	0.06	0.27	0.32
0.0090	0.20	0.13	0.06	0.27	0.34
0.0094	0.21	0.08	0.06	0.27	0.38
0.0098	0.23	0.04	0.06	0.27	0.40
0.0102	0.24	0.00	0.06	0.27	0.43
0.0106	0.21	0.00	0.06	0.27	0.46
0.0110	0.17	0.00	0.06	0.27	0.50
0.0115	0.14	0.00	0.06	0.27	0.53
0.0119	0.10	0.00	0.06	0.27	0.57
0.0123	0.07	0.00	0.06	0.27	0.60
0.0127	0.03	0.00	0.06	0.27	0.64
0.0131	0.00	0.00	0.06	0.27	0.67
0.0135	0.00	0.00	0.06	0.23	0.71
0.0140	0.00	0.00	0.06	0.19	0.75
0.0144	0.00	0.00	0.06	0.16	0.78
0.0148	0.00	0.00	0.06	0.12	0.82
0.0152	0.00	0.00	0.06	0.09	0.85
0.0156	0.00	0.00	0.06	0.05	0.89
0.0160	0.01	0.00	0.06	0.00	0.93
0.0165	0.00	0.00	0.02	0.00	0.98
0.0169	0.00	0.00	0.00	0.00	1.00

The improvement and percentage improvement in the accumulated ending balance attributable to the investment options outside the TIAA-CREF family is also shown in the second and third rows of Table 9. Each of the portfolios studied performs more effectively in the COVA ORP plan, as compared to the case where only the TIAA-CREF funds are available. The increase in performance is primarily due to the AEPGX fund. The VAAPX fund is not included in the recommended portfolios because the Multi-Asset

class is never suggested, but is does enter the optimal allocation in the mean-variance efficient portfolios in certain periods for each risk classification.

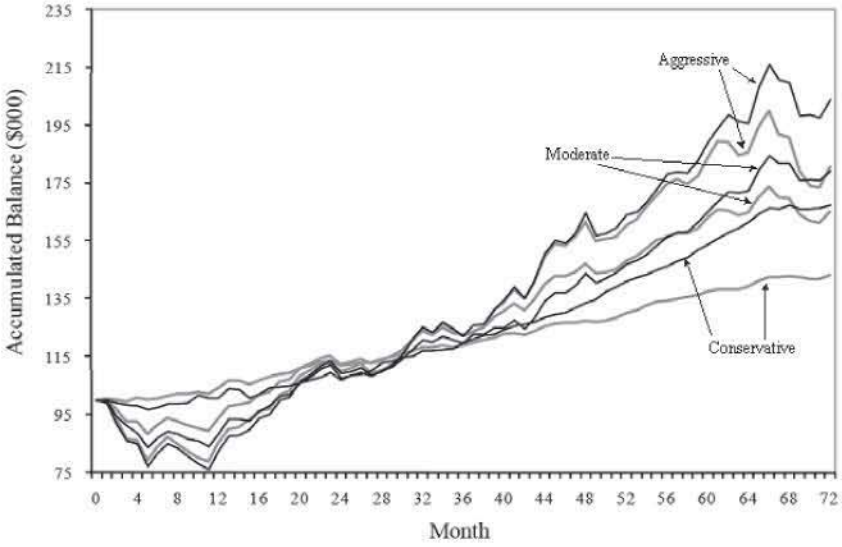
Table 9: Accumulated investment balance after 72 months for investors employing mean-variance efficient portfolios and TIAA-CREF recommended portfolios in the COVA ORP retirement plan (in thousands of dollars).

The change and percentage change in the accumulated balances in the COVA ORP plan from the TIAA-CREF only portfolios are shown below the accumulated balances, in addition to the differences between the mean-variance efficient and TIAA-CREF recommended portfolios.

	Mean-Variance Efficient Portfolios					Asset Allocation Allocator Recommended Portfolios				
	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.
Accumulated Balance	167	161	179	184	204	144	155	164	175	179
Change from TIAA-CREF only Portfolios (from Table 6)	11	23	22	28	51	3	9	15	21	25
% Change from TIAA-CREF only Portfolios (from Table 6)	7%	17%	14%	18%	33%	2%	6%	10%	14%	16%
	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.	Cons.	Mod. Cons.	Mod.	Mod. Agg.	Agg.
Difference and average per annum % return difference (Mean-Variance Efficient minus Asset Allocation Recommended)	23	6	15	9	25	2.5%	0.6%	1.4%	0.8%	2.1%

As shown in the bottom row of Table 9 and in Figure 4, the mean-variance efficient portfolios produce larger ending accumulations than the TIAA-CREF recommended portfolios in all risk classifications. For clarity, Figure 4 only shows the Conservative, Moderate, and Aggressive portfolios. As in Figure 2, the mean-variance efficient portfolios are shown with black lines, whereas the TIAA-CREF recommended portfolios are shown with lighter gray lines.

Figure 4
Accumulated Investment Balance Over a 72-Month Period for Investors Employing Mean-Variance Efficient Portfolios and TIAA-CREF Recommended Portfolios (In Thousands Of Dollars) in the COVA ORP Plan
The rebalancing interval used is optimal for each individual portfolio. The mean-variance efficient portfolios are shown with black lines, while the TIAA-CREF suggested portfolios are shown with the lighter-shaded lines.



While the finding of McClatchey et al. (2003) that mean-variance efficient portfolios contain only one equity fund were confirmed earlier in this paper when no minimum or maximum allocations were instituted for each asset class, mean-variance efficient portfolios *within the restrictions of the TIAA-CREF recommendations* sometimes combine investments in different asset classes when outside equity funds (such as AEPGX) are included in the offerings. For instance, consider the portfolio rebalancing that occurs in the historical experiment on May 1, 2005. Based on the previous 60 months of historical returns, the following statistics on the AEPGX and Stock funds are used to determine optimal portfolios:

- **AEPGX** – mean: -0.02%; standard deviation: 4.26%; correlation with Stock: 0.90.
- **Stock** – mean: -0.18%; standard deviation: 4.54%; correlation with AEPGX: 0.90.

When the Moderately Aggressive recommendations are followed without allowing investments in AEPGX, 75% of investment funds are placed

in the Stock account. The contribution of this fund to the portfolio variance is equal to $0.75^2 \cdot 0.00454^2 = 0.001162$. Only one fund is included since the correlations of Stock (which has the lowest standard deviation among TIAA-CREF equity funds at that date) with Equity Index, Global Equities, and Growth are very close to one. However, when AEPGX is included, the Moderately Aggressive portfolio consists of an allocation of 61% to AEPGX and 14% to Stock. The contributions of these investments to portfolio variance is

$$0.61^2 \cdot 0.0426^2 + 0.14^2 \cdot 0.0454^2 + 2 \cdot 0.61^2 \cdot 0.14^2 \cdot 0.90 \cdot 0.0426 \cdot 0.0454 = 0.001013.$$

This is lower than the contribution to portfolio variance that would be produced by investing the entire 75% in AEPGX of $0.75^2 \cdot 0.00426^2 = 0.001019$. AEPGX thus becomes an important component in the recommended portfolios in the COVA ORP. With this option, investing in more than one equity account within the guidelines of the recommended portfolio becomes optimal. The total portfolio variance when the outside funds are included in this scenario is 0.000994, as additional investments of 13% in the Bond fund, 5% in the Real Estate fund, and 7% in the Traditional fund serve to further reduce the portfolio variance. The expected return on this portfolio is 0.1080% per month.

If the investor chooses to ignore the Moderately Aggressive recommendations, a portfolio with a variance of 0.000994 can be constructed from the VAAPX and Inflation-Linked Bond funds, with allocations of 89% and 11%, respectively. Based on the previous 60 months of historical returns, the following statistics on the VAAPX and Inflation-Linked Bond funds are used to determine optimal portfolios:

- **VAAPX** – mean: 0.14%; standard deviation: 3.58%; correlation with Inflation-Linked Bond: -0.21.
- **Inflation-Linked Bond** – mean: 0.76%; standard deviation: 1.79%; correlation with VAAPX: -0.21.

The variance of this portfolio is calculated as

$$0.89^2 \cdot 0.0358^2 + 0.11^2 \cdot 0.0179^2 + 2 \cdot 0.89^2 \cdot 0.11^2 \cdot -0.21 \cdot 0.0358 \cdot 0.0179 = 0.000994.$$

The expected return on this portfolio is 0.2122%. Depending on the rebalancing period, the Moderately Aggressive mean-variance efficient portfolio produces an ending balance that is $9,000 to $21,000 higher than the corresponding TIAA-CREF recommended portfolio.

The previous example demonstrates that the negative correlation of the VAAPX fund with one of the TIAA-CREF bond funds is one factor that allows the mean-variance efficient portfolios to outperform the recommended portfolios. Another significant factor is that while the TIAA-CREF equity funds have positive correlations with the Real Estate fund, the AEPGX account has *negative* correlations with the Real Estate fund. When the

maximum Real Estate allocation restrictions are lifted in the mean-variance efficient portfolios, the AEPGX fund is often combined with Real Estate to construct portfolios that earn higher returns at the same variance than portfolios obtained by combining the much smaller investments in Real Estate with TIAA-CREF equity, bond, and money market funds.

Conclusions

This analysis in this paper serves two primary purposes. First, an examination of mean-variance efficient portfolios composed of funds provided by TIAA-CREF was conducted using monthly data from May 2003 to April 2008. The 60 month period is used in both the analysis of mean-variance efficient portfolios and the historical comparison for consistency. In effect, this brings up-to-date the work of McClatchey et al. (2003) that performed similar analysis based on data collected over the period of 1994-2002. Their finding that mean-variance efficient portfolios include only one equity account is confirmed when no restrictions are placed on the portion of the portfolio allocated to equity funds. Second, the performance of the portfolios suggested by the TIAA-CREF Asset Allocation Evaluator was studied. Understanding the usefulness of this tool as a means of investor guidance is important because it is readily available and individuals can easily construct and implement their own portfolios using TIAA-CREF's account management website.

The analysis of mean-variance efficient portfolios was made first by considering all TIAA-CREF funds, then by placing restrictions on the Real Estate and Traditional funds. This has been done because these two funds carry some limitations on the frequency and ease of outgoing balance transfers, a characteristic that may cause some issues with certain approaches to portfolio rebalancing. TIAA-CREF includes some outside funds in retirement plans on an institution-by-institution basis. In the case of the Commonwealth of Virginia Optional Retirement Plan, the addition of an additional equity fund extends the capability of investors to hold mean-variance efficient portfolios over a wider range of potential levels of return.

The suggestions of the Asset Allocation Evaluator should be used with caution. The survey may assist investors in determining their attitudes toward investment risk and understand how market fluctuations might affect their retirement savings. However, the historical performance of the portfolios suggested by this instrument falls short of the performance of the mean-variance efficient portfolios when only TIAA-CREF funds are included in the analysis (as shown in Figure 2 and Table 6) for investors in certain risk classifications. When additional funds outside the TIAA-CREF family are available, as in the COVA ORP plan, the recommended portfolios performed much better in the historical experiment (as shown in the top row of Table 9). Although the TIAA-CREF recommendations were more effective with the

inclusion of the outside funds, portfolios with higher expected mean returns that match the variance of the TIAA-CREF recommended portfolios can be constructed, and this resulted in larger accumulated wealth in the historical experiment (as shown in Figure 4).

This finding suggests some interesting questions about the investment options offered in defined contribution retirement plans. TIAA-CREF has offered COVA employees additional options that expand the potential for greater returns, particularly for aggressive investors. The AEPGX fund replaces all TIAA-CREF equity funds in mean-variance efficient portfolios when the most recent 60 months of return data are considered. The AEPGX fund has a lower than average correlation with the TIAA-CREF equity funds and a negative correlation with the Real Estate fund. While the mean-variance efficient portfolios calculated using the most recent 60 months of data included only one equity fund, in some periods explored in the historical comparison, the variance of TIAA-CREF's recommended portfolios was reduced by holding AEPGX in combination with other equity funds. Table 9 reveals the benefits of this additional diversification opportunity for TIAA-CREF participants. Similar research focused on the retirement plans administered by other companies may be of use to participants in those systems.

The results presented in this paper have some important implications for investors and financial planners. When implementing the TIAA-CREF recommended portfolios, investors should consider the investment options available outside the TIAA-CREF family. If such accounts are not offered as part of the retirement plan, investors may need to combine their holdings in the TIAA-CREF accounts with those in other retirement accounts, such as Roth IRAs, when considering the prescribed allocations. The TIAA-CREF Asset Allocation Evaluator is available to anyone on the TIAA-CREF website. If an investor uses this tool without logging in to the account management facility, the suggested accounts include only TIAA-CREF accounts. If the investor does log in, additional accounts outside the TIAA-CREF family available in that particular plan appear as suggestions. The investor must be careful when determining how to allocate funds based on the recommendations because there may be instances where blending of investments in TIAA-CREF equity funds with outside funds is beneficial.

Further, if an investor is willing to abandon the TIAA-CREF recommended portfolios, greater returns might be achieved by matching the variance of the recommended portfolio corresponding to his or her risk preferences, and using the mean-variance optimization technique to search for a portfolio that earns a higher return at similar risk. The investor can still employ the TIAA-CREF Asset Allocation Evaluator to assess his or her risk, but then evoke the mean-variance optimization process to determine an optimal allocation of retirement assets.

Acknowledgements

The authors wish to thank two anonymous reviewers for extensive comments and suggestions that significantly improved the paper.

References

Agnew, J., Balduzzi, P. & Sundén, A. (2003). Portfolio choice and trading in a large 401(k) plan. *American Economic Review*, 93(1), 193-215.

Choi, J.J., Laibson, D. & Madrian, B.C. (2005). Are empowerment and education enough? Underdiversification in 401(k) plans. *Brookings Papers on Economic Activity*, 2, 151-198.

Droms, W.G. & Strauss, S.N. (2003). Assessing risk tolerance for asset allocation. *Journal of Financial Planning*, 16(3), 72-77.

Kroll, Y., Levy, H. & Markowitz, H.M. (1984). Mean-variance versus direct utility maximization. *Journal of Finance*, 39(1), 47-61.

Levy, H. & Markowitz, H.M. (1979). Approximating expected utility by a function of mean and variance. *American Economic Review*, 69(3), 308-317.

Markowitz, H.M. (1952). Portfolio selection. *Journal of Finance*, 7(1), 77-91.

McClatchey, C.A & VandenHul (2005). The efficacy of optimization modeling as a retirement strategy in the presence of estimation error. *Financial Services Review*, 14(4), 269-284.

McClatchey, C.A, Moon, K.P., VandenHul, S.P. & Griswold, M.C. (2003). Are there diversification benefits among the TIAA-CREF retirement funds? *Journal of Personal Finance*, 2(2), 54-94.

Moreschi, R.W. (2004). Incorporating investor risk tolerance into the financial planning process. *Journal of Personal Finance*, 3(3), 89-98.

Systematic Withdrawals and Transfers from the TIAA Traditional Account. (2005). Retrieved May 22, 2008 from http://www.tiaa-cref.org/pubs/pdf.

TIAA Traditional Annuity Fact Sheet. (2008). Retrieved May 22, 2008 from http://www.tiaa-cref.org/fyi/pdf/fact_sheets.

TIAA Real Estate Account Prospectus. (2008). Retrieved May 22, 2008 from http://www.tiaa-cref.org/pdf/prospectuses.

TIAA-CREF. Systematic Withdrawals and Transfers from TIAA Traditional. (2005). Retrieved May 22, 2008 from http://www.tiaa-cref.org/pubs/pdf.

TIAA-CREF Annual Report. (2006). Retrieved May 21, 2008 from http://www.tiaa-cref.org/pdf/annual_reports.

TIAA-CREF Asset Allocation Evaluator. (2008). Retrieved May 21, 2008 from https://ais4.tiaa-cref.org/assetallocguidance/nsjsp/start.do.

Appendix. TIAA-CREF Asset Allocation Evaluator (2008)

1. Inflation, the rise in prices over time, can erode your investment return. Long-term investors should be aware that, if portfolio returns are less than the inflation rate, their ability to purchase goods and services in the future might actually decline. However, portfolios with long-term returns that significantly exceed inflation are associated with a higher degree of risk. **Which of the following portfolios is most consistent with your investment philosophy?**
   a. Portfolio A will most likely exceed long-term inflation by a significant margin and has a high degree of risk.
   b. Portfolio B will most likely exceed long-term inflation by a moderate margin and has a high to moderate degree of risk.
   c. Portfolio C will most likely exceed long-term inflation by a small margin and has a moderate degree of risk.
   d. Portfolio D will most likely match long-term inflation and has a low degree of risk.
2. Portfolios with the highest average returns also tend to have the highest chance of short-term losses. The table at right provides the average dollar return of four hypothetical investments of $100,000 and the possibility of losing money (ending value of less than $100,000) over a *one-year holding period*. **Please select the portfolio with which you are most comfortable based on the following average value and chance of losing money at the end of one year.**
   a. $106,000; 16%
   b. $107,000; 21%
   c. $108,000; 25%
   d. $109,000; 28%
3. Investing involves a trade-off between risk and return. Historically, investors who have received high long-term average returns have experienced greater fluctuations in the value of their portfolio and more frequent short-term losses than investors in more conservative investments have. **Which statement best describes your investment goals?**
   a. *Protect the value of the account.* In order to minimize the chance for loss, I am willing to accept the lower long-term returns provided by conservative investments.
   b. *Keep risk to a minimum* while trying to achieve slightly higher returns than the returns provided by investments that are more conservative.
   c. *Balance* moderate levels of risk with moderate levels of returns.
   d. *Maximize long-term investment returns.* I am willing to accept large and sometimes dramatic fluctuations in the value of my investments.
4. Historically, markets have experienced downturns, both short-term and prolonged, followed by market recoveries. Suppose you owned a well-

diversified portfolio that fell by 20% (i.e. $1,000 initial investment would now be worth $800) over a short period, consistent with the overall market. **Assuming you still have 10 years until you begin withdrawals, how would you react?**

a. I would *not* change my portfolio.
b. I would *wait at least one year* before changing to options that are more conservative.
c. I would *wait at least three months* before changing to options that are more conservative.
d. I would immediately change to options that are more conservative.

5. The graph (omitted) at right shows the hypothetical results of four sample portfolios over a one-year holding period. The best potential and worst potential gains and losses are presented. Note that the portfolio with the best potential gain also has the largest potential loss. **Which of these portfolios would you prefer to hold?**
   a. Portfolio A (with best gain 45% and worst loss 26%)
   b. Portfolio B (with best gain 34% and worst loss 20%)
   c. Portfolio C (with best gain 26% and worst loss 15%)
   d. Portfolio D (with best gain 15% and worst loss 7%)
6. **I am comfortable with investments that may frequently experience large declines in value if there is a potential for higher returns.**
   a. Agree
   b. Disagree
   c. Strongly Disagree

Contact Information: Barry R. Cobb, PhD., Associate Professor, Department of Economics and Business, Virginia Military Institute, 335 Scott Shipp Hall, Lexington, VA 24450; E-mail: cobbbr@vmi.edu
Alex J. Menas, 2nd Lt., U.S. Air Force. Graduate, Virginia Military Institute, Lexington, VA