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# Managing a 401(k) Account: An Experiment on Asset Allocation

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This paper reports the results of a behavioral finance experiment on asset allocation. Subjects managed a portfolio and made repeated asset allocations to stocks, bonds, and cash. The task was designed to be similar to what a typical investor would face in managing a 401(k) account for twenty years. The primary manipulation in the experiment was the introduction of portfolio future value projections. The results indicate that subjects who receive future value projections create portfolios with higher allocations to stocks and higher portfolio expected return, and allocations to stocks tends to increase with age. In the aggregate subjects do reasonably well in creating efficient portfolios. The results have implications for reducing myopic loss aversion and for the efficient financial engineering of defined contribution accounts.

***Keywords:*** Behavioral finance, Asset allocation, Future value, 401(k) investing, Myopic loss aversion, Age effects on risk taking

## INTRODUCTION

As recently as 1990, 62% of U.S. retirement assets were held in professionally managed accounts. By 2003, 51% of retirement assets were held in professionally managed accounts, and 49%, or $5.8 trillion, were individually managed (Investment Company Institute [2004]).[1] This trend will continue as employers have begun to shift rapidly from defined benefit pension plans[2] to defined contribution plans.[3] According to the Bureau of Labor Statistics, the percentage of full-time employees in medium and large size establishments participating in defined benefit plans has fallen precipitously from 80% in 1985 to 36% in 2000. Adding to these trends is the ongoing national debate over Social Security reform and the various proposals to introduce privately managed accounts. Taken together, it is clear that individuals are going to bear a much greater responsibility for their long-term retirement investment decisions.

The bulk of individually managed employee retirement savings will likely be held in defined contribution (DC) pension plans. A typical employer-sponsored DC plan, such as a 401(k) or 403(b) plan, is like a savings account into which the employer and the employee contribute a specified dollar amount or percentage of earnings into the account. The employee is given a choice of various investments such as stocks, bonds, mutual funds, company stock, cash, guaranteed investment contracts, and real estate investment trusts. It is the employee's responsibility to both properly fund and manage this account, which includes making appropriate asset allocation decisions. At retirement, the balance in the account forms the basis of the employee's retirement income. The employee will have various options on how and when to withdraw the savings and will likely continue to manage and make investment decisions on the savings well into retirement.

Saving for retirement poses a number of challenges for the individual investor. Mitchell and Utkus [2004] argue that the main problems individuals face in retirement planning can be organized around three decisions: 1) the decision to save, 2) the investment decision, and 3) the decumulation decision. In this paper we focus on the investment decision and, specifically, the type of repeated asset allocation decisions an investor must make in managing a typical 401(k) over a long period of time. The problem that we will focus on concerns how individuals choose to allocate their assets when the time horizon is long, such as the beginning of a career, and how asset allocations change as the time horizon shortens, such as when retirement nears. In doing so, we examine the effects that additional information regarding the projected

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value of the portfolio has on individuals' portfolio choices, an issue of importance from both theoretical and policy perspectives.

The rest of this paper is organized as follows. First, we review normative investment theory regarding how optimal asset allocations decisions should be made, followed by a summary of prescriptive asset allocation advice commonly offered by financial advisors. Next, a review of the behavioral finance literature is offered, focusing on results related to investors making long-term asset allocation decisions. We then present an experiment designed to assess how individuals make asset allocation decisions, including the introduction of a manipulation designed to reduce myopic loss aversion. We conclude with a discussion, limitations, and directions for future research.

## LITERATURE REVIEW

The Mean-Variance (MV) model[4] (Markowitz [1959]) is commonly used to describe optimal choice behavior in asset allocation decisions.[5] Imagine an investor who wishes to allocate a certain amount of wealth today, $X$, among $n$ different risky investment opportunities. Each of the $n$ investment opportunities offers rates of return $R_1, \ldots, R_n$, which are assumed to be random variables with given joint probability distribution. If amount $x_i$, $i = 1, \ldots, n$, is the current wealth allocated to opportunity $i$, where $X = \Sigma_{i=1}^{n} x_i$, then the final wealth of the investor is a random variable $w$ given by

$$w = \sum_{i=1}^{n} x_i(1 + R_i)$$

where $R_i$ = the return on asset i.

The investor's problem is to select $x_1, \ldots, x_n$ so as to maximize $E\{U(w)\}$ where $U$ is his or her utility function and $w$ is the end-of-period wealth (Kroll, Levy, and Rapoport [1988a]). In this problem, if the distribution of returns offered by the assets is *jointly normal*, then an investor's expected utility can be maximized by selecting the most efficient portfolio, which is the best combination of mean and variance (Copeland and Weston, [1988]). That is, an investor's expected utility is maximized if he or she selects an allocation of assets that provides the highest expected return for a given level of risk consistent with his or her preference for return and risk.

The MV model prescribes the optimal asset allocation behavior for an investor who only cares about the mean and variance of portfolio returns over a single period. Campbell and Viceira [2002] provide a graphical representation of this analysis that is reproduced in Figure 1. The normative asset allocation advice offered from the MV analysis is straightforward and somewhat surprising. All investors who care only about the mean and standard deviation of portfolio returns will hold the same portfolio of risky assets, or the best mix

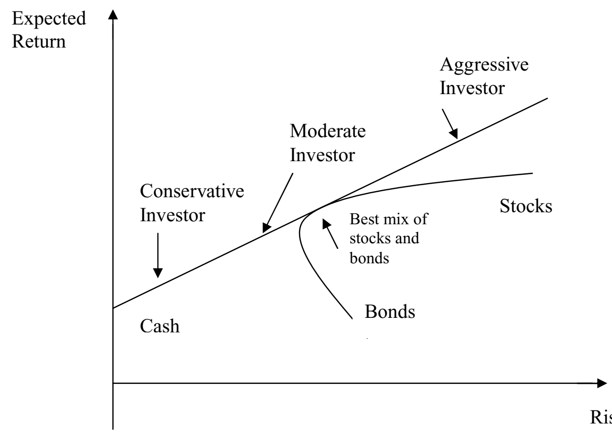


FIGURE 1 Mean-standard deviation diagram (Campbell and Viceira [2002]).

of stocks and bonds (Tobin [1958], Campbell and Viceira [2002]). All investors will create portfolios on the MV efficient frontier, represented by the straight line in Figure 1, by holding the same optimal risky portfolio and/or cash. Conservative investors will hold large proportions of cash and locate on the lower left of the efficient frontier while aggressive investors may borrow to create leverage and locate on the upper right of the efficient frontier. No matter where on the frontier investors choose to locate, the mutual fund theorem of Tobin [1958] specifies that all investors will hold the same proportion of assets in the risky portfolio.

Applying the recommendations from the MV model to a typical DC plan participant is straightforward. First, a DC plan participant would decide on his or her risk tolerance and thus where on the efficient frontier to locate. Second, the optimal combination of the risky portfolio and cash would then be chosen. In practice, the risky portfolio would likely be constructed of broad based index funds.[6] While this approach may not put the average investor exactly on the frontier, for practical purposes it is likely a close enough approximation. Since the MV analysis is a single period model, the investor would then presumably repeat these steps each period an asset allocation decision is to be made. Assuming the investor's risk preferences do not change, there would be little change in the asset allocation over time.[7]

The recommendations of the MV model contrast with commonly proffered advice of investment professionals. A common practice of investment advisors is to recommend different asset allocations depending upon the length of the investment horizon. For example, one heuristic used is that the percentage of risky assets in a portfolio should be equal to 100 minus the investor's age. Thus, a young employee with many years until retirement would be advised to choose an aggressive asset allocation strategy and overweight the portfolio with stocks. In contrast, an employee on the verge of retirement might be advised to allocate his portfolio more conservatively and overweight cash. The logic behind this advice rests on a time diversification argument. The time diversification principle states that portfolio risk decreases as the investment horizon increases (Jaggia and Thosar [2000]). Samuelson [1969] showed that if stock returns follow a random walk, investors exhibit constant relative risk aversion, and the portfolio is the only asset in investors' wealth (i.e., human capital is ignored in the analysis), the asset allocation decision should be independent of the time horizon. Using an otherwise identical setup with a modified utility function, Jaggia and Thosar [2000] have shown that the time diversification argument can be supported, but only at the expense of introducing time-inconsistent portfolio choices. Similarly, Gollier and Zeckhauser [2002] have shown that young investors hold more risky assets than the old if and only if the Arrow-Pratt measure of absolute risk tolerance is convex in consumption, a condition whose empirical validity is still under examination (Gollier and Zeckhauser [2002, p. 206]). Kritzman [1994] provides a clear and intuitive discussion of arguments that tend to validate the time diversification argument.

While the above arguments relate to the question of how investors with long time horizons *should* allocate their assets, we now look at some of the research showing how investors *do* allocate their assets. A survey of the behavioral finance literature suggests that investors may be subject to several biases when allocating their portfolio over a long time horizon. In a series of papers, Benartzi and Thaler [1995, 1999, 2001, 2002] have identified several potential biases possibly influencing long-term asset allocation decisions. First is the "1/n strategy." Since many employees may not have the expertise required in making allocation decisions, the 1/n heuristic applied to a DC pension plan is to allocate the portfolio evenly across the different mutual funds offered within the plan. For example, if five different funds were offered in a 401(k) plan, an employee would allocate 20% to each. Examining the distribution of 401(k) account balances, Benartzi and Thaler [2001, p. 79] conclude that "consistent with this naïve notion of diversification, we find that the proportion invested in stocks depends strongly on the proportion of stock funds in the plans".[8]

Another bias affecting asset allocation is myopic loss aversion (Benartzi and Thaler [1995]). Loss aversion (Kahneman and Tversky [1979]) implies that investors are more sensitive to losses than gains. Benartzi and Thaler [1999] suggest that a typical investor will psychologically weight a loss in wealth about twice as much as an equal gain in wealth. Myopia results from mental accounting and aggregation rules (Kahneman and Tversky [1984], Thaler [1985]), which cause investors to aggregate gains and losses differently and to evaluate their portfolio too frequently. Investors will tend to avoid riskier (higher variance) investments if their time horizon in viewing those investments is short (myopic) because the losses over the short term will weigh more heavily on them than the gains. The result of myopic loss aversion is that long term investors will under-invest in riskier assets (namely stocks) compared to what would be consider optimal or rational.

Framing effects can also affect asset allocation. Benartzi and Thaler [1999] examined how university employees might allocate their pension assets contingent upon the presentation of historical asset returns. Utilizing a survey methodology and asking subjects to make hypothetical asset allocation decisions, the study manipulated the presentation of fund returns. One group was shown a graphical representation detailing the historical performance of stocks and bonds based upon one-year rates of return, while a second group was shown such results based upon hypothetically constructed 30-year rates of return. The results show that when charts were constructed from the actual return data from 1926–1993, a period in which stocks outperformed bonds by about 6% annually,[9] subjects who saw the one-year rates of return were significantly less likely to invest in stocks compared to subjects who saw the 30-year rates of return. However, in an additional study in which the simulated return information was created using an equity premium of only 3% rather than 6%, there was no significant difference in the choice of funds between the subjects in the different conditions.

In summary, we propose two perspectives on the ability of average investors to make asset allocation decisions over the long term. On the one hand, the theoretical simplicity of the MV model suggests that it should not be a difficult task for the average investor to create a reasonably efficient portfolio assuming the underlying assets to choose from are reasonably efficient. Probably the greater challenge with the MV approach for the average investor is figuring out one's risk tolerance and the desired location on the efficient frontier. Thus, the MV perspective suggests the average investor should be able to reasonably and efficiently allocate his assets over a long time horizon.

On the other hand, the behavioral finance perspective (or the heuristics and biases perspective) suggests the average investor is likely to perform poorly in allocating assets over a long time horizon. The cause of this poor performance is systemic cognitive biases, such as myopic loss aversion, and cannot easily be overcome. This perspective suggests that investors will likely make numerous mistakes in their investment behavior leading to significantly suboptimal results.

We next introduce an experiment designed to broadly test these two perspectives and to examine how myopic loss aversion is affected by the presentation of future value calculations. The motivation for the experiment comes from the fact that prior empirical results on asset allocation decisions are primarily based upon survey methodologies or on examining account balances in pension accounts. We believe that an experimental investigation where control can be exerted on some of the critical determinants driving investors' behavior on asset allocation decisions allows for greater internal validity and permits a more explicit testing of specific behavioral hypotheses.

TABLE 1
Spreadsheet Interface.

| Year | Beginning Account Balance ($) | % Asset Allocation to: Stocks | Bonds | Cash | Total % Allocation (100%) | Expected Rate of Return (%) | Year 20 Projected Value ($) | Actual Annual % Return on: Stocks | Bonds | Cash | Annual Return ($) | Ending Account Balance ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | $ 5.00 | 34 | 33 | 33 | 100% | 7.3% | $ *20.55* | 10.0% | 5.0% | 4.0% | $ 0.32 | $ 5.32 |
| P2 | $ 5.32 | 50 | 50 | 0 | 100% | 9.0% | $ *29.57* | −10.0% | −5.0% | 3.0% | $ (0.40) | $ 4.92 |
| 1 | $ 5.00 | 100 | 0 | 0 | 100% | 12.3% | $ *50.95* | 3.9% | 18.9% | 6.5% | $ 0.20 | $ 5.20 |
| 2 | $ 5.20 | 0 | 100 | 0 | 100% | 5.6% | $ *14.65* | 14.3% | 11.2% | 4.4% | $ 0.58 | $ 5.78 |
| 3 | $ 5.78 | 0 | 0 | 100 | 100% | 3.9% | $ *11.52* | | | | $ - | $ 5.78 |
| 4 | | | | | 0% | 0.0% | $ - | | | | $ - | $ - |
| 5 | | | | | 0% | 0.0% | $ - | | | | $ - | $ - |

- **Year** – This column is the current period or year of the experiment. You will play two practice periods (P1 and P2) followed by 20 (1–20) years. You will not be paid for your decisions or the results of the practice period.
- **Beginning Account Balance** – This column keeps track of the amount of money you have at the beginning of each year. To begin the experiment you have been given an endowment of $5.00. The amount of money that you make or lose from your investment decisions each year will be added or subtracted from this balance.
- **% Asset Allocation to: Stocks/Bonds/Cash** – In these three columns you will enter the percentage of your beginning account balance (%) to invest in each of the investments. For example, if you wish to invest 33% of your money in Stocks, 34% in Bonds, and 33% in Cash, you will enter 33 in the Stock column, 34 in the Bond column, and 33 in the Cash column. The cells where you should enter your decisions are highlighted in yellow. These are the only three columns of the spreadsheet into which you will add data. *Note: To insure that your allocations have been entered in a cell, after you typed a number in a cell be sure to hit the "Enter" key.*
- **Total % Allocation (100%)** – This column checks to insure that that total amount of your allocations sums to 100%. If it does not, you will receive an error message asking you to correct your allocations.
- **Expected Portfolio Rate of Return –** Each year you will decide the percentage of your total money you want to invest in each of the three investments. As you enter your allocation decisions into the spreadsheet the program will calculate the "Expected Portfolio Rate of Return (%)" for that year.
    - ○ The Expected Portfolio Rate of Return is based upon the *average* rate of return on each investment from the historical distribution. The average rate of return on Stocks is 11.0%, on Bonds is 8.3%, and on Cash is 6.2%. The Expected Portfolio Rate of Return is calculated by multiplying the average rate of return on an investment by the percentage of your portfolio allocated to this investment. For example, if you allocated 33%/ 34%/33% of your portfolio to Stocks/Bonds/Cash then the expected return on your portfolio is $((0.33*0.11) + (0.34*0.083) + (0.33*0.062)) = 8.5\%$.
    - ○ Note that the expected rate of return on an investment is what the investment will return "on average." The actual return may be significantly higher or lower than this average.

- **Expected Year 20 Portfolio Value** – The spreadsheet will calculate the expected Year 20 portfolio value given your current year asset allocation decisions. This calculation is made by multiplying the current portfolio value by the expected rate of return while taking into account the number of years remaining until Year 20. The formula for this future value calculation is (Beginning Portfolio Value * $(1 + \text{Expected Annual Rate of Return})^{\text{Number of Investment Years Remaining}}$).
    - ○ Again, this calculation is built upon the expected rate of return which can be significantly higher or lower than the historical average. Depending upon the actual rate of return the ending portfolio value may be significantly higher or lower than the forecasted future value.

- **Actual Annual % Return on: Stocks/Bonds/Cash** – After you have made your asset allocation decisions and clicked the "Final Decision" button, the actual annual return for each of the investments will be shown.
- **Annual Return ($)** – This column displays how much money you made or lost for that year depending upon your beginning account balance (BAC), your asset allocations (AA), and the actual return (AR) on each investment. The calculation in this column is: (BAC * AA Stocks * AR Stock) + (BAC * AA Bonds * AR Bonds) + (BAC * AA Cash * AR Cash).

## AN ASSET ALLOCATION TASK

Subjects in the experiment are presented with an asset allocation that is designed to mimic the problem an individual might face in managing an endowment of money over a 20-year time horizon. To begin, a subject is given an endowment. Each "year," the subject must decide how to invest the endowment. The investment options in the experiment include Stocks, Bonds, and Cash. Stocks are represented by the Standard and Poor's 500 Index, bonds are represented by the 10-year U.S. Treasury note, and cash is represented by the one-month U.S. Treasury bill.[10] A spreadsheet is used to facilitate the asset allocation decisions. A sample spreadsheet and an explanation of each column are provided in Table 1.

The asset allocation decision is made by the subject entering a number in the appropriate cell for the chosen investment. For example, if a subject decides to invest 50% of his funds in stocks for that year, he would enter 50 in the Asset Allocation Column for Stocks. The spreadsheet provides checks and error messages to insure that 100% of all monies are invested for a particular year. Once a subject is satisfied with their asset allocation decisions for a particular year, he or she would then click a "Final Decision" button on the spreadsheet. The actual return information for each investment for that year is then added to the spreadsheet and the subject's gain or loss for the year is calculated and displayed. The spreadsheet allows a subject to only enter data into the asset allocation cells for a particular year. All of the other cells are locked and if a subject attempts data entry into another cell then an error message appeared. In addition, the columns of the spreadsheets are color coded to ease reading of the information displayed.

The base experimental task is kept quite simple. The only decision for the subject is the percentage of his or her portfolio to allocate to stocks, bonds, and cash. Each subject made this asset allocation decision at the beginning of each year. Subjects were clearly informed that their compensation in the experiment was tied solely to the performance of the portfolio they constructed during the experiment. Thus, as much as is possible in an experiment of this sort, the experiment was designed to exclude the influence of external factors and have subjects make decisions based upon the internal motivations provided.

## EXPERIMENTAL MANIPULATIONS

Two experimental manipulations are introduced to the asset allocation task. The first manipulation is motivated by the myopic loss aversion problem. The basic problem of myopic loss aversion is that investors do not adopt a long enough time horizon in their investment decision-making and therefore under-invest in risky assets. As discussed earlier, Benartzi and Thaler [1999] found evidence the investors would increase the stock allocations if they were shown hypothetical 30-year stock returns rather than one-year returns. The presumed explanation for this result is that 30 year stock returns can reduce myopia by reducing the amount of perceived or experienced volatility and thus cause investors to hold riskier investments such as stocks.

We hypothesize that myopic loss aversion may be reduced by giving investors future value projections of their portfolios. Future value projections are commonly provided in the end of year retirement account statements sent out by mutual fund companies. A future value projection shows how much an investment will be worth after a certain amount of time and a given rate of return. Such calculations are used extensively in financial planning. For example, TIAA-CREF[11] provides its investors with future value income projection on their year end statements. The calculation will project for the investor what his retirement income will be, given his current level of saving and various annual rates of return. For example, an investor's statement might project that with annual contributions of \$5,000 and 30 years until retirement, the income during the first year of retirement would be \$16,000, \$75,000, or \$160,000, assuming constant annual investment returns of 3%, 9%, or 12%, respectively, and 20 years in retirement.[12] The future value projections highlight the impact of compounded annual returns. We hypothesize that such projections will shift investors' attention from the short term to the long term by emphasizing the payoff that can be earned by accepting the increased volatility that comes with increased risk. Thus future value projections do not change an individual's perception of risk, but rather they focus attention on the payoff that comes from tolerating that risk.

To test this hypothesis, we introduce a future value calculation into the experimental task. As shown in Table 1, a future value projection for a subject is made each year by multiplying the current portfolio value by the expected rate of return, based upon the subject's asset allocation, while taking into account the number of years remaining until Year 20. The subject is told that "this calculation is built upon the expected rate of return which can be significantly higher or lower than the historical average. Depending upon the actual rate of return the ending portfolio value may be significantly higher or lower than the forecasted future value."

The second manipulation introduced into the experiment is to vary the asset returns for the 20 years of the experiment. The subject instructions stated that the returns in the experiment are "generated using the same historical distribution of annual returns" from 1926–2003. To achieve this result, the returns on the experimental assets were the actual market returns on each asset for a consecutive 20-year period drawn from the 1926–2003 time-frame. Since there are 78 years in this time frame, there are 59 possible 20-year return streams to select from. Three out of the 59 possible 20-year return streams were randomly selected. The three periods and the actual assets returns for each year are shown in Table 2. Note that Condition 1 and 2 differ by only two years; condition 1 data begins in 1972 and condition 2 begins in 1970.[13] Also noteworthy is that the average return on stocks in condition 3 is 8.08%, well below the historical average of 12.3%. Varying the asset returns allows for a more comprehensive investigation of how gains and losses affect repeated asset allocation decisions.

The experiment is a 2 × 3 design with six experimental conditions. The between subject experimental design compares subjects who receive future value information with those that do not (FV vs. NFV), and compares subjects in three different return stream conditions (1960, 1970, 1972). Ten subjects participated in each condition (FV × RS).

## EXPERIMENT

Subjects were recruited through an advertisement sent out through the campus mail to all University of Nevada, Reno staff employees, a total of approximately 1,400 employees. The flyer stated that a subject could earn between \$5.00 and \$50.00, depending upon performance for participation in a one hour experiment on investment decision making. Sixty subjects signed up to participate in the experiment.

The experiment was conducted in the Nevada Experimental Economics Laboratory. The laboratory consists of 12

TABLE 2
Asset Returns in Experiment.

| Condition 1 | | | | Condition 2 | | | | Condition 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | S&P 500 | T-BONDS 10 Year | T-BILLS | Year | S&P 500 | T-BONDS 10 Year | T-BILLS | Year | S&P 500 | T-BONDS 10 Year | T-BILLS |
| 1972 | 18.99% | 2.39% | 4.23% | 1970 | 3.94% | 18.92% | 6.50% | 1960 | 0.48% | 11.21% | 2.81% |
| 1973 | −14.69% | 3.30% | 7.29% | 1971 | 14.30% | 11.24% | 4.36% | 1961 | 26.81% | 2.20% | 2.40% |
| 1974 | −26.47% | 4.00% | 7.99% | 1972 | 18.99% | 2.39% | 4.23% | 1962 | −8.78% | 5.72% | 2.82% |
| 1975 | 37.23% | 5.52% | 5.87% | 1973 | −14.69% | 3.30% | 7.29% | 1963 | 22.69% | 1.79% | 3.23% |
| 1976 | 23.93% | 15.56% | 5.07% | 1974 | −26.47% | 4.00% | 7.99% | 1964 | 16.36% | 3.71% | 3.62% |
| 1977 | −7.16% | 0.38% | 5.45% | 1975 | 37.23% | 5.52% | 5.87% | 1965 | 12.36% | 0.93% | 4.06% |
| 1978 | 6.57% | −1.26% | 7.64% | 1976 | 23.93% | 15.56% | 5.07% | 1966 | −10.10% | 5.12% | 4.94% |
| 1979 | 18.61% | 1.26% | 10.56% | 1977 | −7.16% | 0.38% | 5.45% | 1967 | 23.94% | −2.86% | 4.39% |
| 1980 | 32.50% | −2.48% | 12.10% | 1978 | 6.57% | −1.26% | 7.64% | 1968 | 11.00% | 2.25% | 5.49% |
| 1981 | −4.92% | 4.04% | 14.60% | 1979 | 18.61% | 1.26% | 10.56% | 1969 | −8.47% | −5.63% | 6.90% |
| 1982 | 21.55% | 44.28% | 10.94% | 1980 | 32.50% | −2.48% | 12.10% | 1970 | 3.94% | 18.92% | 6.50% |
| 1983 | 22.56% | 1.29% | 8.99% | 1981 | −4.92% | 4.04% | 14.60% | 1971 | 14.30% | 11.24% | 4.36% |
| 1984 | 6.27% | 15.29% | 9.90% | 1982 | 21.55% | 44.28% | 10.94% | 1972 | 18.99% | 2.39% | 4.23% |
| 1985 | 31.73% | 32.27% | 7.71% | 1983 | 22.56% | 1.29% | 8.99% | 1973 | −14.69% | 3.30% | 7.29% |
| 1986 | 18.67% | 22.39% | 6.09% | 1984 | 6.27% | 15.29% | 9.90% | 1974 | −26.47% | 4.00% | 7.99% |
| 1987 | 5.25% | −3.03% | 5.88% | 1985 | 31.73% | 32.27% | 7.71% | 1975 | 37.23% | 5.52% | 5.87% |
| 1988 | 16.61% | 6.84% | 6.94% | 1986 | 18.67% | 22.39% | 6.09% | 1976 | 23.93% | 15.56% | 5.07% |
| 1989 | 31.69% | 18.54% | 8.44% | 1987 | 5.25% | −3.03% | 5.88% | 1977 | −7.16% | 0.38% | 5.45% |
| 1990 | −3.10% | 7.74% | 7.69% | 1988 | 16.61% | 6.84% | 6.94% | 1978 | 6.57% | −1.26% | 7.64% |
| 1991 | 30.46% | 19.36% | 5.43% | 1989 | 31.69% | 18.54% | 8.44% | 1979 | 18.61% | 1.26% | 10.56% |
| Average | 13.31% | 9.88% | 7.94% | | 12.86% | 10.04% | 7.83% | | 8.08% | 4.29% | 5.28% |

networked personal computer stations. Each station is separated by large partitions such that a subject cannot see the computer station of another subject. Upon arriving at the laboratory, each subject took a seat at a station and received a copy of the human subject consent form and condition instructions. After all subjects for the session arrived the experiment commenced.

The experiment began with the reading aloud of the consent form and instructions. After consent was obtained, each subject received a $5.00 show-up fee. Since the recruitment flyer stated that subjects would receive a minimum compensation of $5.00, the show-up fee was given to fulfill this promise. Subjects were then told that any further compensation in the experiment was contingent on their performance in an asset allocation task.

The procedure of the asset allocation task was then explained. Table 3 provides the information given to subjects regarding the potential return on the assets in the task. To explain the statistical information contained in the table the subjects were told that for "stocks – the annual return on stocks has averaged 12% over the last 78 years. One year the return on stocks was as high as 53% and another year as low as (negative) −44%. The majority of the annual returns on stocks fell within one standard deviation of the average, or between −8% and 32%." To explain how the actual returns would be generated in the experiment the subjects were told: "[I]n this experiment the annual returns on stocks, bonds, and cash will be generated using the same historical distribution of annual returns shown in Table 1. Thus, while past performance is no guarantee of future results, the annual returns on stocks, bonds, and cash in this experiment will be similar to those produced over the last 78 years."

After all the instructions were read and questions answered, the subjects then made allocation decisions for two practice periods. The subjects could then ask any remaining

TABLE 3
Asset Return Information Given to Subjects.

| | Stocks* | Bonds** | Cash*** |
|---|---|---|---|
| Average | 12% | 6% | 4% |
| Standard Deviation | 20% | 9% | 3% |
| Minimum | −44% | −8% | 0% |
| Maximum | 53% | 44% | 15% |

*Stocks – Measured by the Standard & Poor's 500 Index. The S&P 500 is "Widely regarded as the best single gauge of the U.S. equities market, this world-renowned index includes a representative sample of 500 leading companies in leading industries of the U.S. economy. Although the S&P 500 focuses on the large-cap segment of the market, with over 80% coverage of U.S. equities, it is also an ideal proxy for the total market" (http://www2.standardandpoors.com).

**Bonds – Measured by the 10-year U.S. Treasury Note. "Treasury bills, notes, and bonds are marketable securities the U.S. government sells in order to pay off maturing debt and raise the cash needed to run the federal government. When you buy one of these securities, you are lending your money to the U.S. government" (http://www.publicdebt.treas.gov).

***Cash – Measured by the one-month U.S. Treasury Bill rate. "Treasury bills are short-term obligations issued with a term of one year or less" (http://www.publicdebt.treas.gov).

questions answered prior to beginning. Each subject then proceeded at his or her own pace in making the asset allocation decisions for the 20 years. Most subjects took approximately 25 minutes to make all of their decisions. After all the decisions were completed, each subject filled out a short questionnaire and a receipt documenting their earnings. Each subject then walked to the front of the room where they were paid individually and anonymously in cash for their performance, thanked, and dismissed from the laboratory.

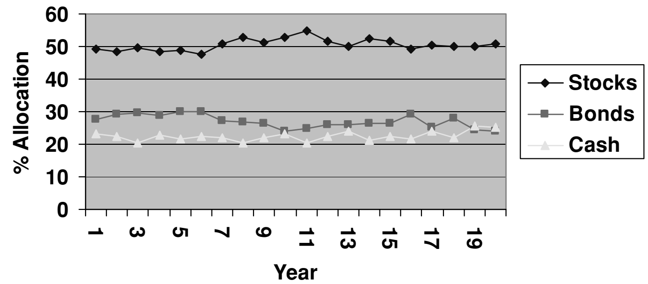


FIGURE 2 Mean percentage allocation to stocks, bonds, and cash by year.

## RESULTS

The results section is organized as follows. We begin by describing the demographics of subject population and their self reported knowledge and experience with investing. Next, the data are analyzed at the aggregate level to describe the mean characteristics of the portfolios created. The subject portfolios are then plotted on the efficient frontier for the assets available in the experiment. ANOVA models are used to test for between subject differences across the experimental conditions. Regression models are then presented to explain the variables impacting the construction of portfolios. We conclude with an analysis of a survey questionnaire that subjects filled out at the end of the experiment.

### Sample Demographics

Sixty subjects participated in the asset allocation task. The population ranges in age from 20 to 63, the mean age is 38.5 years with 16 subjects under the age of 25 and 35 subjects over the age of 35.[14] Sixty six percent of the population is female, 48% report having investments in a defined benefit plan, 34% report having investments in a defined contribution plan, and 36% indicate they had an IRA account separate from their employer.[15] Sixty three percent of the subjects are employed at the University and 39% are students. The mean response to the question "[H]ow much experience do you have in making investment decisions similar to those in this experiment" is 3.42 on a 7 point Likert scale.

#### *Mean Portfolios*

The mean percentage allocation to stocks, bonds, and cash and the associated standard deviations across subjects and years are shown in Figure 2 and Table 4. Across subjects the mean asset allocation is 51% stocks, 27% bonds, and 22% cash (please refer to Table 5). Forty three percent of subjects (26/60) allocated between 40% and 60% of their portfolio to the stock fund. The most frequent allocation to the bond fund is between 25% and 45%, and 10% to 35% is the most frequent cash allocation. Thirteen percent of subjects (8/60) allocated more than 75% to stocks. These stock allocations are roughly consistent[16] with results reported by TIAA-CREF[17] (Rugh [2003]).

Most subjects allocated significantly more of their money to stocks than to bonds or cash. The average ratio of stocks to bonds is calculated for each subject and shown in the last column of Table 5. Only 8 of 60 subjects (13%) allocated more to bonds than stocks. Thirty seven percent of subjects allocated at least twice as much to stocks than bonds. These results are not consistent with the 1/n naïve diversification strategy reported by Benartzi and Thaler [2001]. Subjects clearly did not choose to allocate their money one-third, one-third, one-third to stocks, bonds, and cash.

As seen in Figure 2, there is no significant change in allocations across time. Recall that the time diversification argument suggests that as the time horizon shortens asset allocations will become more conservative. While there are no clear trends across subjects we will test these hypotheses at the individual level.

TABLE 4
Mean Percentage Allocation to Stocks, Bonds, and Cash by Year.

| Year | Stock Mean | Stock STD | Bond Mean | Bond STD | Cash Mean | Cash STD |
|---|---|---|---|---|---|---|
| Practice1 | 51.0 | 22.5 | 28.7 | 13.8 | 20.3 | 15.7 |
| Practice2 | 48.8 | 22.0 | 33.2 | 20.3 | 18.0 | 17.4 |
| 1 | 49.3 | 23.5 | 27.5 | 14.4 | 23.2 | 22.3 |
| 2 | 48.4 | 24.1 | 29.2 | 12.9 | 22.5 | 21.2 |
| 3 | 49.7 | 21.7 | 29.8 | 13.2 | 20.6 | 19.8 |
| 4 | 48.5 | 25.8 | 28.7 | 18.1 | 22.8 | 21.3 |
| 5 | 48.7 | 25.6 | 29.9 | 18.5 | 21.5 | 20.2 |
| 6 | 47.8 | 26.3 | 30.0 | 18.3 | 22.2 | 22.5 |
| 7 | 50.8 | 25.7 | 27.3 | 17.9 | 22.0 | 23.1 |
| 8 | 52.7 | 24.0 | 26.8 | 17.1 | 20.6 | 18.8 |
| 9 | 51.3 | 24.0 | 26.5 | 19.0 | 22.2 | 20.2 |
| 10 | 52.6 | 23.1 | 24.2 | 17.5 | 23.2 | 20.2 |
| 11 | 55.0 | 24.1 | 24.7 | 17.5 | 20.3 | 19.6 |
| 12 | 51.7 | 25.5 | 26.1 | 16.6 | 22.2 | 20.7 |
| 13 | 49.8 | 27.2 | 26.0 | 17.8 | 24.2 | 23.1 |
| 14 | 52.3 | 22.8 | 26.4 | 16.6 | 21.3 | 17.7 |
| 15 | 51.5 | 25.5 | 26.3 | 19.3 | 22.3 | 19.9 |
| 16 | 49.4 | 26.7 | 29.2 | 20.0 | 21.4 | 22.3 |
| 17 | 50.6 | 23.2 | 25.3 | 14.3 | 24.1 | 22.0 |
| 18 | 49.9 | 24.2 | 27.9 | 15.4 | 22.2 | 20.3 |
| 19 | 50.0 | 25.5 | 24.4 | 13.7 | 25.6 | 23.9 |
| 20 | 50.8 | 27.8 | 24.0 | 18.8 | 25.2 | 26.2 |

TABLE 5
Average Asset Allocation by Subject across Years.

| Subject | Average % Allocation to: Stocks | Bonds | Cash | Ratio of Stocks/Bonds | Subject | Average % Allocation to: Stocks | Bonds | Cash | Ratio of Stocks/Bonds |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 80 | 10 | 11 | 8.4 | 31 | 40 | 30 | 30 | 1.3 |
| 2 | 52 | 36 | 12 | 1.5 | 32 | 80 | 18 | 3 | 4.5 |
| 3 | 86 | 7 | 7 | 12.3 | 33 | 70 | 25 | 6 | 2.8 |
| 4 | 20 | 30 | 50 | 0.7 | 34 | 38 | 31 | 31 | 1.2 |
| 5 | 46 | 28 | 26 | 1.6 | 35 | 8 | 81 | 12 | 0.1 |
| 6 | 31 | 29 | 40 | 1.1 | 36 | 45 | 21 | 34 | 2.1 |
| 7 | 43 | 38 | 19 | 1.1 | 37 | 57 | 19 | 25 | 3.0 |
| 8 | 54 | 35 | 11 | 1.5 | 38 | 52 | 17 | 31 | 3.1 |
| 9 | 70 | 13 | 17 | 5.5 | 39 | 42 | 32 | 26 | 1.3 |
| 10 | 95 | 4 | 2 | 27.1 | 40 | 48 | 30 | 22 | 1.6 |
| 11 | 40 | 31 | 30 | 1.3 | 41 | 51 | 45 | 5 | 1.1 |
| 12 | 31 | 28 | 41 | 1.1 | 42 | 78 | 14 | 9 | 5.7 |
| 13 | 54 | 22 | 24 | 2.5 | 43 | 32 | 27 | 41 | 1.2 |
| 14 | 44 | 56 | 0 | 0.8 | 44 | 88 | 12 | 0 | 7.3 |
| 15 | 44 | 32 | 25 | 1.4 | 45 | 43 | 34 | 23 | 1.3 |
| 16 | 42 | 44 | 14 | 1.0 | 46 | 31 | 28 | 41 | 1.1 |
| 17 | 68 | 25 | 6 | 2.7 | 47 | 28 | 26 | 46 | 1.1 |
| 18 | 9 | 6 | 84 | 1.4 | 48 | 83 | 12 | 6 | 7.0 |
| 19 | 31 | 46 | 23 | 0.7 | 49 | 67 | 19 | 14 | 3.6 |
| 20 | 34 | 34 | 33 | 1.0 | 50 | 62 | 14 | 24 | 4.4 |
| 21 | 21 | 24 | 55 | 0.9 | 51 | 61 | 38 | 1 | 1.6 |
| 22 | 30 | 29 | 41 | 1.0 | 52 | 59 | 29 | 13 | 2.0 |
| 23 | 80 | 14 | 6 | 5.7 | 53 | 60 | 31 | 10 | 1.9 |
| 24 | 19 | 13 | 68 | 1.5 | 54 | 51 | 32 | 17 | 1.6 |
| 25 | 29 | 38 | 34 | 0.8 | 55 | 47 | 27 | 26 | 1.8 |
| 26 | 56 | 35 | 10 | 1.6 | 56 | 73 | 21 | 6 | 3.6 |
| 27 | 46 | 26 | 28 | 1.8 | 57 | 71 | 13 | 15 | 5.3 |
| 28 | 64 | 28 | 9 | 2.3 | 58 | 47 | 27 | 27 | 1.8 |
| 29 | 38 | 32 | 30 | 1.2 | 59 | 48 | 26 | 26 | 1.8 |
| 30 | 71 | 23 | 7 | 3.1 | 60 | 47 | 30 | 23 | 1.6 |
| | | | | | Average | 51% | 27% | 22% | 3.1 |

### *Efficient Frontier*

Individual subject portfolios are next described by their expected return and standard deviation. Figure 3 shows the efficient frontier for the three assets used in this experiment.[18] The efficient frontier is the *efficient set* of portfolios. Each portfolio in this set is the best combination of expected return and standard deviation given the underlying assets available. The portfolio with the highest expected return of 12.3% requires a 100% asset allocation to stocks and has a portfolio standard deviation of 20.3%. The portfolio with the lowest standard deviation of 3.1% requires an asset allocation of 2% stocks, 2% bonds, and 96% cash and has an expected return of 4.1%. Note that there is no true risk-free asset available in this experiment and hence the efficient frontier does not intersect with the vertical axis (please refer to Figure 3).

Figure 4 plots all of the subject portfolios onto the efficient frontier. As expected, given the assets used in the experiment, the subject portfolios generally fall quite close to the efficient frontier. For example, in year 1 Subject 1 held a portfolio of 80% stocks, 10% bonds, and 10% cash. The expected return on this portfolio is 10.80% and the standard deviation is 16.38%. There is a portfolio on the efficient frontier that provides an expected return of 10.83% with a standard deviation of 16.27%. There are a few portfolios with expected returns between 5% and 7% that are relatively inefficient, suggesting that there is room for improvement in the choice set of assets made available to the subjects. The graph also shows that subject portfolios were spread out across the entire range of the frontier, but with strong clustering in the lower to middle end of the frontier.

### *Between Subject Differences*

We first test for whether subjects in the different experimental conditions constructed significantly different portfolios. To test for differences between subjects the General Linear Model is used. Since a portfolio of three assets can be described by either the expected return or the standard deviation of the portfolio, we run the models with these two different dependent variables. Three classification variables are included in the model: 1) whether the subject received the year 20 future value calculations (FV or NFV), 2) which historical return stream did the subject experience (RS1972,

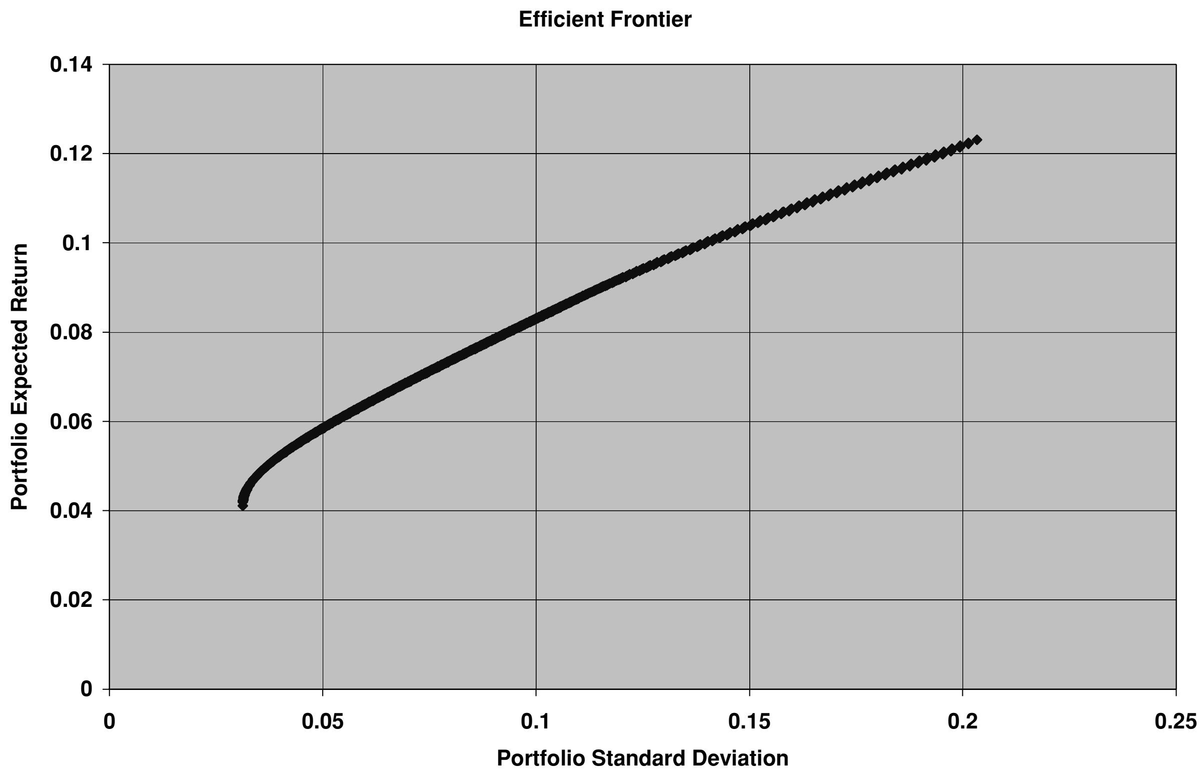


FIGURE 3 Efficient frontier.

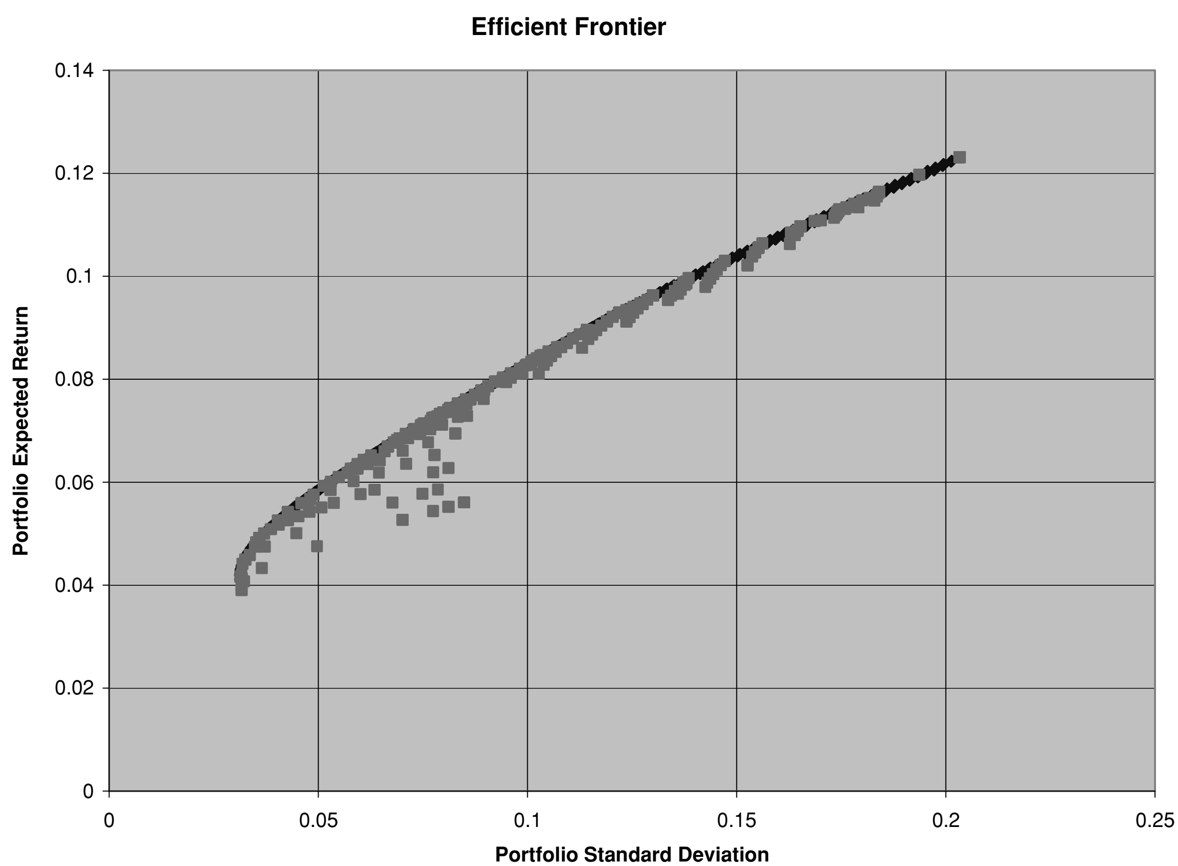


FIGURE 4 Efficient frontier with subject portfolios.

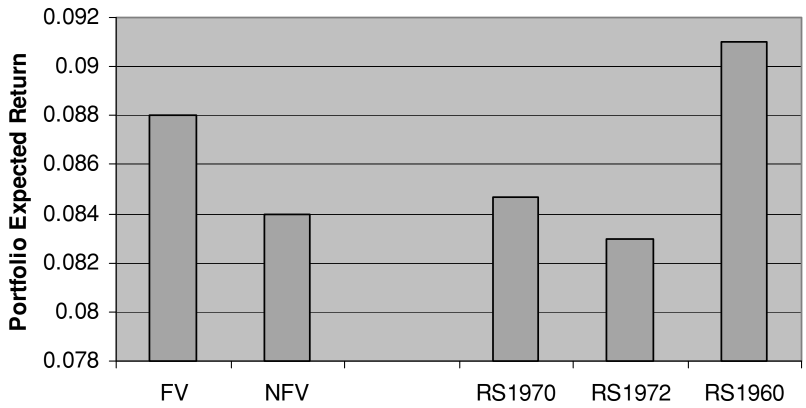


FIGURE 5 Portfolio expected return by condition.

RS1970, RS1960), and 3) the interaction effect of these two variables. The results are shown in Table 6 and Figure 5. With either portfolio expected return or portfolio standard deviation as the dependent variable, all three classification variables are significant. As seen in Figure 5, subjects who received the future value calculation created portfolios with higher expected return (and higher standard deviation) compared to subjects who did not receive this calculation. Subjects who experienced asset returns in 1960–1979 also created portfolios with higher expected return.

The average allocations to stocks, bonds and cash in the different experimental conditions are shown in Figure 6. In the FV condition the average allocation is 53% stocks, 24% bonds, and 23% cash, versus an allocation of 48% stocks, 30% bonds, and 22% cash in the NFV condition. On average subjects who received the future value calculations increased their allocation to stocks by 5% and decreased their allocation to bonds by 6%. On average subjects in the condition that received asset returns from 1960–1979 increased their allocations to stocks 8–10% and reduced their allocations to cash by a similar amount compared to subjects who experienced asset returns beginning in 1970 or 1972.

### *Variables Affecting Portfolio Construction*

The next set of analyses attempts to explain the variables that significantly impact portfolio construction. Since a portfolio can be described based upon the expected return and standard deviation of the portfolio, and also based upon the underlying assets in the portfolio, a series of regressions were run. We begin with analyses using the expected return and standard deviation of the portfolio as the dependent variables. The set of explanatory variables used in the regression model are shown in Table 7 and included: a dummy for gender (1 = male, 0 = female); an indicator for age; a self-reported survey measure of risk tolerance; an indicator for the existence (or lack of) of information on the expected future value of the portfolio; a dummy variable for the last period (to capture potential reversals in behavior at the end of the horizon); a dummy for the last two periods (with a similar idea); a dummy for positive returns in the previous period (to capture the degree of inertia); a self-reported indicator of experience in dealing with stocks; and dummies to identify the return stream experimental condition (i.e., 1970, 1972, 1960). These variables can be classified into two main categories as shown in Table 7.

Given space limitations, we will only comment briefly on the results stemming from the regression exercises. The variables that came up statistically significant at the 5% level to explain both the expected return and the standard deviation of the portfolio were: gender (being a male is associated with slightly higher expected returns and portfolio variance), age

TABLE 6
Statistical Tests for Condition Effects.

| Classification Variables | DV = Expected Return | | DV = Portfolio Standard Deviation | |
|---|---|---|---|---|
| | F Value | Pr > F | F Value | Pr > F |
| Future Value | 9.34 | 0.0023 | 10.61 | 0.0012 |
| Return Stream | 18.41 | 0.0001 | 15.80 | 0.0001 |
| FV*RS | 22.77 | 0.0001 | 29.51 | 0.0001 |

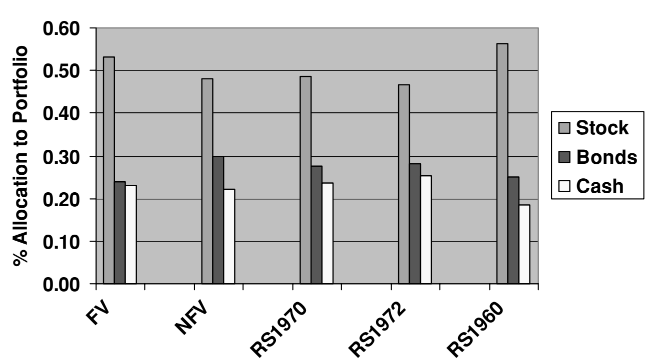


FIGURE 6 Portfolio asset allocation by condition.

TABLE 7
Regression Model Variables for Portfolio ER and STD.

Dependent Variables:
- Portfolio Expected Return
- Portfolio STD

Explanatory Variables

| Demographic and Dispositional Factors | Situational Factors |
|---|---|
| • Age | • FV Calculations |
| • Gender | • Return Stream (Block effects) |
| • Self-reported Risk Aversion (Risk tolerance category indicator) | • Last period effect dummy |
| • Self-reported Experience in dealing with stocks | • Last two periods effect dummy |
| | • Previous period positive returns dummy |

TABLE 8
Regression Model Variables for Stocks and Bonds.

Dependent Variables:
- Share of stocks in the portfolio
- Share of bonds in the portfolio

Explanatory Variables

| Demographic and Dispositional Factors | Situational Factors |
|---|---|
| • Age | • FV Calculations |
| • Dummy for people 40 and over | • Return Stream (Block effects) |
| • Gender | • Last period effect dummy |
| • Self-reported Risk Aversion (Risk tolerance category indicator) | • Last two periods effect dummy |
| • Self-reported Experience in dealing with stocks | • Previous period positive returns dummy |

(older people hold portfolios with slightly higher expected returns and portfolio variance), the existence of information of the expected future value of the portfolio (subjects who were given projected future values of the portfolio chose allocations with slightly higher expected returns and portfolio variance, relative to subjects without the same information), and the risk tolerance category indicator. In all those cases, the quantitative effect was positive and very small. Only one variable produced a negative effect (on both the expected return and the standard deviation of the portfolio): the dummy variable for positive returns in the previous period. Once again, the quantitative effect was very small (−0.01). All the remaining explanatory variables came up to be statistically insignificant at standard levels. In conclusion, all but one of the demographic and dispositional factors played a statistically significant role in explaining both the expected return and the standard deviation of the portfolio (the exception being the self-reported experience indicator), but only two of the situational factors turned up to be statistically significant in accounting for the changes in the portfolio's expected return and standard deviation: the dummy for existence of information on the future expected value of the portfolio and the dummy for positive returns in the previous period.

Using the findings from this first set of regressions, a second set of regressions was run replacing the dependent variables of portfolio expected return and standard deviation with the proportion of stocks and bonds in the portfolio. Table 8 presents a summary of the variables used in these regressions.

The first interesting finding is the influence of age.[19] Across individuals the share of stocks reaches a maximum at age 45 and then declines almost imperceptibly (−0.02% per each additional year of age) as the individuals reach age 60, the maximum age in the sample. All in all, this finding is in line with the evidence reported in Guiso et al. [1996], who found that the share of risky assets increased with age for a cross-section of Italian households. Before controlling for other determinants of the share of stocks in the portfolio, each additional year of age increases the share of stocks 2% up to year 45 (p-value = 0.16) and then decreases the share of stocks 0.02% every year until year 60 is reached (p-value = 0.23). However, when other relevant determinants of the share of stocks in the portfolio (refer to Table 8) are included in the regression, the effect of the variable Age remains statistically significant at the 5% level but becomes very small quantitatively (an increment of one-year leads to a 0.4 of a percentage point increase). The effect is even smaller for the share of bonds (an increment of 1 year leads to a 0.16 of a percentage point increase).

Another interesting and related finding is connected to the influence of a dummy variable reflecting the behavior of the people over 40 years of age. In that case, the influence is not only statistically significant at the 1% level for both stocks and bonds but also strong quantitatively after controlling for other relevant factors affecting the share of stocks; people 40 or older hold, on average, 8 extra percentage points of their portfolios in the form of stocks. The effect is less quantitatively strong in the case of bonds, but still important: 40+ people hold 4.5 extra percentage points of their portfolio in the form of bonds relative to people in the 40- group. Figure 7 summarizes the findings on the influence of being over 40 on the percentage of stocks held in the portfolio.

The result summarized in Figure 7 may seem somewhat surprising, but it may be explained by the interaction of pre-existing DB plans with the asset allocations of the 40+

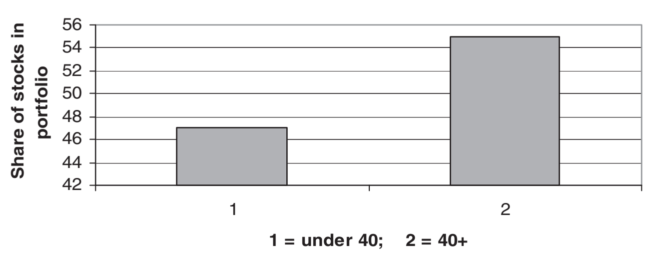


FIGURE 7 Share of stocks for people over and under 40.

people (Reichenstein [1998]).[20] DB plans are in essence "large bonds" in an individual's extended portfolio –the extended portfolio includes the DB plan and the 401(k) account, and so an individual should hold a larger share of stocks if (s)he has a DB plan than if (s)he does not. In our experiments, the after task surveys revealed that 48% of the experiments' participants had DB plans. Furthermore, 30% of that 48% were 40+ people. Therefore, if the existence of DB plans affected the individuals' experimental decisions –in spite of the fact that they were instructed to just follow the experiment's rules, which did not include DB plans—then almost two-thirds of the effect of the 40+ dummy variable on the share of stocks could be attributed to 40+ people also having a DB retirement plan (64% = (0.48*0.30)*100). Indeed, when an interaction variable involving the dummy variable for people over 40 years of age and a dummy variable identifying people with a DB plan in real life is introduced in the regressions, both the dummy for Age and the interaction variable have strong positive impacts (7% and 5.5%, respectively) on the share of stocks, effects that are statistically significant at the 5% level.

The effect of financial experience is another likely explanation for the effect of 40+ people on the allocations to stocks, but in the present case a measure for the (self-reported) financial experience of the participants drawn from the after task survey comes up with a statistically significant (at the 5% level) negative effect on the share of stocks when included in the regressions. The effects of age on stocks' allocations deserve further investigation.

A second interesting finding is that projected portfolio future value information had a significant impact on asset allocation. Subjects that received the future value information created portfolios with a higher percentage of stocks and a lower percentage of bonds, and the effect was statistically significant at the 1% level and quantitatively strong. Providing information on projected portfolio future values raises the asset allocation to stocks by some 5–7 percentage points (depending on the composition of the vector of explanatory variables), and it reduces the share of bonds in the portfolio by a similar amount.

Other interesting regression findings included: 1) an increase in the self-reported risk tolerance level led to an increase in the percentage of stock held in the portfolio; 2) there was a negative correlation between self reported investment experience and the percentage of stock in the portfolio; and 3) a positive return of stocks in the previous year decreased the holdings of stocks in the typical portfolio by some 6 percentage points. Readers interested in these results are asked to contact the authors directly.

### *Questionnaire Results*

At the conclusion of the asset allocation task the subjects were asked to fill out a questionnaire. In addition to collecting basic demographic information, the subjects were asked

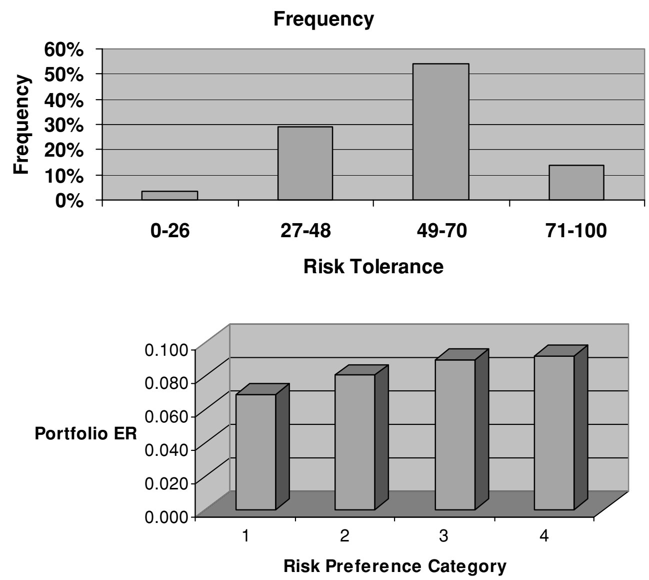


FIGURE 8 Risk tolerance questionnaire results.

all the questions on the TIAA-CREF Risk Questionnaire. The questionnaire is contained in the Appendix. Subjects responded to six questions designed to ascertain their attitude toward risk, their desire for high investment returns, their attitude toward investment gains and losses, and which of several investments they would be most comfortable with. The scoring guidelines for the Risk Questionnaire given by TIAA-CREF indicate that if the summation of the responses on the six questions is between 0 and 26, then the respondent would probably prefer a *conservative* portfolio; responses from 27–48 suggest a *moderately conservative* portfolio; responses from 49–70 suggest a *moderately aggressive* portfolio; and responses between 71 and 100 suggest an *aggressive* portfolio. As seen in Figure 8, 54% of subjects in this experiment fell into the moderately aggressive category, 29% into the moderately conservative category, 14% into the aggressive category, and only 3% in the conservative category. While the survey responses were positively correlated with the expected return on a subject's portfolio ($r = 0.33$, $p < 0.01$), the strength of the relationship was relatively weak, suggesting a weak relationship between a subject's attitude and behavior.

## DISCUSSION

The intent of this paper was to examine in an experimental framework how well subjects do in an asset allocation task, which is one important component in the management of one's retirement assets. The results of this research both confirm and deny some of the problems that are thought to confound investors.

In this experiment most subjects tended to allocate the majority of their portfolios to stocks. Although there was some variance at the individual level, subjects generally invested twice as much in stocks compared to bonds or cash. Given the historical returns of the assets used in this experiment, this finding is consistent with reasonable investment behavior, in the sense that the subjects clearly understood that stocks had outperformed other asset classes over the last 78 years and thus are a good investment choice in terms of expected returns. There was no evidence to confirm the naïve diversification theory since subjects did not blindly allocate one-third of their portfolio to each asset.

Subjects in the experiment tended to pick an allocation policy early on and stick with it. This finding is contrasted with the evidence that once most employees make their initial allocation decision in a defined contribution plan they rarely make any changes in their account. There is an important distinction to be made regarding the effects of these inertia decisions. An investor who never changes his allocation policy but must annually choose how to allocate his entire portfolio will always end up with a portfolio allocation equal to his policy. In contrast, an investor who makes an initial allocation decision but never rebalances the account will end up with a portfolio that is more heavily weighted in the best performing asset class. A question for future research is whether defined contribution plan participants understand this distinction. It may be that when investors make their initial asset allocation decisions, they naively believe that their account will automatically remain at this allocation. A simple remedy to this problem is to give investors the choice to have their accounts automatically rebalanced to their initial allocation decision on some set time schedule.

Subjects did not lower their allocations to stocks as the end of the exercise approached. This finding is consistent with the theories of Samuelson [1969] that investors should be willing to hold the same portfolio across time. These results are inconsistent with the time diversification argument since the subjects did not significantly change their allocations as the end of the investment horizon approached.

Another important aspect of this experiment was to assess whether giving subjects future value information would alter asset allocation. Subjects in the condition that received future value calculations did allocate more (about 5%) to stocks than subjects who did not receive such information. While the reason for this finding is debatable, the following explanation is offered. It is likely that most individuals do not appreciate the power of compounding and the effect that it can have on long-term investments. Thus when subjects are given a future value calculation they come to appreciate how small changes in expected return can lead to large increases in end states of wealth. But subjects are also aware that additional expected return comes with additional risk. The future value information combines with a subject's preference for risk and leads to small adjustments in allocation policy.

The historical return stream (1960, 1970, 1972) that subjects experienced affected asset allocation and portfolio construction. On average, subjects in the 1960 condition allocated a higher percentage (about 6–8%) to stocks than subjects in the 1970 and 1972 conditions. This finding is likely a result of the fact that the average return of stocks in the 1960 condition was significantly lower (8.08%) than in the other two conditions (13.31% and 12.86%).[21] The low returns in the 1960 condition may have induced subjects to search for higher returns and accept more risk leading them to increase their holdings of stocks. Also, as previously reported, subjects tended to decrease (increase) their holding of stocks by about 6% after a positive (negative) return of stocks in the prior year. Since the subjects in the 1960 condition experienced more negative return years (6 years) compared to the 1972 and 1970 (5 and 4, respectively) conditions, this contributed to the higher stock holdings in this condition. Behaviorally, this result may be partially explained by the gambler's fallacy bias (Estes [1964], Croson and Sundali [2005]). The gambler's fallacy is a belief in a negative autocorrelation in a nonautocorrelated random sequence. For example, a roulette player who believes in the gambler's fallacy is more likely to bet red after a series of black outcomes have just occurred. Subjects in the experiment could be changing their asset allocations on the belief that a positive (negative) return on stocks is more likely after a negative (positive) return has just occurred.

The efficiency of subjects' portfolios was quite high. This was likely a result of the fact that almost any combination of the assets used in this experiment results in a relatively efficient portfolio. However, this finding is important on another level. It would be naïve to think that the average investor has an appreciation of the MV problem and the elegant solution provided by the efficient frontier. The fact that subjects did create portfolios on the frontier suggests that with proper financial engineering the investors' burden can be greatly reduced. This leads to our final point.

If employers and government pension providers are going to continue the shift away from DB plans and into DC plans, then the challenge is to financially engineer DC pension plans to minimize the negative impacts on investors. Along those lines, two results from this experiment are relevant. First, efficient portfolios are more easily created when the set of assets to choose from is carefully constructed. Thus, financial engineers should be given the responsibility for choosing the assets available to plan participants and ensuring that combinations of these assets will fall on the efficient frontier. If followed, this advice would likely significantly reduce the amount of individual company stock offered in DC plans in place of well-constructed low cost index funds from multiple asset classes. Second, if the assets selected for inclusion in DC plans allow the investor to easily create portfolios on the efficient frontier, then the challenge for the investor is not how to get onto the frontier but where to locate on the frontier. We believe that designing instruments to help investors accurately assess their risk tolerance and locate themselves on the efficient frontier is a critical task for future research.

Our results suggest additional avenues for research in behavioral finance. First, the design of our experimental task could be extended by including additional asset classes typically found in retirement accounts such as international equity investments and real estate investment trusts. Subjects could also be given the option to invest in lifecycle funds that provide automatic asset allocation. Further basic research is necessary to explore and better explain why future value information affects asset allocation. We suspect the result is connected to the causes of myopic loss aversion but there may be alternative mechanisms at play. Additional applied research is necessary to develop instruments to measure risk tolerance and to locate investors on the efficient frontier. Finally, more research is necessary to explain why subjects over 40 years of age held higher concentrations of stock than younger investors.

The strength of laboratory studies is the internal validity they provide and the ability to control and test for certain effects. We believe this experiment provides strong experimental evidence that knowledge of future values affects asset allocation. The challenge of laboratory studies is in making appropriate generalizations from the lab to the field (Levitt and List [2007]). We caution readers that when investors make actual asset allocation decisions a host of uncontrolled variables are relevant and influential in the decision-making process. For example, in making optimal asset allocation decisions investors must consider how assets are distributed across taxable and tax-deferred accounts (Dammon et al. [2004], Reichenstein [1998]), a consideration that was not relevant in the current experiment and should affect actual allocations. Likewise, some of the experimental results connected to the impact of the variable Age on the share of stocks in the portfolio seem to suggest that holding constant the existence of DB plans in the subject's actual life may pose a difficult problem. Thus, readers should be mindful of the additional intervening variables that must be considered when generalizing these laboratory results into the field.

## ACKNOWLEDGMENTS

The authors would like to thank Kevin Kneafsey and Rahul Bhargava for significant assistance in the development of this paper. We also thank an anonymous reviewer for insightful comments and suggestions.

## NOTES

1. Professionally managed accounts include state and local government pension plans, private defined benefit plans, federal pension plans, and annuities. Individually managed monies include IRAs and defined contribution pension plans.
2. Under a defined benefit plan the employer agrees to the amount of the benefits to be paid and bears the responsibility to fund this liability. The employer makes the decisions on how to invest money to fund this liability and bears the risk of the performance resulting from these investment decisions.
3. Under a defined contribution plan the employer agrees to contribute a specified amount toward employee retirement. The decision of how to invest that money, and the risk of the performance resulting from the investment decision is borne by the employee.
4. The MV model implies that investors behave as if they had quadratic utility functions over the relevant range, or that returns are normally distributed.
5. Waring [1994] was among the first to argue that mean-variance optimization could be used to structure 401(k) retirement plans.
6. An index is a portfolio of assets selected according to some established criteria. An index *fund* is a real mutual fund that buys assets, such as stocks or bonds, and holds them in a portfolio that approximates the index. The most widely followed index is the Standard and Poor's 500, and the best known index fund is the Vanguard 500 from The Vanguard Group, which tracks the S&P 500 (http://www.moneychimp.com/articles/index_funds/overview.htm).
7. An investor's optimal asset allocation policy will also depend upon whether assets are held in taxable or tax-deferred accounts (Dammon et al. [2004], Reichenstein [1998]). When tax consequences and after-tax spending needs are taken into account investors generally should hold taxable bonds in tax-deferred accounts and equity in taxable accounts. Tax considerations will thus affect optimal allocation decisions.
8. For empirical evidence showing mixed support of the 1/n strategy, see Rugh [2003].
9. The difference in the returns on stocks and bonds is referred to as the equity premium.
10. As pointed out by a reviewer, a more realistic approximation to individuals' actual DC choices would have dictated the inclusion of other assets such as an international equity fund and, possibly, a real estate index. Such assets are included in follow up studies to this paper.
11. TIAA-CREF is one of the largest financial services organizations in the United States and the largest retirement system in the world. TIAA-CREF is a retirement system for some 2 million staff members of more than 8,000 colleges, universities, and related education and research institutions across the nation.
12. To calculate these amounts, first calculate the value of the portfolio at retirement, and then calculate the amount of annual income assuming a standard annuity. The formula is: $\frac{C(1+i)^n}{[1-1/_{(1+i)}{}^m]/1}$, where $C =$ the annual contribution amount, $i =$ constant annual rate of return, $n =$ the number of years until retirement, and $m =$ the number of years in retirement.

13. Given the lack of a clear-cut ex-ante established selection criterion for choosing return streams in an experiment of this type, we chose to keep both conditions despite their similarity, instead of arbitrarily dropping one of them, ex-post.
14. One subject did not complete the survey at the end of the asset allocation task.
15. The University of Nevada, Reno has both a defined benefit and defined contribution plan. The defined benefit plan is primarily for classified employees, whereas most faculty are covered by a defined contribution plan.
16. In 2002, employees contributing to TIAA-CREF funds allocated 50.5% to stock funds, 32.8% to guaranteed or annuity contracts, 13.2% to fixed income funds which includes both bonds and cash, and 3.5% to real estate funds.
17. Since TIAA-CREF funds are primarily from university employees and since our sample of subjects is primarily university employees this seems a sensible comparison.
18. The efficient frontier shown was estimated by constructing every possible three asset portfolio, assuming one percent increments in asset allocations, and then finding the best asset allocations to provide the highest portfolio expected return for a given level of portfolio variance. Portfolio expected return is the weighted average of the expected return on individual assets. Portfolio variance is a weighted sum of variance and covariance terms and for a three asset portfolio can be written as: w12VAR(R1) + w22VAR(R2) + w32VAR(R3) + 2w1 w2COV(R1, R2) + 2w1 w3COV(R1, R3) + 2w2 w3COV(R2, R3) (Copeland and Weston, 1988). The data set used consisted of the annual returns on the S&P 500, 10-year U.S. Treasury Bonds, and one-month U.S. Treasury Bills from 1926 to 2003.
19. There are many reasons to control for the effects of age. Bodie et al. [1992] noted that since young people enjoy greater labor supply flexibility than the old they may be more inclined to hold risky assets. King and Leape [1987] stressed that since financial information is acquired slowly during an individual's life cycle, this may explain why the young have both a less diversified portfolio and hold a lower share of risky assets. In a cross-section of Italian households, Guiso et al. [1996, p. 165] found that young people hold the smallest proportion of risky assets and that the share of risky assets increases 20% over the life cycle to reach its peak at age 61.
20. We thank an anonymous referee for suggesting the following explanation.
21. Recall that all subjects had access to the summary statistics characterizing all three returns' streams (refer to Table 3).

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## APPENDIX—END OF EXPERIMENT QUESTIONAIRE

Please circle or mark the appropriate box.

1. Gender: Female_____ Male_____
2. Age:______
3. Are you:
   a. UNR Faculty/Staff: Yes____ No_____
   b. UNR Student: Yes____ No_____
4. Do you currently have investments in:
   a. A defined benefit pension plan such as Nevada Public Employees Retirement System (PERS)

      Yes____ No_____

   b. A defined contribution pension plan such as the UCCSN Defined Contribution Plan (TIAA-CREF) or a 401(k) plan from another employer.

      Yes____ No_____

   c. An Individual Retirement Account (IRA) separate from your employer?

      Yes____ No_____

5. How much experience do you have in making investment decisions similar to those in this experiment?

   1————2————3————4————5————6————7

   None at all | Some | A great deal

   *Please answer each of the next six questions and circle the number that best represents your opinion.*

6. "Protecting the principal of my investment is more important than achieving significant growth." Do you. . .

| | |
|---|---|
| A. Strongly Agree? | 0 |
| B. Agree? | 4 |
| C. Disagree? | 11 |
| D. Strongly Disagree? | 16 |

7. Which of the following three investment strategies best suits you?

| | |
|---|---|
| A. One that seeks to avoid loss | 0 |
| B. One that has the potential for both moderate gain and moderate loss | 9 |
| C. One that maximizes potential gain regardless of the potential for loss | 18 |

8. Let's assume you own a stock fund that has lost 15% of its value of the past year, despite previous years solid performance. The loss is consistent with the performance of similar funds during the past year. At this time would you

| | |
|---|---|
| A. Sell all of your fund shares? | 0 |
| B. Sell some buT not all of your fund shares? | 4 |
| C. Continue to hold all of your fund shares? | 9 |
| D. Buy more shares to increase your investment in the fund? | 12 |

9. Inflation can greatly reduce the real rate of return on your investments over time. Which of the following best describes how you feel about investment risk with respect to inflation?

| | |
|---|---|
| A. Minimal potential for loss, although my investment may only keep pace with inflation | 0 |
| B. Moderate potential for loss and lower volatility in trying to exceed the rate of inflation | 9 |
| C. Signficant potential for loss and high volatility in trying to greatly exceed the rate of inflation | 18 |

10. Which of the following three descriptions of hypothetical investment portfolio returns over a one-year period are you most comfortable with?

| | |
|---|---|
| A. Portfolio A: a likely return of 6% and slight chance of losing value | 0 |
| B. Portfolio B: a likely return of 10% and moderate chance of losing value | 9 |
| C. Portfolio C: a likely return of 14% and a signficant chances of losing value | 18 |

11. Which of the following hypothetical portfolio average annual returns over a three-year period are you most comfortable with? A portfolio with a average annual returns that are likely to fall between:

| | |
|---|---|
| A. 0% and 10% | 0 |
| B. −5% and 18% | 9 |
| C. −10% and 26% | 18 |

*When you have finished, please leave this questionnaire on the desk.*