ARE U.S. HOUSEHOLD PORTFOLIOS EFFICIENT?

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the
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By

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ABSTRACT

The theoretical mean-variance efficient portfolio model was modified to incorporate human wealth and net primary residence. Eight traded assets were selected to represent the set of risky assets available to the household investors: combined stock index, large stocks, small stocks, the average return series for individual stocks in the CRSP Decile 10 (smallest) stock portfolio to proxy business ownership, corporate bonds, long-term government bonds, intermediate government bonds, and Ibbotson Associate’s real estate return series. Treasury bill represents the risk-free rate in this study. Simulation programs were developed to identify the efficient portfolios by finding the portfolio weights in risky assets that result in the minimum-variance frontier for the total portfolio. The results of the simulation programs give the efficient asset allocations to different household investors with different human wealth ratios, net primary residence ratios, and planned investment horizons, once the diversification of investment portfolios are related to the perceived stability of future employment income.

The simulation results show that when rational household investors have a high human wealth ratio (e.g., those with ages between 30 to 40 years old), and a long investment time horizon (e.g., 15 year before their retirement), their efficient frontier is a
combination of intermediate government bond, real estate, large stocks, small stocks and business ownership. People with high risk aversion should invest in intermediate government bonds and real estate for a 15-year horizon. People with low risk aversion should invest in real estate, small stock funds, and business ownership for a 15-year horizon. People who have risk aversion between these two points should choose a combination in the order of intermediate government bonds, real estate, large stocks, small stocks, and business ownership.

The efficient portfolios from the simulation results are compared to the current portfolios of U.S. households estimated from the 1998 Survey of Consumer Finances. In the formal efficiency test of households’ current portfolios, about one-third of total households hold inefficient mean-variance portfolios, compared with the same characteristics as those used to produce the simulation results in this study.
Dedicated to my family
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CHAPTER 1

INTRODUCTION

1.1 Motivation and Justification

Over the past 20 years, the importance of asset allocation decisions has increased for typical American households. One reason for this is that employers are now more likely to offer defined contribution retirement plans than defined benefit pension plans because defined contribution plans tend to be more cost effective for the employer. This change has resulted in individual workers being more likely than in the past to have to make investment allocation decisions. In addition, the need for the impending massive numbers of Baby Boomers retiring over the next 20 years to manage portfolios in retirement will result in even more important asset allocation decisions for the large retired population. Therefore, the question of whether households are rational in their asset allocation decisions will be even more important in the future.
The mean-variance efficient portfolio model of asset choice has been used extensively since its development by Markowitz (1952). In this model, a preference for high expected return and an aversion to variance is implied by the monotonicity and strict concavity of an individual investor’s utility function. For arbitrage preference but some specific return distribution, expected utility can be defined over the mean and variances. In previous empirical studies of asset allocation, an efficient frontier has been obtained without dealing with human wealth. For most mean-variance efficient portfolio studies, calculations have been based on the distribution of one-year returns. Furthermore, most studies have included only stocks, bonds and indexes of stocks and/or bonds in the covariance matrix for the market portfolio. However, these three simplifications are not suitable for individual investors in the United States.

Furthermore, the primary residence of a household investor is not like a liquid asset and is not easy altered without incurring a lot of cost. In addition, the major purpose of owning a primary residence is for consumption and psychological reasons, not the investment return. Therefore, the primary residence should be treated as an exogenous variable in the analysis of efficient portfolios for household investors.

The purpose of this paper is to analyze the rationality of asset allocation among U.S. households, based on inclusion of human wealth in the model, treating net primary residence as an exogenous variable, considering different planning horizons for investments for household investors, and including proxies for real estate return and for small business ownership in the market portfolio.

In this study, the proxy to the return on human wealth is constructed to capture the diversity of individual-held human capital and the perceived stability of future income.
This proxy will be included in the variance-covariance matrix in the objective function for each household in the simulation programs. Therefore, when individual investors hold nontraded assets and their primary residences, and are concerned with their total return, the optimal quantities of traded assets will reflect the covariance of the traded assets with the nontraded assets and the primary residence.

1.2 Contributions of the Study

This study estimates each household’s current asset allocations from the 1998 Survey of Consumer Finances (SCF). In addition, the expected return and risk of each household’s portfolios are estimated based on matching the household investor’s planned investment horizon as stated in SCF to corresponding return series. These return series range from 1 year to 15 years and long run return series are obtained from Bootstrap resampling simulation procedures. Interesting findings related to the composition of asset allocations across households and the distribution of expected returns of U.S. household investors’ current portfolios are discussed.

In particular, these estimations directly relate to the following research question in this study. Given the household investors' current asset allocations, and therefore the expected risk, would typical risk-averse U.S. households be better off reallocating their financial resources among investment assets to increase their expected return?” This kind of trade-off between expected return and risk and thus portfolio choices for a
rational household investor can be analyzed in the mean-variance efficient portfolio framework proposed by Harry Markowitz (1952).

In addition, in constructing investment portfolios, it appears that, even among relatively wealthy households in the U.S., the shares of financial assets held in different asset classes vary widely (e.g., Lucas (2000), King and Leape (1987), Blume and Zeldes (1994)). A number of previous empirical studies focus on the level and variability of wage income growth as one of the largest sources of undiversified income risk to explain these cross-sectional differences in portfolio composition. This potential importance of idiosyncratic risk from labor income for portfolio choice is also well established in theoretical literature, where the idea is that in the absence of complete markets, investors will alter their portfolios to offset non-market risk exposure over the life cycle, where the non-market risk exposure includes variability of labor income (e.g., Merton (1971), Mayers (1974), Duffie et al. (1997)).

In line with previous research theoretical and empirical research results, labor income can have important effects on portfolio choice, especially for long–term investors. Therefore, in this study, the traditional mean-variance efficient portfolio framework has been modified by including human wealth.

Human wealth is defined as the present value of future labor earnings and non-investment pension income, the largest nontraded assets household investors have. When human wealth is included in the mean-variance efficient portfolio framework, household investors hold both nontraded assets and investment assets and are concerned with the reward-to-variability for their total portfolios, including both traded and
nontraded assets. Therefore, the optimal holdings of traded assets will reflect their covariance with nontraded assets.

In order to obtain the covariance of human wealth with financial and real estate investments, it is necessary to obtain return series which can capture the diversity of individual-held human capital and the perceived stability of future income. In this study, the rates in per capita production worker earnings for seven industry classifications are used to proxy the returns on human wealth before retirement. Seven industry classifications partially capture the lack of diversification of individually held human wealth. Furthermore, these proxies are adjusted by unemployment probability and unemployment duration, so that they can represent the perceived stability of future labor income. This proxy will be included in variance-covariance matrix in the objective function of the modified mean-variance efficient portfolio model.

The resulting efficient portfolio for each household will have the same expected return as that of each household's current asset allocations but with risk no higher. Once the efficient portfolio for each household is obtained, it is compared to the household investor’s current portfolio. A statistic test is used to test the efficiency of the household investors’ current portfolios in the sample.

Finally, the efficient frontiers for different households with different life cycle stages and human wealth measures have been presented in this study. An efficient frontier represents the set of portfolios that has the minimum risk for every level of return. In basic economic theory, an individual investor’s utility curves specify the trade-offs he or she is willing to make between expected return and risk. In conjunction with the efficient frontier, these utility curves determine which particular efficient portfolio
best suits an individual. The optimal portfolio for the household investor lies at the point of tangency between the efficient frontier and the curve with the highest possible utility.

Compared to the asset allocation recommendations made by popular investment advisors, the efficient frontiers provided in this study can serve as more detailed guidelines. In this study, the real estate-related assets are included in the model to obtain the mean-variance efficient portfolios for household investors, which has not been done before. Furthermore, most of the recommended allocations from advisors are among stocks, bonds, and cash. However, there are different types of stocks and bonds, such as small stocks, large stocks, intermediate government bonds, or corporate bonds, and the performance of these securities are quite different. Most of the investment advisors do not give specific recommendations within one category, such as small or large stocks in the category of stocks. This study tries to give a more detailed analysis on this issue. Not only the broad categories of securities, such as stocks and bond, are studied, but also different types of stocks and bonds, such as small stocks and intermediate government bonds, are included in the model to obtain the efficient portfolios.

Furthermore, this study also provides efficient portfolios based on individual investors’ ex ante expected investment horizons, and individual investors’ “risk capacity”. In “A Random Walk Down Wall Street”, Burton Malkiel (1996) assets that risk tolerance is a function of both an individual’s attitude toward risk as well as his or her risk capacity. Risk attitude is a purely subjective matter and is usually measured in terms of risk aversion, but risk capacity, according to Malkiel, tends to be related to an investor’s place in the life cycle. In this study, the content of risk capacity is extended. In addition to stages in life cycle of household investors, the size of household’s expected future labor
income, expected labor income growth, perceived stability of labor income, and the correlation of labor income with other financial assets are all considered in the measure of human wealth ratio and the modified mean-variance efficient portfolio model.

Following is a description of the organization of this study. In Chapter 2, a literature review about the role of human wealth in portfolio selection is provided. In addition, reviews of literature about proxies to the returns on human wealth, business ownerships and real estate are also presented in this chapter. In Chapter 3, the theoretical mean-variance efficient portfolio model is modified to incorporate human wealth and primary residence. Chapter 4 describes the empirical methodology to estimate U.S. households’ current asset allocations based on the 1998 Survey of Consumer Finances. The return series of investment assets and the procedures used to estimate the expected return and risk of households’ current portfolios are described in Chapter 4. Chapter 5 illustrates the construction of simulation programs, including the construction of the proxy to the return on human wealth and some adjustments to the risk of holding undiversified business ownerships and real estate assets for U.S. households. Chapter 6 presents both empirical results and simulation results based on the modified theoretical model. In addition, the efficient frontiers for households with different human wealth measures are also presented in this chapter. Finally, a discussion about future research implication has been provided in Chapter 7.
CHAPTER 2

LITERATURE REVIEW

2.1 Optimal Portfolio Allocation for Individual Investors

2.1.1 Theoretical Studies about Portfolio Allocation for Individual Investors

*One-Period Portfolio Allocations for Individual Investors - Static Models*

This idea of diversification mentioned above is age-old. The phrase “don’t put all your eggs in one basket” existed long before modern financed theory. It was not until 1952, however, that Harry Markowitz (1952) published a formal model of portfolio selection embodying diversification principles, thereby paving the way for his 1990 Nobel Prize for economics\(^1\). His model is precisely step one of portfolio management:

\(^1\) Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel - Laureates. URL: [http://www.nobel.se/economics/laurates/index.html](http://www.nobel.se/economics/laurates/index.html)
the identification of the efficient set of portfolios, or, as it is often called, the efficient frontier of risky assets. What explains cross-sectional variation in portfolio holdings across households? In Markowitz’s mean-variance efficient portfolio model, a household's utility function should be known to locate the exact optimal asset allocation along the efficient frontier for individual investors.

The mean-variance efficient frontier summaries the portfolios rational investors will hold. The curve in the mean-variance efficient frontier decreases steadily as you move upward. This implies that adding equal increments of risk as you move up the efficient frontier gives you diminishing increments of expected return. On the other hand, an individual investor’s utility curve specify the trade-offs of he or she is willing to make between expected return and risk. In conjunction with the efficient frontier these utility curve determine which particular efficient portfolio best suits an individual investor. Two investors will choose the same portfolio from the efficient set only if their utility curves are identical. Therefore, the optimal portfolio for an individual investor is the efficient portfolio that has the highest utility for a given investor. It lies at the point of tangency between the efficient frontier and the curve with the highest possible utility.

Another approach is using the expected utility analysis. This could be similar to mean variance analysis, since mean variance analysis is an approximation of expected utility analysis. Hanna and Chen (1997) shows that the distinction between subjective and objective risk tolerance is illustrated by expected utility analyses of portfolios. Optimal portfolios were derived for one, 5, and 20 year investment horizons for 6 major financial asset categories. The important aspects of objective risk tolerance are the proportion of an investor's total wealth (including human wealth) in financial
assets, and the investment horizon. Even investors with very low subjective risk tolerance levels should have aggressive portfolios if their horizons are 20 years or more.

*Multi-Period Portfolio Allocations for Individual Investors – Dynamic Models*

The difficult task faced by modern portfolio theory is to extend these insights to a multiperiod setting in which investors seek to finance a stream of consumption over a long lifetime. Financial economists have understood that the solution to a static portfolio choice problem can be very different from the solution to a multiperiod portfolio choice problem. Samuelson (1969) derived restrictive conditions under which these two solutions are the same. These results are based on several assumptions. (1) For an investor with no labor income or nontraded asset. (2) Asset returns are independently and identically distributed over time. (3) Agents have utility functions of the CRRA class that are time-invariant and additively separable over time. (4) Markets are frictionless and complete. If these assumptions are relaxed, then change in age or wealth of individual investors, as well as change in variables that themselves change with age or wealth will affect portfolio decision. Since labor income is the most important nontraded assets of households, this issue has been studied extensively. If labor income is included in the portfolio choice model, the results will be that individual investors optimally change their allocations of financial assets in a pattern related to the life-cycle pattern.

Labor income can also have important effects on portfolio choice for long-term investors. An important paper on this topic is Bodie, Merton and Samuelson (1991). These authors show that exogenous, riskless labor income is equivalent to an implicit
holding of riskless assets. Riskless labor income tilts explicit asset holdings toward risky assets. Exogenous labor income that is perfectly correlated with risky assets, on the other hand, is equivalent to an implicit holding of risky assets and tilts the financial portfolio toward safe assets. They also consider the possibility that investors can vary their labor supply endogenously. They find that investors will increase the willingness to take risks because investors can absorb financial losses both by cutting consumption and by adjusting labor supply.

However, they do not consider idiosyncratic risk in labor income. Viceira (1999) shows that lognormally distributed labor income, uncorrelated with financial asset risk, reduce the tilt toward risky assets but does not reserve it. This type of risk also has a large effect in stimulating wealth accumulation through precautionary savings emphasized by Carroll (1997).

Bertaut and Haliassos (1997), Heaton and Lucas (1997), Cocco, Gomes, and Maenhout (1998), and Storesletten, Telmer, and Yaron (1998) have explored the effects of realistically calibrated labor income risk on portfolio choice over the life cycle. Because the ratio of labor income to wealth rises early in adult life and then gradually declines, the willingness to take equity risk follows a similar pattern.

2.1.2 Empirical Studies about Portfolio Allocation for Individual Investors

Bodie and Crane (1997) analyze the TIAA-CREF data and find evidence in cross section indicative of a strong negative relationship between the age of participants and the amount of financial wealth held in equities. They conclude that individual asset
allocations are consistent with the recommendations of expert practitioners and with the prescriptions of economic theory.

VanDerhei, Galer, Quick, and Rea (1999) use cross-sectional data from 1996 for over 6.6 million participants in 401(k) plans (collected by the Employee Benefits Research Institute and the Investment Company Institute). Their results appear to indicate that age-related patterns exist in the allocation of assets in retirement accounts. “….the mean share held in stocks through equity funds, company stock, and balanced funds declined from 76.8 percent for participants in their twenties to 53.2 percent for participants in their sixties. In contrast, fixed income investments rise from 22.1 percent for participants in their twenties to 45.9 percent for participants in their sixties.”

Yoo (1994) uses three separate cross-sections of data, from 1962 Survey of Financial Characteristics of Consumers and the 1983 and 1986 Surveys of Consumer Finances, to analyze age patterns in asset allocations. He finds that within each of these three separate cross-sections, the share of financial wealth in equities increases over the working life, and then declines after retirement, generating a hump-shaped pattern. His multivariate regression analysis indicates that these age patterns are robust to the inclusion of covariates such as measure of human wealth capital and total wealth.

Using pooled data from the Survey of Consumer Finance from 1983, 1989, and 1992, Poterba and Samwick (1997) attempt to distinguish the separate impact of age and cohort membership on household asset ownership and portfolio shares (as fraction of financial assets) for several types of financial assets. They assume no time effects and focus on age and cohort effects. They find that age profiles for ownership and portfolio shares of all taxable equity (i.e. directly held stock plus stock mutual funds and brokerage
accounts) are generally increasing, although they flatten at older ages. They find no cohort effects in this measure of equity exposure.

Heaton and Lucas (2000) use three separate cross-sections of data from the 1989, 1992, 1995 Surveys of Consumer Finances to analyze household asset portfolios. Their analysis implicitly assumes no cohort effects. Also, they exclude households with less than $500 in stocks or with less than $10,000 in a broad measure of net worth. They find age profiles that are generally decreasing, in that households older than 65 hold a smaller fraction of what they call liquid assets (financial assets) in stocks than do younger ones.

Ameriks and Zeldes (2000) use pooled cross-sectional data from Surveys of Consumer Finances, and new panel data from TIAA-CREF to examine the empirical relationship between age and portfolio choice, focusing on the observed relationship between age and the fraction of wealth held in the stock market. They document three important features of household portfolio behavior: significant non-stockownership, wide-ranging heterogeneity in allocation choices, and the infrequency of active portfolio changes. Based on a specification including age effects and time effects (excluding cohort effects), they find that equity ownership has a hump-shape pattern with age, while equity shares conditional on ownership are nearly constant across age groups. Based on a specification that includes age effects and cohort effects (excluding time effects), they find that equity portfolio shares increase strongly with age. Following the same individual over time, they find that almost half of the sample members made no active changes to their portfolio allocations over their nine-year sample period, while the vast majority of those who did make changes increased their allocations to equity as they aged.
2.2 Proxy to Return on Human Wealth

Fama and Schwert (1977) estimated the covariance between NYSE market portfolio and aggregate income received at t by the labor force employed from t-1 to study the effect of human capital on the capital market equilibrium. To get appropriate measures of the covariances of income with returns, they argued that one must first abstract from the variation through time in aggregate income that just reflected changes in the size of labor force. They solved this problem by using income per capita of the labor force to measure the variation through time in the payoff to a unit of human wealth.

Furthermore, to estimate covariance between income and return from time series data, one should assume that the bivariate distributions of the income and the return variables are stationary through time, which implies that the marginal distributions of the variables are stationary. However, the distribution of per capita income is not stationary; income has an upward trend, and the autocorrelations of per capita income are close to one for many lags.

Fama and Schwert cured this type of mean non-stationarity by work with a percent change in per capita income. They found that the autocorrelations of this percentage change are rather close to zero, and their behavior in general is quite consistent with stationarity.

Campbell (1996) derived a measure for the return on human wealth, which was the current growth rates of labor income, plus a term that depends on expected future growth rates of labor income and expected future asset returns (see equation (3.12) in Campbell (1996)). If both the forecastable part of the growth rates of labor income and
the forecastable part of returns on assets are not important, Campbell’s measure and Fama-Schwert’s measure for the return on human capital are approximately the same.

Jagannathan and Wang (1996) arrived at a similar measure based on different lines of reasoning. They followed the idea that labor income could be thought of as the dividend of human wealth. They further assumed that, to a first order of approximation, the expected rate of return on human wealth was a constant \( r \), and the date-\( t \) per capital labor income \( L_t \) follows an autoregressive process of the form

\[
L_t = (1+g) L_{t-1} + \varepsilon_t.
\]

Then based on dividend discounted model, human wealth can be written as

\[
W_t = \frac{L_t}{r - g}.
\]

Therefore, the rate of change in human wealth is then given by

\[
R_t = \frac{W_t - W_{t-1}}{W_{t-1}} = \frac{L_t - L_{t-1}}{L_{t-1}}.
\]

In such a case, the rate of change in human wealth (not corrected for additional investment in human wealth made during the period) will be the realized growth rate in per capital labor income.

2.3 Proxy to Return on Real Estate

Table 2.1 summarizes the data sets about real estate return series. Comparisons have been made among the data sets in this table. In addition, Table 2.2 summarizes the portfolio optimization benefit of real estate.
<table>
<thead>
<tr>
<th>Return</th>
<th>Years</th>
<th>Composition</th>
<th>Methodology</th>
<th>Return</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ibbotson and Associates</td>
<td>Since 1947</td>
<td>Residential real estate, farm land returns, business real estate returns, and an all-equity composite.</td>
<td>Based on the appraised values.</td>
<td>Annual total returns comprised of an income component and a capital component reflecting percentage changes in price over time.</td>
<td>Longest series</td>
<td>The changes in the data sources over the series, the differences in methods and source used per property and the need to develop the data for components.</td>
</tr>
<tr>
<td>National Council of Real Estate Investment Fiduciaries (NCPREIF)</td>
<td>Since 1977</td>
<td>Institutional-grade properties owned by pension fund, insurance companies and other portfolio managers.</td>
<td>Based on the relationship of current leases to appraised values, modified by actual transactions that have occurred during periods.</td>
<td>Annual total returns comprised of an income component and a capital component reflecting appraised values and transactions.</td>
<td>Aggregation of property asset data contributed by members of NCREIF.</td>
<td>The survivorship issue as identified by Sagalyn (1990). This issue arises because of the changes in the data set over time. The impact of appraisal smoothing.</td>
</tr>
<tr>
<td>American Council of Life Insurance (ACLI)</td>
<td>Since 1951</td>
<td>The capitalization or ratio rates use property-level data, representing stabilized current income divided by an estimated value.</td>
<td>This is developed quarterly from insurance companies’ mortgage commitment reports.</td>
<td>Capitalization rate</td>
<td>The data set reflects new mortgage activity and produce an ex ante return perspective since it is based on underwriting criteria.</td>
<td>The return measures employed in analysis can be influenced by the researchers’ choice of model and thus subject to interpretation.</td>
</tr>
<tr>
<td>National Real Estate Index (NREI), published by Koll</td>
<td>Since 1993</td>
<td>CBD office buildings, retail facilities, warehouse, and apartments.</td>
<td>Rents and sales per square foot and cap rates. This can be developed into components of total return artifacts.</td>
<td>Rents and sales per square foot and cap rates. This can be developed into components of total return artifacts.</td>
<td>Developed from aggregated transaction data on four property types and segmented for many markets.</td>
<td>The dataset is discontinuous and, because of changing transactions used in the series, poses a survival problem.</td>
</tr>
</tbody>
</table>

Table 2.1 Comparisons of the Data Sets for Real Estate Return Series
(Continued)

<table>
<thead>
<tr>
<th>Return Series</th>
<th>Periods</th>
<th>Composition</th>
<th>Methodology</th>
<th>Return</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Korpacz (KYI)</td>
<td>Since 1988</td>
<td>A quarterly mail survey of professionals concerning office, industrial, retail, apartment, and hotel returns.</td>
<td>Quarterly mail survey of professionals</td>
<td>IRR</td>
<td>It samples professionals’ expectations of specific property types in specific geographic markets or the nation as a whole (for a nation, the segmented return data is aggregated with a weighted technique). It reflects expected return (ex ante)</td>
<td>This series limits its regional data to Dallas, Washington, New York, Los Angeles, and Chicago.</td>
</tr>
<tr>
<td>RERCI/RERC</td>
<td>Since 1992</td>
<td>Overall real estate market as well as an array of property types</td>
<td>Personal interview of market participants regarding their acquisition pricing parameters for real estate.</td>
<td>Cap rates / Yield Update in-house quarterly</td>
<td>1. The combined RERC and RERC series offer return measure to overall real estate market. 2. Ex-ante direct return measures developed from survey.</td>
<td></td>
</tr>
</tbody>
</table>

17
<table>
<thead>
<tr>
<th>Article</th>
<th>Assets Examined</th>
<th>Period</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eichholtz, Hoesli, MacGregor and Nanthakumaran (1995)</td>
<td>Commercial real estate in the U.S. and U.K.</td>
<td>1983-1992</td>
<td>Examines whether, starting from one property type in one region, it is more beneficial to diversify across regions within a single property type or across property types within a region.</td>
</tr>
<tr>
<td>Grauer and Hakansson (1995)</td>
<td>U.S. financial assets and I&amp;A real estate return</td>
<td>1955-1988</td>
<td>The inclusion of real estate on an equally-weighted basis to U.S. or global financial assets results in modest benefits while adding real estate to all U.S. real financial assets under an active strategy results in very large gains. Adding U.S. real estate to a portfolio of global financial assets causes mixed results, but typically improves the highly risk-averse structured portfolio.</td>
</tr>
<tr>
<td>Kallberg, Liu and Greig (1996)</td>
<td>Appraised values of 22 properties from a large real estate fund</td>
<td>1982-1989</td>
<td>Smaller properties have lower correlations with financial assets. Real estate diversification benefits are best with small properties at higher target levels of return. 9% of a portfolio should be allocated to real estate.</td>
</tr>
<tr>
<td>Bond and Seiler (1998)</td>
<td>Residential real estate</td>
<td>1969-1994</td>
<td>While financial assets do not protect against inflation, portfolio managers could decrease the variance of their portfolio returns by including real estate in their investment.</td>
</tr>
<tr>
<td>Liao and Mei (1998)</td>
<td>Real estate securities</td>
<td>1980-89</td>
<td>Real estate sticks are too stock market sensitive to provide diversification benefits.</td>
</tr>
<tr>
<td>Rubens, Louson and Yabaccio (1998)</td>
<td>NCRIEF returns</td>
<td>1979-1993</td>
<td>Neither international assets nor unadjusted real estate ever significantly improve portfolio returns. When the Geltner adjustment to the risk measure is made. Even less real estate asset in the portfolio is suggested, but returns still do not improve performance.</td>
</tr>
<tr>
<td>Sivtanides (1998)</td>
<td>NCRIEF returns</td>
<td>1979-1997</td>
<td>Most efficient portfolios differ across investors with different Minimum Required Return levels. MPT and Downside risk approaches produce optimal portfolios with different compositions only within a limited range of returns in the efficient frontier.</td>
</tr>
</tbody>
</table>
| Chenge, Ziobrowski, Caines and Ziobrowski (1999) | Ibboston Associates 
And Evaluation Association | 1973-1994 | By introducing uncertainty into the mixed-asset portfolio analysis, little benefits are found in holding small amounts of foreign real estate. Improved diversification benefits come from holding foreign bonds and bills. Holding large amount of foreign real estate (＞20%) is optimal. |
| Corgel and DeRoos (1999)                    | NCRIEF                               | 1979-1997 | Correcting for appraisal-based smoothing indicates that weights of real estate in a portfolio are sensitive to the effects of recovered returns. Increasing the volatility of real estate reduces its weight in the mixed-asset portfolio. |

Table 2.2 Literature Reviews about the Diversification and Portfolio Optimization Benefits of Real Estate
CHAPTER 3

THEORETICAL FRAMEWORK

3.1 Chapter Overview

In this chapter, a framework for mean-variance efficient portfolio allocations is presented. Then this model is compared to the Expected Utility Theorem and the relationship between these two models is discussed. The results from analysis of the expected utility function will be exactly the same as the results from analysis of mean-variance analysis if one additional assumption is made. In this study, the effect of human wealth on household investors’ assets allocation and the efficient portfolios for household investors with diverse human wealth and investment assets (defined as risky assets plus real estate investment in this study) are of particular interest. Therefore, the model for mean-variance efficient portfolio allocation will be modified to incorporate human wealth into the model. In addition, the primary residence of household investors will be treated as an exogenous variable in this study. The modification of this model is presented at the end of this chapter.
3.2 Mean-Variance Efficient Portfolio Theory

From the basic statistical calculations, we know that portfolio variance is reduced if the covariance term is negative. This is the case in the use of hedge assets. It is important to recognize that even if the covariance term is positive, the portfolio standard deviation is still less than the weighted average of the individual security standard deviations, unless the two securities are perfectly positively correlated. Because the portfolio expected return is always the weighted average of its component expected returns, whereas its standard deviation is less than the weighted average of the component standard deviation, portfolios of less than perfectly correlated assets always offer better risk-return opportunities than the individual component securities on their own. The gain in efficiency is greater for lower correlations between assets.

The idea of diversification mentioned above is age-old. The phrase “don’t put all your eggs in one basket” existed long before modern finance theory. It was not until 1952, however, that Harry Markowitz (1952) published a formal model of portfolio selection embodying diversification principles, thereby paving the way for his 1990 Nobel Prize for economics. His model is precisely step one of portfolio management: the identification of the efficient set of portfolios or, as it is often called, the efficient frontier of risky assets.

The principal idea behind the frontier of risky portfolios is that, for any risk level, rational investors are interested only in that portfolio with the highest expected return. Alternatively, the optimal portfolio allocation frontier is the set of portfolios that minimize the variance for any target expected return. Indeed, these two methods of
computing the efficient set of risky portfolios are equivalent. When a horizontal line is
drawn at the level of required expected return, rational risk averse investors will look for
the portfolio with the lowest standard deviation that plots on this horizontal line. When
we repeat this for various levels of required rates of return, the shape of the minimum-
variance frontier emerges. In the alternative approach, when a vertical line is drawn to
represent the standard deviation constraint, rational utility maximizing investors will
choose the one with the highest expected return. When this procedure is repeated for
various levels of standard deviation, the shape of the minimum-variance frontier emerges.

Therefore, the efficient portfolio allocations will be obtained by determining all
the risk-return opportunities available to the investors. These are summarized by the
minimum variance-covariance efficient frontier. The minimum variance-covariance
efficient frontier is obtained by choosing the weights for each financial asset available to
investors to minimize the variance-covariance matrix subjected to the target expected
return. Therefore, given the set of data for expected returns, variance, and covariance, we
can calculate the minimum-variance portfolio for any target expected return.

This method is also called the data-based approach to obtaining efficient portfolios. A
data-based approach assumes a functional form for the distribution of asset returns and
estimates its parameters from the time series of returns. For example, sample estimates
of the mean and covariance matrix of asset returns can be used to compute the weights in
a mean-variance framework.
3.2.1 The Formal Mean – Variance Efficient Portfolio Analysis

In this section, some assumptions are made and the formal model for mean-variance efficient portfolio allocation is presented to summarize the explanations of the efficient portfolio in the previous section.

Assumption

(1) There are N>2 risky assets in the economy.

(2) Asset returns are assumed to have multivariate normality, which is a sufficient distributional condition to allow all individuals to choose mean-variance efficient portfolios.

(3) The rate of return of each asset cannot be expressed as a linear combination of the rates of return of any other assets. Therefore, the variance and covariance matrices are nonsingular.

Formal Model

A portfolio P is an efficient portfolio if it has a minimum variance among portfolios that have the same expected rate of return. That is, portfolio P is an efficient portfolio if and only if w, the N-vector portfolio weights of portfolio P, is the solution to the quadratic program
Min \{w'Vw\} \quad \text{with respect to } w \quad (3.1)
\begin{align*}
\text{s.t. } w'e=\mu, w'I=1
\end{align*}

where

\begin{align*}
w &= \text{the } N \text{-vector portfolio weights}, \\
V &= \text{the variance and covariance matrix for the } N \text{-risky assets}, \\
e &= \text{the } N \text{-vector of expected rates of return on the } N \text{-risky assets}, \\
\mu &= \text{the expected rate of return for optimal portfolio } P, \text{ and} \\
I &= \text{an } N \text{-vector of units } (1.0). \\
\end{align*}

The above model minimizes portfolio variance and covariance subject to the constraint that the portfolio P expected rate of return is equal to \(\mu\) and that portfolio weights sum to unity. This model summarizes the mean-variance efficient frontier. Therefore, given the set of data for expected returns, variance, and covariance, we can calculate the minimum-variance portfolio for any target expected return. Although this data-based model assumes a functional form for the distribution of asset returns and estimates its parameters from the time series of returns, the model is still consistent with the theoretical framework of the economic expected utility theorem, which is illustrated in the following section.
3.2.2 The Relationship Between the Expected Utility Theorem and Mean-Variance Analysis

In this section, first, the economic expected utility theorem is defined. Second, it is shown that by using the technique of Taylor Approximation of the utility function, mean-variance analysis can be shown to be a good approximation of expected utility analysis. Following are the definitions of the utility function and notation used to illustrate the idea of expected utility function.

\( u(.) \): utility function.
\( r \): the return of one risky asset. \( r \) is a random variable.
\( r_f \): the return of one risk-free asset. \( r_f \) is known in current period.
\( W_0 \): total wealth in current period.
\( W \): total wealth in next period. \( W \) is a random variable.
\( E(W) \): expected value of total wealth in next period.
\( a \): the proportion invested in the risky asset.

Therefore, the total wealth next period can be expressed as

\[
W = a*W_0*(1+r) + (1-a)*W_0*(1+ r_f).
\]

The Expected Utility Theorem can be expressed as
Max $E[u(W)]$ \hspace{1cm} (3.2)

where $u$ can be any utility function and $r$ can be any arbitrary distribution, and (3.2) means that the proportion of $a$ is chosen in this period to maximize the expected utility of total wealth in the next period.

Based on the expected utility theory definition, the mean-variance efficient portfolio will be deduced from this expected utility theorem in the following paragraphs.

$z = (W - E[W])$ then $E[z] = 0$,

then the utility function $u(W)$ can be expressed as

$$u(W) = u(E[W] + W - E[W]) = u(E[W] + z). \hspace{1cm} (3.3)$$

Using Taylor Approximation of function $u(W)$ (3.3) at the expected value $E(W)$, the utility function (3.3) can be expressed as:

$$u(W) = u(E[W] + z)$$

$$= u(W) + z \cdot u'(E[W]) + \frac{(z^2}{2!}) \cdot u''(E[W]) + \frac{(z^3}{3!}) \cdot u'''(E[W]) + \ldots (3.4)$$

When expectation of utility function is taken, then

$$E[u(W)] = u(E(W)) + \frac{1}{2} \cdot \text{Var}(W) \cdot u''(E[W]) + \ldots \hspace{1cm} (3.5)$$
If higher order terms are “small” (for example, \(( z^3 / 3! )u'' (E[W])\) is small), then mean-variance analysis is a good approximation of expected utility analysis. If we further assume that the rate of return \((r)\) is normally distributed, then because the sum of normal distributions has normal distribution, all higher order moments in (3.5) can be written in terms of mean and variance. Thus, the results from the analysis of expected utility will be exactly the same as the results from the mean-variance analysis once the return of one risky asset is assumed to have a normal distribution. When there are several risky assets in the economy, the assumption that asset returns follow multivariate normality should be made if the results from the analysis of expected utility are going to be the same as the results from mean-variance analysis. This assumption is expressed as assumption (2) of Section 3.2.1. Therefore, with this assumption, the mean-variance efficient portfolio model in Section 3.2.1 can be connected to the Expected Utility framework. Although there have been many studies investigating the assumption of normality, discussion of this topic is beyond the scope of this study. In this study, the effect of human wealth on household investors’ asset allocation and the efficient portfolios for household investors are of particular interest. In the following section, the mean-variance efficient portfolio model (3.1) will be modified to incorporate human wealth and net primary residence.

3.2.3 Including Human Wealth and Net Primary Residence in the Model

In this study, human wealth will be taken into account in the model. Most asset allocation models are based on the assumption that all assets are traded. Yet much wealth
is not traded as readily as stocks and bonds. Human wealth – the present value of future labor earnings and non-investment pension income – is the most important nontraded asset. Gutter (2000a) showed that the mean value of human wealth represents 83% of total wealth for the households from the 1998 SCF dataset. When individual investors hold nontraded assets and are concerned with their total return, the optimal quantities of traded assets will reflect their covariance with the nontraded assets.

Human wealth is defined as the present value of the future cash flow of non-investment income to the households. Since the value of human wealth can be calculated by the discounted cash flow (DCF) formula, the return on human wealth can be estimated by analyzing the risk of the cash flow. Human wealth includes two major types of cash flow streams. One is future earned income, mainly salaries and wages before retirement. The second is anticipated defined benefit pension income, including Social Security. The risk for the first type of cash flow is different from the risk for latter one. The cash flow stream for anticipated pensions including Social Security is not risky for the purpose of capital preservation. In this study, the intermediate government bond return will be used as the risk-adjusted discount rate for defined benefit pension income.

In addition, household investors can make their asset allocation decisions based only on financial assets, not on human wealth. Nevertheless, human wealth as a percentage of total wealth is known when individual investors make their asset allocation decisions. Thus, the model can be modified as follows to incorporate human wealth. The variance-covariance matrix and the weighted components in the budget constraint differ from those in the original model in order to incorporate human wealth.
Furthermore, the primary residence of a household investor is not like a liquid asset and is not easy altered without incurring a lot of cost. In addition, the primary purpose of having a primary residence is for consumption and psychological reasons, not the investment return. Therefore, the primary residence should be treated as an exogenous variable in the analysis of efficient portfolios for household investors.

When both the human wealth and the primary residence are treated as exogenous variables, the mean-variance efficient model is modified as following.

\[
\text{Min } \{w'Vw\} \quad \text{with respect to } w
\]
\[
\text{s.t. } w'e=\mu, w' I =1
\]
where
\[
w=[\gamma, \nu, (1-\gamma-\nu)*w_1, (1-\gamma-\nu)*w_2, (1-\gamma-\nu)*w_3, \ldots, (1-\gamma-\nu)*W_N]',
\]
\[
\gamma = \text{human wealth as a percentage of total wealth},
\nu = \text{net primary residence as a percentage of total wealth},
w = \text{the (N+2)-vector portfolio weights},
V = \text{the variance and covariance matrix for the (N+2) assets. N financial assets and human wealth (non-traded asset) and primary residence are included,}
e = \text{the (N+2)-vector of expected rates of return on the N-financial assets},
\mu = \text{the expected rate of return for optimal portfolio } P,
I = \text{an (N+2)-vector of ones.}
\]

After forming the Lagrangian, one can find the unique set of portfolio weights \( w \) for the frontier portfolio having an expected rate of return of \( \mu \).
When human wealth and net primary residence, exogenous variables, are included in this study, the modified model can be used to explain the following research question. When individual investors hold nontraded assets and their primary residences, and are concerned with their total return, the optimal quantities of traded assets will reflect their covariance with the nontraded assets and the primary residence.
CHAPTER 4

EMPIRICAL METHODOLOGY

4.1 Chapter Overview

There are several data sets used in this study. In this chapter, the data sets used to analyze household portfolios will be described. In the next chapter (Chapter 5), the data set used for the simulation studies will be explained further. The actual asset allocations of U.S. households are estimated from the 1998 Survey of Consumer Finances (SCF). The procedure for estimating the portfolio holdings of respondents in the 1998 SCF is mentioned in Section 4.2.3 in this chapter.

Furthermore, the planned investment time horizons for household investors’ actual portfolios can also be obtained from the 1998 SCF. Therefore, the expected return and risk of U.S. household investors’ current portfolios can be estimated by using the corresponding return series for each of five separate asset categories. The return series for stock-related assets, bond-related assets, and real-estate-related assets are from
Ibbotson Associates. The return series for business ownership are obtained by averaging the individual stock return series of the smallest stocks (in portfolio Decile 10) in the CRSP data set. The procedure used to calculate expected return and risk for each household’s portfolio is illustrated in Section 4.3.3.

4.2 Asset Allocations of U.S. Households

4.2.1 Data and Sample

The household data for this study will come from the 1998 Survey of Consumer Finances (SCF). The Federal Reserve Board sponsors the SCF in cooperation with the Department of Treasury. The SCF is an idea choice for a study on human wealth and household asset allocation because the SCF is a large national data set that contains detailed information about household assets, liabilities, and characteristics, as well as some basic information about household preferences. There are three important empirical issues that must be addressed when using the SCF. These issues are related to the over-sampling of wealthy people, the weighting used to correct the over-sampling problem, and multiple imputations.

The SCF has two components in the sample design. The first component over samples high-income households to try to reach wealthy households. The second component is a multi-stage probability sample (Kennickell, 1998). The result of this sample design is that the SCF over-samples wealthy households. Therefore, a weight
variable that can be used to correct point estimates to reflect the total population in U.S. is provided in the public use data set (Kennickell, McManus & Woodburn, 1996).

However, Kennickell and McManus (1993) and Montalto (1998a; 1998b) discuss certain drawbacks of using the weight variable. One concern is that the whole weight would also inflate the degrees of freedom and thus impact the test of significance. Therefore, a scaled weight will be used in this study to produce point estimates that are generalizable to all U.S. households while maintaining the actual degrees of freedom for all statistic tests. The scaled weight is used in all descriptive analyses, as well as in the simulations in order to produce results that can be generalized to all U.S. households.

The Survey of Consumer Finances consists of five data sets due to multiple imputation of missing responses (Kennickell, 1997). Multiple imputation allows the survey to be analyzed as a complete data set but requires greater effort (Rubin, 1987). Additionally, some of the values may vary slightly from one imlicate to the next. Montalto and Sung (1996) describe the application of Rubin’s repeated imputation inference technique for analyzing the SCF’s multiple imputed data. Repeated Imputation Inference (RII) procedures use data from all five implicates and incorporate estimates of error due to missing data, known as imputation error (Rubin, 1987). RII techniques are used for estimating the descriptive statistics in this study, but are not be used in the portfolio efficiency test. In the portfolio efficiency test, the data from the five implicates of the SCF will be pooled, and the efficient portfolio for each of the respondents will be obtained from simulation results. Then each of the portfolios estimated from the SCF will be compared to the matched efficient portfolio, and the F-test used for the test. Since this procedure does not produce the output data set of the
covariance matrix that is required for RII techniques, RII techniques will not be used. Since RII techniques are not used, the estimates of standard error do not account for potential imputation error, and therefore the significance could be overstated. As the amount of imputation error is unknown, p < 0.01 will be used for analysis of significance.

One type of sample selection criteria has been used in this study to facilitate the estimation of human wealth. The sample selection criterion is that the household head should be between the ages of 30-70. Unmarried households were removed if the respondent’s age was not within this range. Married couple households were removed if both spouses did not fit within this range. One reason for this criterion is related to the estimation of life expectancy, which will be discussed in Section 4.2.2. Another reason is that there would be more uncertainty in projecting wages for younger households since their earnings may change dramatically over time. However, the assumption is that once a respondent is in his or her thirties, the current earnings may be a more reasonable proxy for future earnings than they would be if the respondent were younger.

For the purpose of studying investment decisions for households, a married couple will be defined as a household head that reported him/her as married. Although couples living in cohabitation may share current resources, whether or not they consider their partner’s (non-spouse) future resources in investment decisions is questionable. It seems more reasonable to analyze the household investment decisions of a married couple. Couples living together but not married will be treated like other non-married households.
4.2.2 Estimating Human Wealth

Human wealth can be defined as the present value of future non-investment income to the households. Therefore, human wealth includes two major types of cash flow streams. One is the present value of future earned income, mainly salaries and wages before retirement. The second is the present value of anticipated defined benefit pension income including Social Security, and the present value of future disability benefits and income from businesses and partnerships. Estimations of the present value of these two major types of cash flow streams are described in this section.

Present Value of Future Labor Income

Gutter (2000) noted the following: "Although the SCF does not include a specific estimate of income growth, the SCF contains information about whether or not households expect income to grow at a rate higher than, less than, or the same as the rate of price increase over the next year. For households expecting a real increase in the following year, it will be assumed that their income will grow at a real rate of increase of 3% per year until retirement. Households not expecting a real increase or even expecting a decrease will be assumed to have no real change in income throughout the working years." In this study, the same assumption as described above is also made when the present value of future labor income is calculated.

In order to estimate human wealth, the number of working year needs to be known. The planned retirement ages for the respondent and spouse (if married) are
provided in the SCF. Therefore, the number of years before the stated retirement age will be used to estimate the present value of future salaries and wages.

In addition, information about earnings before taxes on the main job and the frequency of receiving earnings are also provided in the SCF. Therefore, the present value of future earned income, mainly salaries and wages before retirement, can be calculated from the SCF.

*The Present Value of Social Security Benefit*

In order to determine the present value of pensions (including Social Security), the years of receiving benefits need to be estimated. The years of receiving benefit need to be predicted individually for the respondents and their spouses, if married. Life expectancy by ages for males and females is based on the National Vital Statistics Reports obtained from the Centers for Disease Control and Prevention United States Life Tables (1998). In these tables, life expectancy at any given age for males and females is the mean number of years remaining to be lived by those surviving to that age on the basis of a given set of age-specific mortality rates.

To determine the years of receiving benefits for households, the sex of respondents in the SCF is determined first. The life expectancy at the respondent’s current age is then determined by using the corresponding male or female 1998 United States Life Tables. The number of the years household head and spouse (if married) will receive benefits is calculated as the life expectancy at the current age minus the difference of years between current age and time the benefits begin. For married couples,
the above Life Tables are also used to separately calculate the single life expectancies of the respondent and the spouse.

Estimation of Social Security retirement benefits is very complex. In this study, the methodology to estimate the Social Security retirement benefits for the households is similar to that of Gutter (2000), who discussed the issue as follows: “The 1998 SCF public use data set does not contain the information as to who is entitled to Social Security benefits. However, according to the Social Security Administration, approximately 96% of all jobs in the United States are covered by Social Security (Social Security Administration, 2002). Therefore, it is assumed that all of the respondents and spouses with income in 1997 will be eligible for Social Security retirement benefits.”

The Primary Insurance Amount (PIA) is the Social Security benefit a person would receive if he/she elected to begin receiving benefits at his/her full retirement age. This means that the benefit is neither reduced for early retirement nor increased for delayed retirement. The following table lists the full retirement age for people born in different years. For example, if a person was born between 1943 and 1954, his/her full retirement age is 66 years old.
Based on the “year of birth” information in the 1998 SCF, the full retirement ages of respondent and respondent’s spouse (if married) can be obtained. The step is to estimate the respondent’s PIA (and PIA of respondent’s spouse, if married) at the full retirement age. Usually, the PIA (or Social Security benefits) at the full retirement age is based on a worker’s earnings averaged over his/her working lifetime, marital status, and national economic trends affecting the level of inflation and wages. Household earnings for 1998 can be obtained from the 1998 SCF. However, since household income information in the SCF is cross-sectional data, not time-series data, no earning pattern over a working lifetime is available in the SCF data set. Therefore, as the assumptions...
made for estimating income growth of future salaries, a 3% constant growth in annual earnings until retirement will be used for households expecting a real rate of increase in earnings over the next year. Once the earnings averaged over working lifetime is calculated, the PIA at full retirement age can be obtained. In this study, Yuh (1998)’s procedure of linear interpolation is applied to estimate the portion of pre-retirement salary that Social Security income will replace.

However, although household members can retire when they reach full retirement age and get their full retirement benefits, they may also retire before reaching full retirement age and receive "reduced" benefits or retire after reaching full retirement age (but before 70) and receive delayed retirement credits. Therefore, estimated Social Security benefits should be adjusted for early retirement or delayed retirement as indicated by the planned retirement ages in the SCF.

The following information is used for the adjustment to PIA (adjusted PIA): no matter what household members’ full retirement ages are, they may start receiving benefits as years of age 62. However, if they start receiving their benefits early, the benefits are reduced five-ninths of one percent for each month before their "full" retirement ages. For example, if a person’s full retirement age is 65 and he/she signs up for Social Security when he/she is 64, he/she will receive 93 percent of his/her full benefit. At age 62, he/she would get 80 percent. (Note: The reduction will be greater in future years as the full retirement age increases. For example, a person retiring at age 62 in the year 2002 will see a reduction of 22.5 percent. A person born in 1960, whose full retirement age will be 67, will see a 30 percent reduction when retiring at age 62.)
The delayed retirement credit works in the opposite manner. Some people continue to work full time beyond their full retirement age—and they don't sign up for Social Security until later. This delay in retirement can increase the Social Security benefit in two ways: First, extra income usually will increase the "average" earnings, and the higher the mean earnings, the higher the Social Security benefit will be. Second, a special credit is given to people who delay retirement beyond their full retirement age. This credit, which is a percentage added to the Social Security benefit, varies depending on a person's date of birth. For people reaching full retirement age in 2002, the rate is 6.5 percent per year. That rate gradually increases in future years, until it reaches 8 percent per year for people reaching full retirement age in 2008 or later. People no longer earn this delayed retirement credit after reaching age 70 (Social Securities Administration.)

For unmarried households, the present value of the Social Security benefit can be calculated based on the adjusted PIA and the assumption of life expectancy estimation mentioned at the beginning of this section. The present value of the Social Security benefit is calculated by the following formula:

\[
\frac{\text{Adjusted annual PIA} \times \left[1 - \frac{1}{(1+i)^{t1}}\right]}{i} / \left[(1+i)^{t2}\right]
\]

where

Adjusted annual PIA: amount of total annual Social Security benefit calculated from SCF; annual Social Security benefit here is adjusted for early or late retirement
t1: the number of years the person will receive benefits during retirement
t2: the number of years prior to receipt of the benefits from current period
i: the discount factor, which is assumed to be 2.4% in this study (the detailed discussion is given in the “Discount Rate” section later in this chapter)

For unmarried households, one thing should be noted about life expectancy. If a household member retires before age 62, the number of years the person will receive benefits during retirement will be the life expectancy at the current age minus the difference of years between current age and age 62, not the individual’s retirement age. It is because Social Security retirement benefits can not begin before age 62. However, if the individual retires after 62, then the actual planned retirement age is used for calculation of years during retirement.

The formula used to calculate the present value of Social Security benefits is the same for both unmarried households and married households. Benefit estimation for unmarried households and married households can be quite different because the estimation for married couples involves several steps. Gutter (2000) discussed the process as follows: “The benefit for the unmarried respondent is based on his or her individual earnings if he or she is employed, and no benefits for other household members are estimated. However, for married couples the issue becomes more complex because of the potential spouse benefit. To calculate the Social Security benefit for married households, the first step is to estimate the benefit for the first member of the household who reaches eligibility. The next step is to estimate the spouse benefit. Spouse benefits are at most half of the other’s benefits based on whether or not both are at full retirement. The first household member who reaches eligibility can only claim the benefit based on his/her earnings. However, when the individual’s spouse reaches
eligibility, the first household member who reached eligibility can choose to claim the benefit based on his/her spouse’s benefit if it is greater. Therefore, it is possible for one member of a married couple to switch benefits once he/she is retired.“

For a married couple, each married individual will choose the greater of his/her own benefit and a spouse's benefit, if available. Gutter (2000) noted: “For a married couple, each married individual will choose the greater of his/her own benefit and a spouse’s benefit, if available. Since it is possible that the first to retire may switch his or her benefit when his/her spouse retires, it is possible for individuals to have more than one stage of benefits. The number of years for the first stage of benefit is known and the number of years in the remaining lifetime of the individual during the second stage of benefit are based on his/her age at the time his/her spouse retires.”

If the couple both retire in the same calendar year, the present value of each spouse’s benefit will be discounted until the age at which both household members begin to receive benefits, which can not be prior to age 62. The present value will then be discounted back to their current age in 1997. Gutter (2000) noted: “If a married couple is not retiring in the same calendar year, there is a multistage Social Security decision to make. The multistage retirement calculation occurs because the first to retire can only choose the benefit based on his/ her individual earnings, but then when the spouse reaches eligibility, the first one must choose between his/her own benefit and the spouse’s benefit.” The second cash flow must be discounted as an annuity and then again as a lump sum, so that it is discounted to the age of the recipient at the time the first stage begins. Furthermore, the present value of the benefit at retirement is then discounted for each spouse to his/her current age.
The Present Value of Defined Benefit Pension Plans

In addition to Social Security retirement benefits, some households are also entitled to one or more defined benefit pension plans. These plans are offered to household members by current or past employers. There are several questions in the SCF that establish information for the estimation of defined pension plans. For each respondent and spouse (if married), the annual defined benefit is estimated up to three plans per person. The amount of each pension benefit can be calculated directly from the information provided in the SCF.

As with the Social Security benefit, the number of years that the defined benefit pensions will be received is estimated from the 1998 United States Life Tables published in National Vital Statistics Reports. If an individual is currently receiving defined benefit pensions, then the life expectancy for the future benefit stream is calculated based on current age of the respondent and spouse (if married). The present value of the defined benefit pensions is as follows:

\[ \frac{DB \times \left[ \frac{1}{1+i} \right]^t_1}{i} \times \left[ \frac{1}{(1+i)^t_2} \right] \]

where

DB: amount of total annual defined benefits calculated from SCF
t1: the number of years the person will receive benefits during retirement
t2: the number of years prior to receipt of the benefits from current period
i: the discount factor, which is assumed to be 2.4% in this study.
Other Human Capital Wealth

Gutter (2000) notes the following: “The SCF provides information about disability payments that are currently being received by household members from Social Security, the military, etc. The amount is provided by the SCF, but the specific life of the benefit is unknown. Typically, the life of a disability benefit does not exceed retirement since it might then be replaced with a retirement benefit, but this information about the households is not available. In this study, the number of years until retirement will be assumed to be the number of years that the disability benefit is received. “

“In addition, there is information in the SCF about household income received for private practice or business. There are a few households which had negative business income. While it is possible that these businesses may become profitable, there is no certainty. Therefore, all negative business incomes will be set to zero. For all households which have positive business income, the present value of this income stream will be included in the estimation of human wealth. It is assumed that business income will last only until the planned retirement age. Therefore, the number of years of receipt of business income will be defined as the number of years until the respondent’s planned retirement age.”

“There is also a concern for households which do not have amounts reported for any of these components of human wealth. Even though there are some households which have zero amounts for human wealth and net worth, we can not assume that these households have no human wealth. For example, these households may expect benefits from a former spouse whose income is not reported in the SCF. Also, these households...”
may receive some form of monetary or non-monetary government aid which is not included in the calculation of human wealth. In this study, it is assumed that households with non-positive income and non-positive net worth have an annual income equivalent to the appropriate household poverty threshold.” This dissertation will use the method used by Gutter (2000). The household poverty thresholds differ by the age of the head of household and the number and composition (18 years and under versus over 18 years) of individuals in the household.

*Discount Rates*

As Gutter (2000) noted, the discount rate used in the present value calculation should be based on the household's opportunity cost. In this study, earned income for the majority of households does not fluctuate with daily market performance, so the labor income stream is quite stable and may change with the long-term business cycle (Canner, Mankiw, & Weil, 1997). Fama and French (1989) showed that the expected returns of the NYSE index have a risk premium that is related to longer term aspects of business conditions. Therefore, the NYSE market-value-weighted average is utilized in this study (c.f., Lee & Hanna, 1995; Wang, 1998; Gutter, 2000b). The cash flow stream for anticipated pensions including Social Security is not risky for the purpose of capital preservation. In this study, following Gutter (2000b) ‘s calculation, the intermediate government bond return will be used as the risk-adjusted discount rate for defined benefit pension income.
To summarize, the present value of defined benefit pension income, the present value of Social Security retirement benefit, the present value of disability income and the present value of salaries for both spouses (if married) will be summed to provide the estimate of total human wealth for the households. Households having none of these measures or having zero or negative net worth will be assumed to earn at least the equivalent of the poverty threshold appropriate for the household’s size and composition.

4.2.3 Estimating Cash Equivalent Assets, Stock-Related Assets, Bond-Related Assets, Real Estate-Related Assets, and Business Ownships of U.S. Households

Variables Available in the 1998 SCF and Measurements in Empirical Analysis

In the 1998 Survey of Consumer Finances, the composition of families’ financial assets includes transaction accounts, certificates of deposit, saving bonds, bonds, stocks, mutual funds, retirement accounts, life insurance, other managed assets and other financial assets.

In order to study the portfolio allocations of U.S. households, it is important to know the percentages households invest in cash equivalent assets, stock-related assets, bond-related assets, real estate-related assets, and business ownership-related assets. All five of these categories have different risk and return patterns and will affect the households’ net worth differently. However, in the 1998 SCF, some types of financial assets are also portfolios of other assets. For example, for Retirement Accounts and
Other Management Assets, the SCF includes more detailed information about “how the money in these assets is invested….stocks, mutual fund, bonds, real estate, or mixed….” To study the risk and return pattern of households in the U.S., these financial assets need to be reclassified into assets consistent with the five types of assets mentioned above: cash equivalent assets, stock-related assets, bond-related assets, real estate-related assets, and business ownership-related assets.

Cash equivalent assets are calculated by adding up the amounts held by household members in the following accounts: checking, saving, certificates of deposit, money market mutual fund, money market deposit accounts, and cash or call money accounts with the brokers.

Stock-related assets are calculated as follows. In the SCF data set, the following assets are included in the survey: stock-related assets in publicly traded stocks, combined mutual funds, thrift, IRA, annuities, trust and managed investment accounts. When respondents in the survey answer that most of their IRA is invested in stock, for example, the amount they report in the IRA is added to stock related assets. Similar calculations are applied to respondents’ accounts of mutual funds, thrift, annuities, trust and managed investment accounts. In addition, there are no specific descriptions of the composition of combined mutual funds and other mutual funds. It is assumed that these mutual funds are balanced funds in this study. Generally speaking, the composition of balanced funds in the U.S. is about 50% in bond and cash equivalent assets and 50% in stocks. Therefore, 50% of households’ combined mutual funds and other mutual funds are assigned as stock funds and 50% of these assets are assigned as bond funds in this study. As a result,

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1 The composition of balanced fund are obtained from the Snapshot of U.S. balanced funds from Morningstar.com. URL: [http://www.morningstar.com](http://www.morningstar.com)
stock-related assets include stock mutual funds, combination and other mutual funds, publicly traded stocks, thrift invested in stock, IRA invested in stock, annuities with equity interest invested in stocks and stock related mutual funds, and trusts and managed investment accounts with equity interest invested in stocks and stock related mutual funds.

Similar reclassifications are applied to bond-related assets. In the SCF, bond-related assets are found among bond mutual funds, saving bonds, combined mutual funds, thrift, IRA, annuities, trust and managed investment accounts. When respondents in the survey answer that most of their IRA is invested in bonds, for example, the amount they report in the IRA is assigned to bond related assets in this study. Similar calculations are applied to respondents’ accounts of mutual funds, thrift, annuities, trust and managed investment accounts. Therefore, bond-related assets include tax-free bond mutual funds, government bond mutual funds, other bond mutual funds, combination and other mutual funds, bonds, not including bond funds or savings bonds, saving bonds, IRA invested in bonds, annuities with equity interest invested in bonds and bond related mutual funds, and trusts and managed investment accounts with equity interest invested in bond and bond related mutual funds.

Real estate-related assets include mortgage bonds, IRA invested in real estate, annuities with equity interest invested in real estate and real estate related mutual funds, trusts and managed investment accounts with equity interest invested in real estate and real estate related mutual funds, other residential real estate Section E properties, and nonresidential debt, including Section E nonresidential, miscellaneous property, and Section I nonresidential real estate.
In this study, the primary residence is not included in the calculation of real estate-related assets because the main purpose of this research is to study the current asset allocation of U.S. households and to investigate whether or not household investors can be better of reallocating their investment assets. The primary residence is not a liquid asset and is not easy altered without incurring a lot of cost. In addition, the main purpose of having a primary residence is for consumption and psychological reasons, not the investment return. Therefore, the primary residence is treated as an exogenous variable in the budget constraint in the mean-variance efficient model. When individual investors hold nontraded assets and their primary residences, and are concerned with their total return, the optimal quantities of traded assets will reflect their covariance with the nontraded asset and the primary residence.

Finally, business ownership-related assets include business interests, IRA invested in business interests, annuities with equity interest invested in businesses and trusts and managed investment accounts w/equity interest invested in business ownership.

The 1998 SCF data set is a rich dataset for the study of financial assets of U.S. households. In addition, this data set can be used to study the relationship between households’ characteristics and their financial assets. Furthermore, human wealth can be estimated from the data set. However, in the 1998 SCF, there is no clear measurement of what percentage of a household’s financial assets is held in the form of stock-related assets, bond-related assets, or even real-estate related assets. This is because some types of financial assets classified in the 1998 SCF are also mixed portfolios of stock-related, bond-related and real-estate related assets. As a result, one needs to make assumptions about the composition of these kinds of financial assets in order to get a better
understanding of the expected return and risk of U.S. household portfolios. Furthermore, there is no information about whether stock-related assets are invested in small capitalization stocks, medium capitalization stocks, or large capitalization stocks in the 1998 SCF data set.

4.3 Expected Return and Risk of U.S. Households’ Current Portfolios

4.3.1 Return Series of Cash Equivalent Assets, Stock-Related Assets, Bond-Related Assets, and Real Estate-Related Assets

The previous section describes how actual portfolio holdings for U.S. households are estimated from the 1998 SCF. There are five asset categories in households’ portfolios: cash equivalent assets, stock-related assets, bond-related assets, business ownership, and real-estate-related assets.

The T-bill return series from Ibbotson Associates is used to calculate the expected return and risk of households’ portfolio holdings in cash equivalent assets. The T-bill return is commonly used in the finance literature to represent the risk-free rate.

As previously mentioned, the SCF does not provide detailed information about whether stock-related assets of U.S. households are invested in small capitalization stocks, medium capitalization stocks, or large capitalization stocks. Therefore, the return series for stock-related assets is calculated by using the value-weighted stock index. The return series beginning at 1948 are used in this study due to there being no information
about return on real estate before 1948. Therefore, 1948 is the start date so that return series across the five asset categories are comparable. This return series for stock-related assets is used to calculate the expected return and risk of households’ portfolio holdings in stock-related assets.

Similarly, it is not possible to distinguish between different types of bonds within mutual funds, including retirement accounts, in the SCF dataset. The return series for bond-related assets is then calculated by averaging the following three return series: corporate bond, intermediate government bond and long-term government bond from 1948-1998 Ibbotson Associates. This return series is used to calculate the expected return and risk of household investors’ portfolio holdings in bond-related assets.

An unpublished real estate series obtained from Ibbotson Associates (updated from Ibbotson & Segel, 1984) is used for the return series of real estate-related assets. This series is a value-weighted index based on real estate returns for residential real estate, farmland returns, and commercial real estate. This index is the longest time series available, dating from 1948.

However, there are some limitations in using an index to proxy the return on real estate—related assets for household investors. The analyses are based on the following assumptions: each household's real estate holdings match the corresponding category in terms of expected return and variance. This assumption may be difficult to accept because those who hold investment real estate often have little geographic diversification – discovery of a Love Canal type of environmental disaster in the area could cause losses much higher than those represented by the aggregate real estate index used in this study. Therefore, a national index for real estate has far too small a standard deviation. This
problem of little geographic and property diversification will affect not only the standard
deviation of household current portfolios but also the simulation results of mean-variance
efficient portfolios discussed later. Some adjustments have been made to mitigate this
problem, and they are discussed further in Chapter 5.

4.3.2 Return Series for Business Ownership

The average return series for individual stocks in the portfolio Decile 10 (smallest
size) in the Center for Research Securities Prices (CRSP) data set is used to calculate the
expected return and risk of households’ portfolio holdings in business ownership.
Business ownership for household investors can be analogous to owning only one stock,
instead of owning an index. Therefore, some adjustments, similar to the adjustments to
the return on households’ real estate-related assets, are made to the risk of business
ownership for U.S. households. These adjustments will also be discussed in Chapter 5.
Following are the procedures used in this study to obtain time series return data
which are used to proxy the return of a household’s business ownership.

1. The CRSP assigns a portfolio number (from 1-10, largest to smallest) to each of the
securities in the NYSE-AMEX-NASDAQ based on securities’ year-end market
capitalization every year from 1/1/1948 to 12/31/1998. One company will move in
and out of a particular assigned portfolio due to the change of year-end market
capitalization. The portfolio number for each security is obtained every year from
1948 to 1998.
2. The annual inflation–adjusted return for each company in portfolio 10 is obtained from 1948-1998.

3. Data from step 2 is sorted by year. The mean of the inflation-adjusted annual return for companies staying in portfolio 10 for a particular year is obtained. This mean is used to proxy the return on business ownership for that particular year. For example, there are 96 companies staying in portfolio 10 in 1948; the mean of these companies’ inflation-adjusted annual return was -4.99%. This is the return to proxy the return on business ownership in 1948. This procedure is repeated every year from 1948 to 1998.

4. A company that stays in portfolio 10 for only one year since 1948 will not be included in the sample to calculate the return.

In step 4, companies that stay in portfolio 10 for only one year since 1926 are not included in the sample to calculate the average variance. In the 1998 SCF, there is a question about when the business ownership is acquired or when household members start their businesses. For households holding business ownership, the mean length of time holding the assets is 8.12 years. Therefore, it is a reasonable assumption to exclude those companies with only one year in portfolio 10 from the sample. However, there is one possible problem when this kind of return series is used to proxy the return on households’ business ownership. That is a survivorship problem. For example, if one company in portfolio 10 goes bankrupt during a particular year, it will be moved out of portfolio 10 and will not be included in the individual stock sample for that year in this study. However, once this company gets out of bankruptcy, it will be counted in the sample again in the year when this company gets out of bankruptcy. Similarly, if one
company in portfolio 10 grows so fast that it has year-end market capitalization above the threshold of portfolio 9 (the second smallest size portfolio number) in a particular year, this company will not be counted in the sample for that year in this study. Therefore, there is some survivorship problem in this procedure.

4.3.3 Procedures to Calculate Expected Return and Risk of U.S. Households’ Current Portfolios Based on Their Planned Investment Time Horizons

The expected return of U.S. households’ current portfolios is the weighted average return of the five asset categories in the households’ portfolios: cash equivalent assets, stock-related assets, bond-related assets, business ownership, and real-estate-related assets. The use of the return series to calculate the expected return and risk has been mentioned in Section 4.3.1. The weights for each household are the percentage holdings in the five asset categories estimated from the 1998 SCF, as mentioned in Section 4.2.3.

However, expected return and risk for each household’s actual portfolio allocations can not be estimated correctly without knowing ex-ante the investment time horizon for each respondent and then using the time-corresponding return series for the five asset categories for each household. Fortunately, the SCF provides sufficient information about each respondent’s planned investment time horizon for his/her portfolio holdings. The respondents can choose their investment time horizons from among the following selections: the next few months, next year, the next few years, the next 5-10 years, and longer than 10 years.
However, to calculate the weighted expected return and standard deviation for a portfolio with a long time horizon, the return distributions facing investors over long holding periods should be estimated. Little is known about what long-run returns and risks to expect from different asset classes because so few observations of long holding period returns are available. Despite this limitation, capital market history represents an objective foundation on which to base forecasts of future investment performance, especially for long holding periods.

An empirical resampling procedure (Butler and Domian, 1991; Hickman, Hunter, Byrd, Beck and Terpening, 2001) is applied in this study to generate future holding-period return distributions directly from observed inflation-adjusted annual return data. The resampling procedure is implemented as follows:

1. Randomly select one of the years from 1948 to 1998. Record the observed inflation-adjusted return for this year for each return index.
2. Repeat this random selection n times with replacement to construct a representative n-year (n = 1, 5, 10, and 15) holding-period return for return series.
3. Repeat this procedure 150 times to generate n-year holding-period return distribution from the observed history of inflation-adjusted returns.

In this study, if the investment time horizons selected by the respondents are the next few months and next year, annual return data for the five asset categories are used to calculate the weighted expected return and standard deviation for their portfolio holdings. If the investment time horizon selected by respondents is the next few years, 150 records of five-year holding-period returns calculated above for the five asset categories are used
to calculate the weighted expected return and standard deviation of the portfolio holdings of these respondents. If the investment time horizon is the next 5-10 years, ten-year holding-period returns data are used. Finally, if the investment time is longer than 15 years, fifteen-year holding-period return data are used for the calculation.
CHAPTER 5

SIMULATION METHODOLOGY

5.1 Chapter Overview

In this study, human wealth is included in the mean-variance efficient portfolio analysis. Model 3.6 presented in Chapter 3 represents the model after modifications. This modified model is used to investigate the household investors’ asset allocations once the human wealth is included in the model, and the reward-to-risk of total portfolios, including human wealth and investment assets, is concerned by households.

Simulation programs based on model 3.6 in Chapter 3 have been developed in SAS language to find the minimum-variance efficient portfolios for each household, subject to the constraint that the parameters (characteristics) for the actual household will be the inputs of the simulation programming. The parameters include the same human wealth ratio as the respondent’s, the same net primary residence ratio as the respondent’s, the same industry as the respondent’s, and the same planned investment time horizon as the respondent’s. Specifically, in the simulation programs, the effect of human wealth is
presented in the first component of the budget constraint and it is presented as a ratio of
human wealth as a percentage of total wealth. This ratio is exogenous, and the estimated
value of this ratio for each household described in Section 4.2.2 is used in the simulation
programs. Since there is a component representing human wealth in the budget
constraint, there should be a corresponding return series on human wealth in the
Objective Function in Equation 3.6. Section 5.2.1 in this chapter illustrates the data and
procedure to construct a return series to proxy the returns on human wealth for different
industries. In Section 5.2.2, the characteristics of these proxies to returns on human
wealth have been investigated.

In regard to the proxies to the returns on investment assets in the objective
function in model (3.6), this has been explored in Section 4.3.1 and 4.3.2. in Chapter 4.
To sum up, the inflation-adjusted stock and bond series from Ibbotson Associates are
used to proxy the returns on stocks and bonds in the simulation programs, respectively.
The inflation-adjusted real estate series obtained from Ibbotson Associates is used to
proxy the return series of real estate-related assets. This series is a value-weighted index
based on real estate returns for residential real estate, farm land returns, and commercial
real estate. Finally, the average inflation-adjusted return series for individual stocks in
the portfolio Decile 10 (smallest size) in the Center for Research Securities Prices (CRSP)
data set is used to proxy the return on households’ business ownership.

However, the standard deviation of this national index return is far too small to
represent the risk of real estate investment for an individual household. Some
adjustments to the risk of real estate investment should be made to mitigate the problem
that there is little geographic and property diversification of U.S. households’ real estate
investment (Eichholtz, Hoesli, MacGregor, and Nanthakumaran, 1995). Furthermore, the proxy to the return on households’ business ownership is like a return series of the equal-weighted portfolio with smallest-size stocks. Therefore, the standard deviation of this return series is also far too small to represent the risk of holding undiversified businesses for U.S. households. The same adjustments as those to real estate investment are also applied to business ownership. These adjustments are discussed in Section 5.2.3.

Once the efficient portfolios can be obtained through simulation programs, the following question can be investigated in this study: given the household investors’ current asset allocations and thus the expected return (mentioned in Chapter 4), could typical risk-averse U.S. households be better off reallocating their financial resources among investment assets and at the same time lowering their exposed risk, once their size of primary residence, size of human wealth, perceived stability of human wealth with other financial assets and planned investment horizon are controlled?

The statistical test mentioned in Section 5.3 in this chapter can be used to test the efficiency of households’ current portfolios, once these portfolios are compared to the corresponding efficient portfolios.

5.2 Simulation Analysis and Proxy Choice

5.2.1 Proxy to the Return on Human Wealth

One of the objectives of this study is to find a proxy to the return on human wealth which can capture the diversity of individual-held human capital and the
perceived stability of future income. This proxy will then be included in the variance-covariance matrix in the objective function in the model 3.6 for each household in the simulation programs.

Human wealth is defined as the present value of the future cash flow of non-investment income to the households. Therefore, human wealth includes two major types of cash flow streams. One is future income, mainly salaries and wages before retirement. The second is anticipated defined benefit pension income, including Social Security. In regard to the second cash flow stream of human wealth for anticipated pensions including Social Security, this cash flow stream is not risky for the purpose of capital preservation. In this study, the intermediate government bond return will be used as the risk-adjusted discount rate for defined benefit pension income, following Gutter (2000).

A literature review related to the proxy to the return on human wealth before retirement has been summarized in Chapter 2. Motivated by these studies, the simple ad hoc assumption that the return on human wealth before retirement is a linear function of the growth rate in per capita labor income is made in this study. Therefore, the growth rate in per capita labor income is used to proxy the return on human wealth before retirement. The data and procedure used to construct this proxy are discussed below.

*Construction of the Proxy to the Return on Human Wealth*

As mentioned above, the growth rate in per capita labor income is used to proxy the measure of return on human wealth before retirement. In addition, the return on intermediate government bonds will be used as the risk-adjusted discount rate for defined
benefit pension income after retirement. Therefore, the weighted average return on growth rate in per capita income and return on intermediate government bonds are used to proxy the individual investor’s required rates of return for human wealth (before retirement plus after retirement). The weights are (pre-retirement human wealth/total human wealth) and (1 - pre-retirement human wealth/total human wealth), respectively, which can be obtained from the 1998 SCF. This calculation method is similar to the weighted average cost of capital (WACC), the expected return on a portfolio with different discount rates.

The Current Employment Statistics (CES) survey of payroll records conducted by the Bureau of Labor Statistics (BLS) is used in this study to obtain the growth rate in per capita labor income. CES covers over 390,000 businesses (approximately 13,000 nonagricultural industries in the state) on a monthly basis and provides detailed industry data on earnings of workers on nonfarm payrolls for all 50 states, the District of Columbia, Puerto Rico, the Virgin Islands, and over 270 metropolitan areas.

Joseph Liberman (1980) used monthly per capita production worker earnings for all eight industry classifications reported for the Employment and Earnings in CES to examine the effect of industry affiliation on human wealth.

In this study, the growth rates in per capita production worker earnings for seven industry classifications reported for the Employment and Earnings in the CES are used to proxy the returns on human wealth before retirement. These seven industry classifications are consistent with the industry classifications in the 1998 SCF public data set. These seven industry classifications include: agriculture; mining and construction; manufacturing; wholesale trade and retail trade; finance, insurance, real estate, business
and repair services; personal services, professional and related services, entertainment
and recreation services, transportation and utilities and sanitary services; public
administration and military. These seven industry classifications partially capture the
lack of diversification of individually held human wealth.

Furthermore, the perceived stability of future employment income is also
considered in this study. Unemployment rates and unemployment duration for the above
seven industry classifications are used to adjust the proxy to the return on human wealth
before retirement in order to represent the stability of future return on human wealth. The
information about unemployment rates and duration can be obtained from the Current
Population Survey (CPS).

The Current Population Survey (CPS) is a monthly survey of about 50,000
households conducted by the Bureau of the Census for the Bureau of Labor Statistics
since 1947. Estimates obtained from the CPS include employment, unemployment rates,
unemployment duration, hours of work, and other indicators. They are available by a
variety of demographic characteristics including age, sex, race, marital status, and
educational attainment. In addition, these estimates are also available by occupation,
industry, and class of worker.

Therefore, a series of proxy to the return on human wealth (considering the
stability of future return on human wealth) is constructed in the following steps.
1. Ratios of pre-retirement human wealth to total human wealth and (1- ratios of pre-
retirement human wealth to total human wealth) for each household investor are
calculated from the 1998 Survey of Consumer Finances.
2. Household investors’ industry classifications and investment time horizons are obtained from the 1998 SCF. It is assumed in this study that one will stay in the same industry for all his/her work life due to the human capital investment.

3. The growth rates in per capita labor income for seven industry classifications are obtained from the BLS’ s Employment and Earnings in CES. These measures are used to proxy the returns on human capital before retirement in the seven major industries. In addition, returns on intermediate government bonds are used to proxy the return of the pension cash flow stream after retirement. The weighted average return on growth rate in per capita income and return on intermediate government bonds are used to proxy the individual investor’s required rates of return for human wealth ( before retirement plus after retirement). The weights are (pre-retirement human wealth/ total human wealth) and (1- pre-retirement human wealth/ total human wealth), which are calculated for each household investor in step 1. The following formula summarizes the calculations. For each household investor i,

The Proxy to the Return on Human Wealth = 

(Ratio of pre-retirement human wealth to total human wealth) * 

Growth rate in per capita labor income in industry j to which he/she belongs in period t + 

(1 - ratio of pre-retirement human wealth to total human wealth) * 

Return on intermediate government bonds in period t.
4. Annual unemployment rates and unemployment duration for each industry are obtained from the Current Population Survey.

5. The growth rate in per capita labor income for each industry is adjusted by the unemployment rates and mean unemployment duration within each industry by using the following formula:

\[ \text{Adjusted growth rate in per capita labor income for industry } j \text{ in period } t = \]
\[ \text{Unemployment rates for industry } j \text{ in period } t \times \]
\[ \frac{\text{The ratio of (52 weeks – duration of unemployment (weeks) in industry } j \text{ ) } / 52}{\text{Growth rate in per capita labor income for industry } j \text{ in period } t + \text{Unemployment rates for industry } j \text{ in period } t} \times \text{Growth rate in per capita labor income for industry } j \text{ in period } t \]

6. The adjusted growth rate in per capita labor income for each industry in period \( t \) is then adjusted by the inflation rate obtained from the Center for Research in Securities Prices (CRSP) by using the following formula:

\[ \text{Adjusted growth rate in per capita labor income for industry } j \text{ in period } t \text{ after inflation} = \]
\[ (1 + \text{Adjusted growth rate in per capita labor income for industry } j \text{ in period } t) \]
\[ \frac{1}{(1 + \text{Inflation})} - 1 \]
Simulation Programming

Once the industry-level earnings growth and asset returns are obtained, the variance-covariance matrix for the simulation programs can be obtained. The minimum variance-covariance efficient portfolio is obtained by choosing weights for each financial asset to minimize the variance-covariance matrix of each industry group subject to the target expected return and human wealth ratios. That is, the minimum-variance efficient portfolios of risky assets will be obtained for different investment horizons, subject to the constraint that individual investors from different industry groups can make their asset allocation decisions only by choosing weights among financial assets while human wealth is exogenous. Individual investors want to get the best reward-to-variability to their total portfolio, including human wealth.

Assessment of the Construction of Human Wealth

When a proxy to return on human wealth is constructed as above, the human wealth will affect the household’s asset allocation decisions by the following channels.

First, the size of human wealth of a household will affect household’s asset allocation decisions. Intuitively, a household investor with high human wealth is usually a person in his/her early life cycle. Then his/her asset allocation decisions may be quite different from those of the person who is going to retire. In the economics literature, Bertaut and Haliassos (1997), Heaton and Lucas (1997), Cocco, Gomes, and Maenhout (1998), and Storesletten, Telmer, and Yaron (1998) have explored the effects of
realistically calibrated labor income risk on portfolio choice over the life cycle. They find that the ratio of labor income to wealth rises early in adult life and then gradually declines. Therefore, the willingness to take equity risk should follow a similar pattern.

The second channel is the covariance of the perceived stability of human wealth (i.e., the growth rate in the household’s labor income after adjusting for the probability of unemployment) with other investment assets. Intuitively, if a household investor’s perceived stability of human wealth is highly correlated with the stability of the stock market, it will be rational for him/her to invest less of his/her assets in the stock market for diversification reasons. This effect is in line with the study of Bodie, Merton, and Samuelson (1991). They show that exogenous, riskless labor income is equivalent to an implicit holding of riskless assets. When the optimal portfolios apply to total asset holdings, riskless labor income tilts explicit asset holdings toward risky assets. Exogenous labor income that is perfectly correlated with risky assets, on the other hand, is equivalent to an implicit holding of risky assets and tilts the financial portfolio toward safe assets.

Third, the components of human wealth for households (pre-retirement human wealth as a percentage of total human wealth vs. human wealth after retirement as a percentage of total human wealth) will affect the covariance of proxy to return on human wealth with other investment assets. This effect comes from the constructing of the proxy to the return on human wealth. Intuitively, the investor with high pre-retirement human wealth (in his/her early life cycle) will have a high ratio of pre-retirement human wealth to total human wealth. Then the weighted average of return on total human wealth will be composed mostly of the growth rate in the investor’s labor income. The
covariance among the perceived stability of one’s labor income and other financial assets will affect one’s asset allocation decisions. On the other hand, a person with low pre-retirement human wealth (in his/her late life cycle, or even in retirement) will have a low ratio of pre-retirement human wealth to total human wealth. Then the weighted average of return on total human wealth will be composed mostly of the returns on intermediate government bonds, which are used to proxy the stable characteristic of his/ her pension income after retirement. Therefore, the latter investor’s optimal asset allocations will be quite different from those of the first investor.

Specifically, in the simulation program the first effect will be presented in the budget constraint as the ratio of human wealth as a percentage of total wealth. Furthermore, as discussed in Section 5.2.1, the proxies to the returns on human wealth in the simulation programs are the industry-level earnings growth rates. Therefore, the second effect will be included in these industry-level proxies to the return on human wealth, and thus in the elements of the variance-covariance matrix of the objective function in the model. The third effect will also be presented in the construction of proxies to return on human wealth for different industries and therefore also in the elements of the variance-covariance matrix of the objective function.

5.2.2 Characteristics of the Proxy to the Return on Human Wealth

Table 5.1 summarizes the characteristics of the proxy to the return on human wealth. As shown in the table, the Service industry has the highest nominal annual growth rate (before adjusting any uncertainty in labor income and inflation) in labor
income while the Trade industry (including wholesale and retail trading) has the lowest nominal growth rate in labor income. In addition, the Mining and Construction industry (actually, the mining industry) has a minimum growth rate in labor income of -4.87%, the lowest among all industries, which occurred during 1949. However, the growth rate in labor income for the mining industry bounced back during the next year. In addition, the Mining and Construction industry has the highest unemployment rate while the Finance & Real Estate industry has the lowest unemployment rate. Once one becomes unemployed in one industry, the unemployment durations are quite similar across all industries, except for the Finance and Real Estate industry.

After adjusting for the probability of unemployment (unemployment rates) and the duration of unemployment, the Finance and Real Estate industry has the highest growth rate in labor income while the Transportation and Public Utilities industry has the lowest growth rate in labor income. Furthermore, after incorporating inflation into the estimation, the Finance and Real Estate industry has the highest mean real growth rate in labor income, 1.06%, while the Transportation and Public Utilities industry has a negative mean real growth rate in labor income. The negative real growth rate in labor income means that the growth of income can not keep the pace with the inflation and the purchasing power is decreasing. In general, most of the industries with real growth rates in labor income (after adjusting the possibility of unemployment) range between 0 and 1.
### Annual Nominal Growth Rate of Earnings of Production Workers

(From the Current Employment Statistics survey, 1947-2001)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Total Private</th>
<th>Mining &amp; Construction</th>
<th>Manufacturing</th>
<th>Transport. Pub. Utilities</th>
<th>Trade</th>
<th>Finance, Real Estate</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>1.19%</td>
<td>-4.87%</td>
<td>0.03%</td>
<td>-0.85%</td>
<td>0.50%</td>
<td>-0.27%</td>
<td>2.28%</td>
</tr>
<tr>
<td>Mean</td>
<td>4.47%</td>
<td>4.90%</td>
<td>4.81%</td>
<td>4.73%</td>
<td>4.20%</td>
<td>4.94%</td>
<td>5.38%</td>
</tr>
<tr>
<td>Median</td>
<td>4.31%</td>
<td>4.70%</td>
<td>4.21%</td>
<td>4.06%</td>
<td>3.76%</td>
<td>4.43%</td>
<td>4.91%</td>
</tr>
<tr>
<td>Maximum</td>
<td>8.90%</td>
<td>13.77%</td>
<td>10.18%</td>
<td>11.28%</td>
<td>8.02%</td>
<td>15.09%</td>
<td>9.57%</td>
</tr>
</tbody>
</table>

### Unemployment Rates

(From Current Population Survey, 1947-2001)

| Minimum           | 3.70%         | 4.39%                  | 3.16%         | 1.99%                     | 3.39% | 1.58%                | 3.41%    |
| Mean              | 6.22%         | 9.02%                  | 5.96%         | 4.13%                     | 6.26% | 2.94%                | 5.35%    |
| Median            | 6.05%         | 8.45%                  | 5.63%         | 4.04%                     | 6.24% | 2.92%                | 5.34%    |
| Maximum           | 11.00%        | 17.53%                 | 12.34%        | 7.39%                     | 10.03%| 4.87%                | 7.94%    |

### Unemployment Duration (In terms of weeks)

(From Current Population Survey, 1947-2001)

| Minimum           | 7.80          | 7.42                   | 8.21          | 7.68                      | 7.39  | 8.51                 | 7.74     |
| Mean              | 12.98         | 12.34                  | 13.67         | 12.78                     | 12.29 | 14.16                | 12.88    |
| Median            | 13.10         | 19.02                  | 13.79         | 12.90                     | 12.41 | 14.29                | 13.00    |
| Maximum           | 20.00         | 12.45                  | 21.06         | 19.70                     | 18.94 | 21.82                | 19.85    |

### Annual Nominal Growth Rate of Earnings of Production Workers

(After the Adjustment of Unemployment Rates and Duration)

| Minimum           | 1.18%         | -0.63%                 | 0.03%         | -0.84%                    | 0.49% | -0.27%               | 0.00%    |
| Mean              | 4.47%         | 4.76%                  | 4.73%         | 3.21%                     | 4.14% | 4.90%                | 3.64%    |
| Median            | 4.21%         | 4.22%                  | 4.14%         | 2.59%                     | 3.71% | 4.39%                | 3.91%    |
| Maximum           | 8.82%         | 10.30%                 | 9.95%         | 11.19%                    | 7.86% | 15.05%               | 9.41%    |

### Annual Inflation-Adjusted Growth Rate of Earnings of Production Workers

(After the Adjustment of Unemployment Rates and Duration)

| Minimum           | -5.30%        | -4.62%                 | -5.52%        | -5.14%                    | -5.31%| -5.86%               | -5.55%   |
| Mean              | 0.64%         | 0.90%                  | 0.88%         | -0.12%                    | 0.33% | 1.06%                | 0.50%    |
| Median            | 0.64%         | 0.75%                  | 0.73%         | -0.22%                    | 0.61% | 1.07%                | 0.45%    |
| Maximum           | 4.67%         | 6.85%                  | 6.34%         | 7.53%                     | 7.39% | 8.53%                | 4.74%    |

Source: Current Employment Statistics (CES) survey of payroll records conducted by the Bureau of Labor Statistics (BLS) and Current Population Survey

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Table 5.1 Characteristics of the Proxy to the Return on Human Wealth

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5.2.3 Adjustments to the Undiversified Problems of Households’ Real Estate Assets

In Section 4.3.1 a real estate return series obtained from Ibbotson Associates is used as proxy to the return on households’ real estate-related assets. This series is a value-weighted index based on real estate returns for residential real estate, farm land returns, and commercial real estate.

However, as mentioned in Section 4.3.1, there are some limitations in using an index to proxy the return on real estate–related assets for households. The problem lies in the low geographic and property diversification of U.S. households’ real estate investment, and then a national index for real estate that may have far too small a standard deviation.

To address this problem, the Sharpe approximation approach is used to adjust the risk of holding real estate in only one region or the risk of holding only one type of real estate instead of a well-diversified portfolio. The Sharp approximation is:

\[ \sigma_1^2 + \frac{1}{M} \sigma e^2 \]  

(5.1)

where

\( \sigma_1^2 \): Variance of a national index for real estate,

\( \sigma e^2 \): Average variance of holding real estate by regions and by types of real estate,

M: is 1 in this case.
To calculate $\sigma^2$, literature reviews about return series for real estate return are presented in Chapter 2. The NCREIF return series provides the most return information on real estate by types and by regions. These real estate return series are conducted by the National Council of Real Estate Investment Fiduciaries, an association of institutional real estate professionals who share a common interest in their industry. These return series are from 1978 to 2002 and are investigated for four regions and four types of real estate across the U.S. The four regions of these data series include East, South, West and Midwest and the four types include Apartment, Industrial, Retail and Office. Means and standard deviations of individual real estate return series by regions and by types are shown in Table 5.2.
Table 5.2  
Means and Standard Deviations of Real Estate Return Series by Regions and by Types

<table>
<thead>
<tr>
<th></th>
<th>East</th>
<th>South</th>
<th>Midwest</th>
<th>West</th>
<th>Apartment</th>
<th>Industrial</th>
<th>Office</th>
<th>Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1-year return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.3%</td>
<td>8.3%</td>
<td>9.7%</td>
<td>10.2%</td>
<td>11.9%</td>
<td>10.2%</td>
<td>9.2%</td>
<td>9.1%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>8.4%</td>
<td>6.0%</td>
<td>6.5%</td>
<td>7.5%</td>
<td>6.4%</td>
<td>6.3%</td>
<td>9.4%</td>
<td>4.9%</td>
</tr>
<tr>
<td><strong>5-year Return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>66.1%</td>
<td>45.2%</td>
<td>54.8%</td>
<td>57.7%</td>
<td>70.3%</td>
<td>59.7%</td>
<td>51.3%</td>
<td>54.8%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>45.7%</td>
<td>29.8%</td>
<td>34.9%</td>
<td>40.9%</td>
<td>34.4%</td>
<td>34.8%</td>
<td>50.6%</td>
<td>27.5%</td>
</tr>
<tr>
<td><strong>10-year Return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>143.9%</td>
<td>86.1%</td>
<td>111.9%</td>
<td>113.5%</td>
<td>159.6%</td>
<td>124.8%</td>
<td>85.7%</td>
<td>130.5%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>109.7%</td>
<td>42.3%</td>
<td>66.0%</td>
<td>71.0%</td>
<td>65.7%</td>
<td>62.7%</td>
<td>80.1%</td>
<td>64.1%</td>
</tr>
<tr>
<td><strong>15-year Return</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>245.1%</td>
<td>141.6%</td>
<td>189.5%</td>
<td>188.3%</td>
<td>302.9%</td>
<td>216.6%</td>
<td>121.2%</td>
<td>240.7%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>79.8%</td>
<td>24.9%</td>
<td>40.9%</td>
<td>44.6%</td>
<td>58.9%</td>
<td>29.4%</td>
<td>42.5%</td>
<td>45.1%</td>
</tr>
</tbody>
</table>

Source: These real estate return series are conducted by the National Council of Real Estate Investment Fiduciaries (NCREIF).

In this study, \( \sigma^2 \) in (5.1) is the average of the standard deviations for these 8 real estate return series. It is 0.4985% for one year, 14.2095% for 5 years, 55.5087% for 10 years and 23.5409% for 15 years. \( \sigma^2 \) can be estimated from the proxy to the return on real estate obtained from Ibbotson Associates.

It needs to be noted that: the indexes of the four regions (East, South, West and Midwest) and four types (Apartment, Industrial, Retail and Office) from the National Council of Real Estate Investment Fiduciaries (NCREIF) are used to calculate \( \sigma^2 \) in this study. Indexes are still used because of the lack of time series return data for individual
real estate holdings. Therefore, the adjustment to the undiversified risk of real estate holding for most households is still limited due to the limitation in data sets.

Furthermore, the average return series for individual stocks in the portfolio Decile 10 (smallest size) in the Center for Research Securities Prices (CRSP) data set is used to calculate the expected return and risk of households’ portfolio holdings in business ownership. However, the mean number of households’ business ownerships estimated from the 1998 SCF is 2.4, not a diversified portfolio. Therefore, some adjustment to the risk of owning a few individual businesses instead of a portfolio with more than 30 individual stocks should be made. The adjustment for the risk of undiversification is similar to the adjustment made for households’ real estate investment. The following steps are applied to obtain the adjustments. The first two steps are the same as in constructing the return series to proxy the return on business ownership mentioned in Section 4.3.2.

1. CRSP assigns a portfolio number (from 1-10, largest to smallest) to each of the securities in NYSE-AMEX-NESDAQ based on securities’ year-end market capitalization every year from 1/1/1948 to 12/31/1998. One company will move in and out of a particular assigned portfolio due to the change in year-end market capitalization. This portfolio number for each security is obtained for every year from 1948 to 1998.

2. The annual inflation–adjusted return for each company in Portfolio 10 is obtained from 1948-1998.

3. Data from step 2 are sorted by company and the standard deviation for each company is obtained. For example, if a company stays in Portfolio 10 for 20 years, then the 20
annual inflation-adjusted returns for this company are pooled together, and the standard deviation of the return of this company is obtained. This procedure is repeated for all of the companies staying in Portfolio 10 since 1926, except for companies who stayed in Portfolio 10 for only one year. The mean standard deviation is obtained by averaging the standard deviation of each company for the periods it stayed in Portfolio 10, which is 44%.

4. The Sharpe approximation approach is used:

\[ \sigma_1 + \frac{1}{M} \sigma_\varepsilon \]

where

\( \sigma_1 \): Variance of a well-diversified portfolio, which is the standard deviation of the return series to proxy the return on business ownership for 1 year, 5 years, 10 years and 15 years, respectively.

\( \sigma_\varepsilon \): Variance of individual stocks in the Portfolio 10.

\( M \): the number of stocks in the portfolios

Therefore, in this study, \( M \) represents the mean number of the household’s business ownerships estimated from the 1998 SCF, which is 2.4, and \( \sigma_\varepsilon \) represents the average variance of individual stocks in the Portfolio 10, which is 44%.

In step 3, the companies who stayed in Portfolio 10 for only one year since 1926 are not included in the sample to calculate the average variance. In the 1998 SCF, there is some question about when the business ownerships were acquired or when household
members started their businesses. The mean length of household business ownership is 8.12 years. Therefore, it is a reasonable assumption to exclude those companies with only one year in Portfolio 10 in the sample.

These adjustments due to the undiversified problems of real estate holdings and business ownership holdings are made in the variance-covariance matrix in the objective function in model 3.6. The elements of variance for proxies to the return on real estate and to the return on business ownership in the matrices of variance-covariance matrix are adjusted by $\sigma \epsilon$, as mentioned above.

5.3 A Test for Empirical Studies

According to Sharpe (1964), a portfolio’s risk-return characteristic can be measured by its Sharpe ratio, defined as excess return per unit of risk. Gibbons, Ross and Shanken (1989) have proposed a test of the significance of the difference between the actual portfolio held by an investor and a corresponding efficient portfolio, based on the difference between the Sharpe ratios of the two portfolios. Given a set of risky assets, any two portfolios $P_i$ and $P_j$ can be constructed to exhibit Sharpe ratios of $S_i$ and $S_j$. If $P_i$ is an efficient portfolio while $P_j$’s efficiency is unknown, then it must be true that $S_i \geq S_j$. To test the significance of their difference, the null hypothesis can be stated as

$H_0: S_i = S_j$. 

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This hypothesis can be tested using the following test statistic:

\[ W = \left[ \frac{(1+S_i^2)^{1/2}}{(1+S_j^2)^{1/2}} \right]^2 - 1. \]

\( W \) follows a Wishart distribution.

Gibbons, Ross and Shanken show, under the assumption that asset returns are multivariate normal and under the null hypothesis that the actual portfolio is an efficient portfolio, that \( W \) can be transferred into a central F distribution as follows:

\[ F = \left[ \frac{T^*(T-N-1)}{N^*(T-2)} \right]^*W \]

where

- \( T \) = the number of observations in a time series used to estimate mean and standard deviation, and
- \( N \) = number of risky assets under analysis,

Degrees of Freedom: \( N \) and \( T-N-1 \).

Gibbons (1989) showed that under the null hypothesis, the transformed \( W \)-statistic is centrally distributed as \( F \) with degree of freedom \( N \), and \( T-N-1 \). Since the power of this test is critically affected by the degrees of freedom of the \( F \) test, Gibbons suggested that the ratio of \( T/N \) should be at least 3.0 as a rule of thumb.

This technique is applied in this paper to test whether the Sharpe ratios of the mean-variance efficient portfolios from prescriptive models are significantly greater than the Sharpe ratios of portfolios from empirical studies. Note that \( W \) is a non-negative
number because $S_i \geq S_j$. In addition, under the null hypothesis $W$ is equal to zero, which implies that the two portfolios have similar mean-variance efficiency. A large $W$ will lead to the rejection of the null hypothesis and the conclusion that the mean-variance efficiency of the two portfolios is significantly different.
CHAPTER 6

RESULTS AND DISCUSSIONS

6.1 Overview

The actual portfolio holdings for U.S. households are estimated from the 1998 SCF. The procedure for estimating the portfolio holdings of respondents in the 1998 SCF are mentioned in Chapter 4. There are five asset categories in household investors’ portfolios: cash equivalent assets, stock-related assets, bond-related assets, business ownership, and real-estate-related assets.

In order to calculate the Sharpe ratios (excess return per unit of risk) of household investors’ portfolios and then do a test of the significance of the difference between the actual portfolios held by U.S. households and corresponding efficient portfolios (as mentioned in Section 6.4), the expected return and risk (in terms of standard deviation) for each household’s portfolio should be calculated. The procedure to calculate the expected return and risk for each household’s portfolio is described in Chapter 4.
Once the expected return and risk of a household’s portfolio are obtained, the Sharpe ratio can be used to summarize the household portfolio’s risk-return characteristic, defined as excess return per unit of risk. Excess return is defined as the return of a portfolio minus the risk free rate. The T-bill return is used to proxy the return of risk-free rate in the financial literature. This measure is also used in this study. Therefore, the Sharpe ratio for each household’s portfolio is calculated as follows:

\[
\text{Sharpe ratio for each household’s portfolio} = \frac{\text{Expected excess return of a household’s portfolio}}{\text{Standard deviation of this household’s portfolio}},
\]

where the time periods of the (accumulated) return series for five asset categories are consistent with the respondent’s planned investment time horizon.

After the Sharpe ratio is obtained for each household’s portfolio, the Sharpe ratio of the efficient portfolio for each household should also be obtained in order to do the test. For each household, simulation programs are developed to search for all possible weights among all investment assets, and the resulting minimum variance-covariance efficient portfolio will be obtained under the constraints that the parameters (characteristics) for the actual household will be the inputs for the simulation programming. The parameters include the same human wealth ratio as that of the respondent, the same net primary residence ratio as that of the respondent, the same industry as that of the respondent, with the same investment time horizon as the
respondent, and the same expected return as estimated from each household's current asset allocations. The definitions of human wealth ratios, net primary residence ratios will be stated in Chapter 6.1.2 below. Therefore, the efficient portfolio for each household will have the same expected return as that of each household's current asset allocations but with no higher risk. Finally, the Sharpe ratios for the efficient portfolio can be calculated by dividing expected excess return by the weighted minimum standard deviation. As a result, the test mentioned in Section 5.3 in this study can be applied.

6.2 The Definitions of Human Wealth Ratios, Net Primary Residence Ratios, Total Wealth and Investment Assets

In this study, the human wealth ratio is defined as net human wealth divided by total wealth. Net human wealth is defined as the human wealth estimated in Chapter 4.2.2 minus the education loan. This number will be set to zero if the education loan is greater than the human wealth. The reason is as follows. One invests in oneself through education to improve one’s future labor income. If the education cost is greater than the present value of future benefit inducing this cost, any rational person will stop investing in his human wealth. Even some individuals may have temporarily low wages while training for a career, but they expect to have much higher wages in the future.

Before the total wealth is defined, there are several other components needed to be defined in advance. First, the investment assets of household investors are defined as the sum of cash equivalent assets after adjusting the transaction account, stock-related
assets, bond-related assets, real estate-related assets and business ownership-related
assets. One month income is used to proxy the transaction account in this study. It is
reasonable to assume that households need cash equivalent assets equal to approximately
one month's income in order to cover current monthly bills and less frequent obligations,
such as quarterly payments for insurance. Therefore, it will be assumed that a portion of
cash equivalent assets up to one month's income actually represents a transaction asset
rather than an Investment asset. Second, in this study the net primary residence is
defined as the market value of household investors’ primary residence minus the account
balance of mortgage loan. Then total wealth in this study is defined as the sum of net
human wealth, household investment assets and net primary residence value. Based on
the above assumptions, the net primary residence ratio is defined as net primary residence
value divided by total wealth, and the human wealth ratio is defined as net human wealth
divided by total wealth.

It is important to note that the definition of total wealth in this study is different
from the sum of human wealth and net worth. The difference for these two definitions
will be the net value of non-investment assets (except primary residence), such as the
market value of car minus the remaining balance of car loan. The new definitions in this
study are to serve the purpose of this study. The purpose of this study is to study the
efficient asset allocations of households in investment assets only, while the human
wealth ratios and net primary residence ratios are taken as exogenous variables. The sum
of the human wealth ratios, the net primary residence ratios and the investment assets as a
percentage of total wealth should be equal to 100% in the budget constraint in the
modified mean-variance efficient portfolio model explained in Chapter 3.
6.3 Empirical Results

6.3.1 U.S. Household Investors’ Actual Asset Allocations

Table 6.1 presents results for seven different ranges of investment assets (before deducting transaction account,) with mid-range investment assets varying from $500 to $6,391,000 (see row 4). Row 5 shows the percentage of the total population in each range. The mean level of investment assets in the U.S. in 1998 was $228,000; the median level of investment was $23,200, lower than the mean value. The mean is higher than the median because of a small proportion of very rich people. Three-quarters of the population had a level of investment below $113,050, and 90% of the population had investment below $356,500.

The asset allocations in different investment assets are shown in rows 7-11 of Table 6.1. For households with investment below $1,720, the mean ratio of cash equivalent assets to investment assets is 92%. For households with investment assets between $1,720 and $3,554,000 (74% of the population), the mean ratio of cash equivalent assets to investment assets decreases from 57% to 9% as the amount of investment assets increase from the $1,720-$23,200 category to the second highest category. Moreover, the mean ratio of stock-related assets to investment assets increases from 28% to 44% while the level of investment assets increases from $1,720 to 3,554,000.

Furthermore, stock-related asset is the largest investment asset category for U.S. households for households with different levels of investment assets, except for households with investment assets below $23,200. Business ownership is an interesting
category. The mean ratio of business ownership-related assets to investment assets increases from 4% to 26% while the level of investment assets increases from $1,720 to $3,554,000. For households in the highest range of investment assets, the mean ratio of business ownership-related assets to investment assets is 42%.

For real estate-related assets, the mean ratio of real estate-related assets to investment assets increases from 4% to 22% while the level of investment assets increases from $1,720 to $74,300. This mean ratio decreases further from 22% to 16% while the level of investment assets increases further from $74,300 to $3,554,000.

As a result, except for the household group with investment assets smaller than $1,720, holdings of investment are overwhelmingly in the form of stock-related assets and business ownership-related assets rather than bond-related assets. The group with the highest value of investment (10% of the population), the mean ratio of stock-related assets to investment assets is 29%.

The efficiency of these asset allocations will be examined later in the section. The question about efficiency is to determine “whether households are better off reallocating their assets in different investment categories, rather than with their current portfolios.” Therefore, money for investment purposes should be considered in terms of asset allocation. Since part of household’s cash is used for transaction purposes, the investment after deducting the transaction account is also examined in this study. In this study, it is assumed that household’s need an amount of cash equal to one month’s income for transactions. Therefore, the transaction account is defined as total income before tax divided by 12. Table 6.2 present the results. The results after deducting transaction account are similar to the results of Table 6.1. The biggest difference between these two
tables is in the holdings of cash equivalent assets. For household with the lowest investment assets, the cash equivalent assets decrease from 92% of total investment holdings in Table 6.1 to 79% in Table 6.2.

Furthermore, the question of whether human wealth will affect the household asset allocation decision is of special interest in this study. Therefore, actual household portfolios by different human wealth ratios are also studied. Table 6.3 presents the results for actual household portfolios estimated from the 1998 SCF by different human wealth ratios. The human wealth ratio in this study is defined in Section 6.2. Mid-range human wealth ratios vary from 0.21 to 1 (see row 4). Row 5 shows the percentage of the total population in each range. The mean level of the human wealth ratio in the U.S. estimated from the 1998 SCF was 0.72; the median level of the human wealth ratio was 0.85, higher than the mean value. Half of the population had a level of human wealth ratio above 0.83. The corresponding median age for each range of human wealth ratios is shown in row 6. As shown in Table 6.3, the median age for respondents with human wealth ratios between 0 and 0.61119 is 54; the median age for respondents with human wealth ratios between 0.6119 and 0.8546 is 50; the median age for respondents with human wealth ratios between 0.8546 and 0.9655 is 43; the median age for respondents with human wealth ratios between 0.9655 and 0.9989 is 41; the median age for respondents with human wealth ratios between 0.9989 and 1 is 40.

The asset allocations in different ranges of human wealth ratios are shown in rows 7-11 of the table. Twenty-five percent of U.S. households have human wealth ratios between 0 and 0.6119. For these people, the median age is 54, and the mean ratio of stock-related assets to investment assets is 29%; the mean ratio of cash equivalent assets
to investment assets is 27%; the mean ratio of real estate-related assets to investment
aves is 16%; and the mean ratio of business ownership-related assets to investment
assets is 14%. Also, 25% of U.S. households have human wealth ratios between 0.6119
and 0.8546. The median age for this group of people is 50 and the mean ratio of stock-
related assets to investment assets is 37%; the mean ratio of cash equivalent assets to
investment assets is 30%; the mean ratio of real estate-related assets to investment assets
is 15%; the mean ratio of business ownership-related assets to investment assets is 8%.

Therefore, except for the group with the highest human wealth ratios (mean age is
40 years old), for total other households, the mean ratio of stock-related assets to
investment assets is 29%; the mean ratio of cash equivalent assets to investment assets is
27%; the mean ratio of real estate-related assets to investment assets is 16%; the mean
ratio of business ownership-related to investment assets is 14%. The percentage holdings
in cash equivalent assets increase as the human wealth ratios increase. The mean ratios
of stock-related assets to investment assets increase from 29% to 41% when human
wealth ratios increase from 0 to 0.9655 (mean ages decrease from 50 to 43 years old).
However, these mean ratios of stock-related assets to investment assets decrease from
41% to 16% while the human wealth ratios increase further from 0.9655 to 1. In addition,
the mean percentage holdings in real estate and business ownership decrease as the
human wealth ratios increase. Furthermore, for households with a human wealth ratio
larger than 0.9989, the mean ratio of stock-related assets to investment assets is 2% while
the mean ratio of cash equivalent assets to investment assets is 16%. To sum up, for
household investors with high value of human wealth (ages between 40 to 54 years old)
or for households with future labor income representing a large percentage of total wealth,
they invest most of their investment assets in cash equivalent assets and stock-related assets. However, for households with very few investment assets and in their young life-cycle, they invest most of their investment assets in cash equivalent assets.

In order to facilitate the comparison between empirical results and simulation results, which will be discussed shortly, Tables 6.4 to 6.7 present actual household investors’ asset allocation by human wealth ratios with human wealth ratios categorized by every 10% increase.

6.3.2 Expected Annualized Return and Risk of U.S. Household Investors’ Actual Portfolios

The expected accumulated return and risk for respondents with different investment time horizons are calculated in Chapter 4 in this study. In order to compare the expected returns and put them on the same scale, all the accumulated return and risk are annualized. Figure 6.2 presents the distribution of U.S. household investors’ annualized expected return based on the actual household portfolios estimated from the 1998 SCF. The horizontal line represents the annualized expected return and the vertical line represents the percentage of total population. For example, about 9.3% of the total population will expect to earn an annualized expected return equal to 0. All these respondents are households with no investment assets. The mean of the annualized expected return is 5.37%, while the median is 6.41%. Compared to the annualized return data calculated from the 1948-1998 Ibboston Associate shown in Table 6.9, both the mean value of 5.37% and median value of 6.41% are close to the annualized real estate
return data. However, as shown in Figure 6.2, the distribution of U.S. household investors’ annualized expected returns from their investment portfolios is widely spread and asymmetric. There are two possible explanations for the shape of this distribution: the extreme values of the total population and the possibility that some household investors are too conservative in their investments.

6.4 Simulation Results

Simulation Programming

The principal idea behind optimal asset allocation is that, for any risk level, rational investors are interested only in that portfolio with the highest expected return given a specific risk level, or, in other words, interested in the portfolio with the lowest variance of investment assets given a target expected return.

The objective of the simulation programs in this study is to find the minimum-variance efficient portfolios for each household, subject to the constraint that the same parameters (characteristics) for the actual household will be the inputs for the simulation programming. The parameters include the same human wealth ratio as the respondent’s, the same net primary residence ratio as the respondent’s, the same industry as the respondent’s, the same planned investment time horizon as the respondent’s, and the same expected return as that calculated from each household’s current asset allocations. Household investors want to get the best reward-to-variability for their total portfolio,
while total portfolio includes human wealth and primary residence. The resulting efficient portfolio for each household will have the same expected return as that for household's current asset allocations but with lower or at least the same risk.

In particular, the following question is investigated in this study: given the household investors’ current asset allocations, and therefore the expected return, would typical risk-averse U.S. households become better off if they reallocate their financial resources among investment assets, lowering their exposed risk, once the size of their human wealth, perceived stability of human wealth with other financial assets, the size of net primary residence and planned investment horizon are controlled?

It is worth noting that an efficient portfolio may be different from an optimal portfolio for a particular household. In basic economic theory, an individual investor’s utility curves specify the trade-offs he or she is willing to make between expected return and risk. In addition, the efficient frontier represents that set of portfolios that has the minimum risk for every level of return. In conjunction with the efficient frontier, these utility curves determine which particular efficient portfolio best suits an individual investor (as shown in Figure 6.1). However, the optimal portfolio is the efficient portfolio that has the highest utility for a given investor. It lies at the point of tangency between the efficient frontier and the curve with the highest possible utility. In this section, the minimum-variance efficient portfolio is found for each household, subject to the constraint that the expected return of the efficient portfolio will be the same as the expected return calculated from a household's current asset allocations. This kind of minimum-variance portfolio is an efficient portfolio, but may not be the optimal portfolio for a particular household investor. If a minimum-variance efficient portfolio is also the
optimal portfolio, then this implies that the expected return calculated from the current portfolio is the target expected return the household investor wants to achieve. However, the F-tests shown below offer a reasonable check of the efficiency of the current household investors’ portfolios. Figure 6.1 can be used to illustrate this statement. If the trade-off between risk and expected return for a particular household is located on A and the minimum-variance efficient portfolio from the simulation program is B, then A may be an inefficient portfolio when the Sharpe ratios (expected return per unit of risk) for A and B are statistically significant. However, if one wants to know the optimal portfolio for a particular investor, some assumptions about the utility function for this person should be made. In conjunction with the efficient frontier mentioned in the last section of this Chapter 6 (Section 6.6: Optimal Asset Allocations Results), this utility will determine the optimal portfolio for a particular household.
Figure 6.1 Efficient Frontier

Findings

The minimum-variance efficient portfolios calculated from the simulation programs are shown in Table 6.11 for 1-year, Table 6.12 for 5-year, Table 6.13 for 10-year and Table 6.14 for 15-year investment horizons. In these tables, the return series used as inputs for the simulation programs are exactly the same as the return series used to calculate the expected return and risk of the current household investors’ portfolios discussed in Section 6.3.2 above. However, the simulation results and thus the tests will
be sensitive to the number of investment assets included in the simulation programs.

Therefore, other sets of simulation programs are run when eight investment assets are included in the pool of assets available to household investors. These eight investment assets include the NYSE/AMEX/NASDAQ value-weighted index, large stock companies, small stock companies, long-term corporate bonds, long-term government bonds, intermediate government bonds, real estate, and business ownership.

The following are the findings for the simulation results.

1. The simulation results from Table 6.10 to Table 6.13 show that the prescriptive investment percentages in real estate-related assets should be above 30% when the households’ investment horizons are larger than 5 years. In addition, the longer the expected time horizons, the higher percentages one had better to invest ones money in some real estate-related assets. This result is consistent with the recommendation from the investment industry that “REITs are conservative, and are good long-term holdings on the seven-year horizon.” (Smart Money, p.71, 1/2003). On the other hand, although there are some exceptions, the prescriptive investment percentages in business ownership should decrease while human wealth ratios increase.

2. Compared to the empirical results in Table 6.4, Table 6.5, Table 6.6, and Table 6.7, respectively, Table 6.10, Table 6.11, Table 6.12, and Table 6.13 show that, investors would be better off allocating their assets among bonds, real estate and business ownership (in terms of the equally-weighted smallest-size stocks in the CRSP data).

It will be easier for household investors to make financial decisions if they know to what kinds of stocks (small stock companies, large stock companies, or value-weighted
index) and what kinds of bonds (corporate bonds, intermediate government bonds, or
long-term government bonds) they should reallocate their investment assets in order to
have the high Sharpe ratios. Table 6.14, Table 6.15, Table 6.16, and Table 6.17 represent
simulation results when eight investment assets are included in the pool of assets
available to household investors. The following are the additional findings in this section.

1. Value-weighted index, corporate bonds, and long-term government bonds will not be
optimal investment assets for household investors no matter what their investment
time horizons are.

2. Intermediate government bonds will be a good investment to be included in the
household investors’ portfolios especially when household investors’ investment time
horizons are within 10 years. As seen in Table 6.15 and Table 6.16, the ratios of
investment in intermediate government bonds to total investment assets increase
dramatically when these ratios are compared to those in Table 6.17.

3. Compared to the empirical results in Table 6.4, Table 6.5, Table 6.6 and Table 6.7,
Table 6.14, Table 6.15, Table 6.16, and Table 6.17 respectively show that, investors
would be better off reallocating more of their assets among intermediate government
bonds, real estate and business ownership (in terms of the smallest-size stocks in the
CRSP data set), especially household investors with investment time horizons larger
than 5 years.

To justify these results, the correlations among investment assets should be
examined. Real estate is a good asset in an efficient portfolio because, for the most part,
it has negative correlation with other investment assets, especially for periods over one
year (Table 6.18, Table 6.19, Table 6.20 and Table 6.21). Real estate returns historically provide rates of return that compare favorably with those of common stocks and bonds, but at remarkably low levels of risk. Furthermore, Tables 6.18 – 6.21 show that real estate typically does not have substantial positive correlation with common stocks or bonds (especially for bonds), a characteristic that allows diversification without sacrificing much return. The diversification advantages of real estate related assets especially benefit those respondents with high human wealth. This is because people who have high human wealth will be sensitive to the business cycle. The risk characteristic of large human wealth can be further diversified away when real estate assets are included in the portfolios.

Tables 6.18 – Table 6.21 also show that intermediate government bonds have the lowest correlation with stock markets among all bond securities and thus will have diversification advantages when they are added to household investors’ portfolios, especially for investment horizons between 5 years and 10 years.

6.5 Efficiency Test Results for Empirical Studies

Table 6.22 presents descriptive results of comparison between the Sharpe ratios of total respondents’ current portfolios by different planned investment horizons and the Sharpe ratios of efficient portfolios from simulation programs. Panel A of Table 6.22 identifies stock, bond, real estate and business ownership as four types of assets considered in the simulation programs. Forty-nine percent of respondents who have an
investment time horizon equal to or less than 1 year hold inefficient portfolios because
the Sharpe ratios of their actual portfolios are smaller than the Sharpe ratios of the
corresponding minimum-variance portfolios obtained from simulation programming. In
addition, 57% of respondents who have investment time horizons equal to 5 years and
35% of respondents who have investment time horizons equal to 10 years hold inefficient
portfolios. Furthermore, 77% of respondents who have investment time horizons equal to
15 years hold inefficient portfolios. Generally speaking, from the descriptive Table 6.22,
the U.S. households that have an extended planned investment horizon would be better
off in terms of reward-to-variability ratios if they reallocated their investment assets,
especially for investment horizons larger than 15 years.

Panel B of Table 6.22 specifies the NYSE/AMEX/NASDAQ value-weighted
index, large stock companies, small stock companies, long-term corporate bonds, long-
term government bonds, intermediate government bonds, real estate, and business
ownership as the eight types of assets considered in the simulation programs. The results
in Panel B of Table 6.22 are similar to those in Panel A, but the percentages of
respondents who hold inefficient portfolios are even larger than the percentages in
corresponding categories in Panel A. Furthermore, in Table 6.22, it is shown that the
Sharpe ratios of efficient portfolios may be sensitive to the number of investment assets
in the simulation programs. Therefore, the two sets of simulation results, four types of
assets and eight types of assets, are presented in this study to test the efficiency of U.S.
household investors’ current portfolios.

Table 6.23 presents the formal statistic test results for the grouping of four types
of assets considered in the simulation programs. There are two sections of this table. On
the left hand side of this table are the statistic results when the probability associated with
the F cumulative distribution is 0.05. On the right hand side of this table are the statistic
results when the probability is 0.01. When the probability associated with F cumulative
distribution is 0.05, table 6.24 shows that 30% to 37% of total households with different
investment time horizons hold statistically significant inefficient mean-variance
portfolios after the human wealth ratio, the net primary residence ratio, industry and thus
the stability of human wealth, and planned investment time horizon are controlled in the
model. When the probability associated with the F cumulative distribution is 0.01, 27%
to 31% of total households hold statistically significant inefficient portfolios.

To analyze the additional expected risk premium (expected return minus the risk
free rate) that can be achieved by moving from the actual to the minimum-variance
efficient portfolios, the following calculation is done. First, households who hold
inefficient portfolios based on the formal statistic tests (p < 0.01) are selected. Second,
for these households in previous step, the Sharpe ratios from these household investors’
current portfolios are deducted from the Sharpe ratios from simulation programs in the
corresponding categories. As a result, the expected risk premium can be improved by
0.60 units per unit of risk (in terms of standard deviation) for households who hold
inefficient portfolios. When Table 6.10 to Table 6.13 (simulation results) are compared
to Table 6.4 and Table 6.7 (empirical results) respectively, this additional expected risk
premium can be achieved for households if they reallocate investments from current
portfolios to some real-estate related assets (such as REIT), government bonds, and
business ownership.
When eight assets are included in the simulation programs, the results are similar to those in Table 6.23. Table 6.24 presents the test results when eight types of assets are considered in the simulation programs. 33% to 50% of total households hold inefficient portfolios when the probability of 0.05 is considered. Table 6.24 shows that the percentages of holding inefficient portfolios become larger than those in corresponding cells in Table 6.24.

However, one important thing that needs to be mentioned here is that the test results may be sensitive to the assumptions made about expected returns and risks. In addition, the analyses and tests are based on the following assumptions:

1. This study is based on the assumption that each household's real estate investment (except their primary residence) matches the corresponding category in terms of expected return and variance. In this study when return and risk of real estate are calculated (in both the empirical and simulation sections), some adjustment have been made to deal with the problem that investment in real estate often has little geographic and type diversification. However, this problem may not be eliminated totally due to the limitations that there is no long-term time series data and no large-scale study of cross sectional individual return data for real estate.

2. Each household's financial asset holdings match the corresponding categories in terms of expected return and variance. For those who invest largely in mutual funds, for instance, in retirement accounts, this may be a reasonable assumption, but for others, it might be unreasonable.
6.6 Optimal Asset Allocations Results: Efficient Frontiers

As mentioned in Section 6.4, if a household investor wants to know the optimal portfolio for him/her, some assumptions about utility function for him/her should be formed. In conjunction with the efficient frontier mentioned in this section this utility will determine the optimal portfolio for a particular household investor.

However, the efficient frontiers are different when the parameters in this study change. Since human wealth are exogenous variables in this study, the size of human wealth, the covariance of the perceived stability of human wealth with other investment assets, and the effects of components composed of human wealth (pre-retirement human wealth as a percentage of total human wealth versus human wealth after retirement as a percentage of total human wealth) on the covariance with other investment assets are all included in the simulation models to get efficient frontiers.

To be more specific, in the simulation program the first effect will be presented in the budget constraint as the ratio of human wealth as a percentage of total wealth. Furthermore, the proxies to the returns on human wealth in the simulation programs are the industry-level earnings growth rates. Therefore, the second effect will be included in these industry-level proxies to the return on human wealth, and thus in the elements of the variance-covariance matrix of the objective function in the model. The third effect in this study will also be presented in the construction of proxies to return on human wealth for different industries (please see Section 5.2.1 for detailed information) and therefore also in the elements of the variance-covariance matrix of the objective function.
Therefore, in order to get some representative efficient frontiers, the mean values of these parameters estimated from the 1998 SCF are used to get efficient frontiers. The human wealth variables and net primary residency ratio from empirical results are the inputs for the efficient frontiers presented in Tables 6.25, 6.26, 6.27, and 6.28. Table 6.25 represents the efficient portfolios for a household investor with mean age between 30 and 40 years old. The mean value of the household investor’s human wealth ratios is 0.72954 for this group and he/she earns an industry-averaged labor income growth. In addition, the industry-averaged unemployment rates and industry-averaged unemployment durations are used for the calculation of stability of future labor income. A household investor can find the mean-variance efficient portfolios in this table based on his/her expected investment horizon and expected target real accumulation. For example, for a household investor with age between 30 and 40 years old and with expected investment horizon equal to 15 years, the efficient portfolio will be 10% in large stock-related assets, 27% in small stock-related assets, 45% in business ownership-related assets (in terms of the equally-weighted smallest-size stocks in the CRSP data set) and 18% in real estate-related assets. This portfolio will expect to result in $5 of real accumulation in 15 years for $1 initial investment.

Tables 6.25 to Table 6.28 show that the efficient frontiers are composed of small stock companies, business ownership (the smallest-size companies in the CRSP dataset), intermediate government bonds, real estate and large stock companies. Table 6.25 to Table 6.28 present that rational people with high risk aversion should invest in intermediate government bonds and real-estate-related assets. Those who have low risk aversion should invest high proportion of investment assets in a small stock fund and
business ownerships. Those who have risk aversion between these two points should choose a combination on the order of intermediate government bonds, real estate, large stock funds, small stock funds and business ownership. The expected return and risk that household investors should choose will depend on their utility functions, but will be on the frontier between these two points.
<table>
<thead>
<tr>
<th>Investment assets without deducting transaction account ($)</th>
<th>0-1,720</th>
<th>1,720-23,200</th>
<th>23,200 -113,050</th>
<th>113,050-356,500</th>
<th>356,500-743,000</th>
<th>743,000-3,554,000</th>
<th>&gt; 3,554,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>589</td>
<td>8,813</td>
<td>57,390</td>
<td>202,972</td>
<td>496,394</td>
<td>1,500,306</td>
<td>9,633,777</td>
</tr>
<tr>
<td>Mid-range investment</td>
<td>500</td>
<td>7,300</td>
<td>52,800</td>
<td>192,300</td>
<td>463,500</td>
<td>1,196,880</td>
<td>6,391,000</td>
</tr>
<tr>
<td>Percentage of total population in range</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>5%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Asset Allocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash Equivalent assets</td>
<td>92%</td>
<td>57%</td>
<td>27%</td>
<td>17%</td>
<td>12%</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Stock</td>
<td>4%</td>
<td>28%</td>
<td>41%</td>
<td>44%</td>
<td>37%</td>
<td>39%</td>
<td>29%</td>
</tr>
<tr>
<td>Bond</td>
<td>4%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>10%</td>
<td>10%</td>
<td>8%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>0%</td>
<td>4%</td>
<td>16%</td>
<td>18%</td>
<td>22%</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>Business Ownership</td>
<td>0%</td>
<td>4%</td>
<td>8%</td>
<td>14%</td>
<td>20%</td>
<td>26%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Table 6.1 (Empirical Results)
Summary Results for Actual Household Investors’ Asset Allocations by Investment Assets Based on 1998 SCF (Before Deducting the Transaction Accounts)
<table>
<thead>
<tr>
<th>Investment assets after deducting transaction account ($)</th>
<th>0-1.050</th>
<th>1,050-21,303</th>
<th>21,303-110,133</th>
<th>110,133-351,090</th>
<th>351,090-733,877</th>
<th>733,877-3,541,397</th>
<th>&gt;3,541,397</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>399</td>
<td>7,386</td>
<td>55,121</td>
<td>199,274</td>
<td>492,972</td>
<td>1,493,458</td>
<td>9,606,585</td>
</tr>
<tr>
<td>Mid-range investment</td>
<td>333</td>
<td>5,733</td>
<td>50,000</td>
<td>188,133</td>
<td>463,000</td>
<td>1,189,800</td>
<td>6,389,500</td>
</tr>
<tr>
<td>Percentage of total population in range</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>5%</td>
<td>4%</td>
<td>1%</td>
</tr>
</tbody>
</table>

**Asset Allocation**

| Cash Equivalent assets | 79% | 49% | 24% | 15% | 12% | 8% | 5% |
| Stock                 | 10% | 34% | 43% | 45% | 36% | 39% | 29% |
| Bond                  | 9%  | 9%  | 8%  | 7%  | 10% | 11% | 8% |
| Real Estate           | 0%  | 5%  | 17% | 19% | 22% | 16% | 16% |
| Business Ownership    | 0%  | 4%  | 9%  | 13% | 20% | 26% | 42% |

Table 6.2 (Empirical Results)

Summary Results for Actual Household Investors’ Asset Allocations by Investment Assets Based on 1998 SCF (After Deducting the Transaction Accounts)
<table>
<thead>
<tr>
<th>Human Wealth Ratios</th>
<th>0-0.6119</th>
<th>0.6119-0.8546</th>
<th>0.8546-0.9655</th>
<th>0.9655-0.9989</th>
<th>0.9989-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.2383</td>
<td>0.7540</td>
<td>0.9156</td>
<td>0.9861</td>
<td>0.9999</td>
</tr>
<tr>
<td>Mid-range ratio</td>
<td>0.2054</td>
<td>0.7609</td>
<td>0.9183</td>
<td>0.9877</td>
<td>1.0000</td>
</tr>
<tr>
<td>Percentage of total population in range</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>Median age in range</td>
<td>54</td>
<td>50</td>
<td>43</td>
<td>41</td>
<td>40</td>
</tr>
<tr>
<td>Asset Allocation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash Equivalent assets</td>
<td>27%</td>
<td>30%</td>
<td>30%</td>
<td>55%</td>
<td>16%</td>
</tr>
<tr>
<td>Stock</td>
<td>29%</td>
<td>37%</td>
<td>41%</td>
<td>26%</td>
<td>2%</td>
</tr>
<tr>
<td>Bond</td>
<td>8%</td>
<td>7%</td>
<td>8%</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Real Estate</td>
<td>16%</td>
<td>15%</td>
<td>8%</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Business Ownership</td>
<td>14%</td>
<td>8%</td>
<td>7%</td>
<td>3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 6.3 (Empirical Results)
Summary Results for Actual Household Investors’ Asset Allocations by the Human Wealth Ratio Based on 1998 SCF (After Deducting the Transaction Accounts)
### Table 6.4 (Empirical Results)

Actual Household Asset Allocations for Households with **One-Year** Planned Investment Horizon (by the ratio of human wealth as a percentage of total wealth, based on 1998 SCF)

<table>
<thead>
<tr>
<th>Ratios</th>
<th>Cash Equivalent Mean</th>
<th>Stock Mean</th>
<th>Bond Mean</th>
<th>Real Estate Mean</th>
<th>Business Ownership Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.0 = \text{Human Wealth} / \text{Total Wealth}$</td>
<td>49.02%</td>
<td>13.55%</td>
<td>4.94%</td>
<td>12.90%</td>
<td>6.90%</td>
</tr>
<tr>
<td>$0.0 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.1$</td>
<td>6.69%</td>
<td>13.67%</td>
<td>3.81%</td>
<td>48.18%</td>
<td>27.66%</td>
</tr>
<tr>
<td>$0.1 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.2$</td>
<td>27.29%</td>
<td>16.27%</td>
<td>3.85%</td>
<td>18.31%</td>
<td>34.28%</td>
</tr>
<tr>
<td>$0.2 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.3$</td>
<td>39.99%</td>
<td>12.75%</td>
<td>1.19%</td>
<td>22.73%</td>
<td>23.34%</td>
</tr>
<tr>
<td>$0.3 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.4$</td>
<td>36.86%</td>
<td>21.17%</td>
<td>6.18%</td>
<td>11.04%</td>
<td>24.75%</td>
</tr>
<tr>
<td>$0.4 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.5$</td>
<td>32.46%</td>
<td>18.42%</td>
<td>15.97%</td>
<td>13.13%</td>
<td>18.08%</td>
</tr>
<tr>
<td>$0.5 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.6$</td>
<td>35.06%</td>
<td>28.15%</td>
<td>3.81%</td>
<td>12.97%</td>
<td>19.08%</td>
</tr>
<tr>
<td>$0.6 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.7$</td>
<td>38.09%</td>
<td>31.43%</td>
<td>5.26%</td>
<td>14.53%</td>
<td>3.50%</td>
</tr>
<tr>
<td>$0.7 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.8$</td>
<td>38.01%</td>
<td>21.58%</td>
<td>9.85%</td>
<td>14.56%</td>
<td>7.03%</td>
</tr>
<tr>
<td>$0.8 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 0.9$</td>
<td>39.37%</td>
<td>25.52%</td>
<td>3.21%</td>
<td>14.50%</td>
<td>8.84%</td>
</tr>
<tr>
<td>$0.9 &lt; \text{Human Wealth} / \text{Total Wealth} \leq 1.0$</td>
<td>38.82%</td>
<td>19.24%</td>
<td>5.00%</td>
<td>3.83%</td>
<td>3.69%</td>
</tr>
</tbody>
</table>

p-value of Chi-Square test for the frequencies between the ratios of human wealth to total wealth and one of the following ratios (Human wealth and primary residency are not included in the following calculation of Investment Assets).

1) Cash equivalent assets as a percentage of total investment assets (Transaction account is deducted from Cash equivalent assets, while transaction account is defined as one month before tax income in this study)

2) Stock-related assets as a percentage of total investment assets

3) Bond-related assets as a percentage of total investment assets

4) Real Estate-related assets as a percentage of total investment assets

5) Business Ownership-related assets as a percentage of total investment assets

p-values for all are smaller than 0.0001.
### p-value of Chi-Square test for the frequencies between the ratios of human wealth to total wealth and one of the following ratios (Human wealth and primary residency are not included in the following calculation of Investment Assets).

1) Cash equivalent assets as a percentage of total investment assets (Transaction account is deducted from Cash equivalent assets, while transaction account is defined as one month before tax income in this study)

2) Stock-related assets as a percentage of total investment assets

3) Bond-related assets as a percentage of total investment assets

4) Real Estate-related assets as a percentage of total investment assets

5) Business Ownership-related assets as a percentage of total investment assets

p-values for all are smaller than 0.0001.

**Table 6.5 (Empirical Results)**

Actual Household Asset Allocations for Households with **Five-Year Planned Investment Horizon** (by the ratio of human wealth as a percentage of total wealth, based on 1998 SCF)
<table>
<thead>
<tr>
<th>Ratios</th>
<th>Cash Equivalent</th>
<th>Stock</th>
<th>Bond</th>
<th>Real Estate</th>
<th>Business Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>22.78%</td>
<td>29.77%</td>
<td>5.97%</td>
<td>17.83%</td>
<td>11.29%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>28.02%</td>
<td>22.09%</td>
<td>11.01%</td>
<td>20.70%</td>
<td>18.19%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>14.23%</td>
<td>21.25%</td>
<td>6.98%</td>
<td>25.86%</td>
<td>31.68%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>21.34%</td>
<td>38.88%</td>
<td>6.23%</td>
<td>12.34%</td>
<td>21.21%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>18.63%</td>
<td>36.51%</td>
<td>9.29%</td>
<td>21.80%</td>
<td>13.76%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>18.87%</td>
<td>44.50%</td>
<td>6.06%</td>
<td>21.42%</td>
<td>9.15%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>23.90%</td>
<td>32.62%</td>
<td>9.44%</td>
<td>15.64%</td>
<td>11.34%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>25.36%</td>
<td>37.56%</td>
<td>9.79%</td>
<td>14.24%</td>
<td>11.61%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>23.71%</td>
<td>43.23%</td>
<td>8.61%</td>
<td>14.95%</td>
<td>7.62%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>26.56%</td>
<td>39.64%</td>
<td>7.38%</td>
<td>16.63%</td>
<td>7.38%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>32.77%</td>
<td>31.40%</td>
<td>6.07%</td>
<td>5.40%</td>
<td>3.37%</td>
</tr>
</tbody>
</table>

p-value of Chi-Square test for the frequencies between the ratios of human wealth to total wealth and one of the following ratios (Human wealth and primary residency are not included in the following calculation of Investment Assets).

1) Cash equivalent assets as a percentage of total investment assets (Transaction account is deducted from Cash equivalent assets, while transaction account is defined as one month before tax income in this study)
2) Stock-related assets as a percentage of total investment assets
3) Bond-related assets as a percentage of total investment assets
4) Real Estate-related assets as a percentage of total investment assets
5) Business Ownership-related assets as a percentage of total investment assets

p-values for all are smaller than 0.0001.

Table 6.6 (Empirical Results)
Actual Household Asset Allocations for Households with **Ten-Year** Planned Investment Horizon (by the ratio of human wealth as a percentage of total wealth, based on 1998 SCF)
p-value of Chi-Square test for the frequencies between the ratios of human wealth to total wealth and one of the following ratios (Human wealth and primary residency are not included in the following calculation of Investment Assets).

1) Cash equivalent assets as a percentage of total investment assets (Transaction account is deducted from Cash equivalent assets, while transaction account is defined as one month before tax income in this study)
2) Stock-related assets as a percentage of total investment assets
3) Bond-related assets as a percentage of total investment assets
4) Real Estate-related assets as a percentage of total investment assets
5) Business Ownership-related assets as a percentage of total investment assets

p-values for all are smaller than 0.0001.

<table>
<thead>
<tr>
<th>Ratios</th>
<th>Cash Equivalent</th>
<th>Stock</th>
<th>Bond</th>
<th>Real Estate</th>
<th>Business Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
</tr>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>22.24%</td>
<td>39.38%</td>
<td>5.51%</td>
<td>12.46%</td>
<td>14.87%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>10.72%</td>
<td>38.17%</td>
<td>20.54%</td>
<td>4.81%</td>
<td>25.77%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>5.94%</td>
<td>27.46%</td>
<td>14.71%</td>
<td>13.16%</td>
<td>38.73%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>5.37%</td>
<td>46.31%</td>
<td>14.78%</td>
<td>12.42%</td>
<td>21.12%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>7.68%</td>
<td>55.94%</td>
<td>20.12%</td>
<td>5.89%</td>
<td>10.37%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>15.06%</td>
<td>33.96%</td>
<td>12.25%</td>
<td>10.94%</td>
<td>27.78%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>39.65%</td>
<td>29.94%</td>
<td>9.41%</td>
<td>13.98%</td>
<td>7.02%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>31.41%</td>
<td>43.54%</td>
<td>8.71%</td>
<td>11.64%</td>
<td>4.70%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>24.65%</td>
<td>42.34%</td>
<td>7.94%</td>
<td>16.02%</td>
<td>8.26%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>19.12%</td>
<td>54.38%</td>
<td>8.66%</td>
<td>7.97%</td>
<td>8.57%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>31.20%</td>
<td>39.80%</td>
<td>6.07%</td>
<td>2.65%</td>
<td>3.48%</td>
</tr>
</tbody>
</table>

Table 6.7 (Empirical Results)
Actual Household Asset Allocations for Households with **Fifteen-Year** Planned Investment Horizon (by the ratio of human wealth as a percentage of total wealth, based on 1998 SCF)
Figure 6.2 (Empirical Results) Expected Annualized Return and Risk of U.S. Household Investors’ Actual Portfolios
<table>
<thead>
<tr>
<th>Mean</th>
<th>Median</th>
<th>Std. Dev.</th>
<th>100%</th>
<th>75% Q3</th>
<th>25% Q1</th>
<th>10%</th>
<th>0% Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.37%</td>
<td>6.41%</td>
<td>1.75%</td>
<td>12.17%</td>
<td>9.20%</td>
<td>1.09%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Table 6.8
Statistic Summary of Annualized Expected Return for Households Based on 1998 SCF

<table>
<thead>
<tr>
<th>Annual return</th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>LT Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>T-Bills</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual return</td>
<td>10.02%</td>
<td>10.51%</td>
<td>12.76%</td>
<td>12.17%</td>
<td>2.70%</td>
<td>2.43%</td>
<td>2.36%</td>
<td>1.09%</td>
<td>6.92%</td>
</tr>
<tr>
<td>Annualized 5-year return</td>
<td>9.04%</td>
<td>9.55%</td>
<td>12.32%</td>
<td>11.00%</td>
<td>2.71%</td>
<td>2.35%</td>
<td>2.41%</td>
<td>1.14%</td>
<td>6.91%</td>
</tr>
<tr>
<td>Annualized 10-year return</td>
<td>8.54%</td>
<td>8.95%</td>
<td>11.31%</td>
<td>10.43%</td>
<td>2.71%</td>
<td>2.35%</td>
<td>2.51%</td>
<td>1.21%</td>
<td>7.11%</td>
</tr>
<tr>
<td>Annualized 15-year return</td>
<td>7.91%</td>
<td>8.29%</td>
<td>10.72%</td>
<td>9.93%</td>
<td>2.57%</td>
<td>2.22%</td>
<td>2.43%</td>
<td>1.20%</td>
<td>7.36%</td>
</tr>
</tbody>
</table>

Table 6.9
Annualized Return Data from 1948 to 1998 (Data source: Ibbotson Associates)
Descriptions of the Methodology for Minimum-Variance Efficient Portfolios from Table 6.10 to Table 6.17

(1) Investment Horizon: 1 year for Table 6.10, 5 years for Table 6.11, 10 years for Table 6.12 and 15 years for Table 6.13.

- Household investors with a planned investment time horizon equal to one of the specific time horizons mentioned above will be included in the sample for respective tables.

- The following four investment assets are used for simulation programs for Tables 6.10, 6.11, 6.12 and 6.13:
  i. Value-weighted stock index from Ibbotson Associates
  ii. Average return series for corporate bond, intermediate government bond, and long-term government bond from Ibbotson Associates
  iii. Equally-weighted individual stock return series in Portfolio Decile 10 from CRSP data set
  iv. Real Estate return series from Ibbotson Associates

- Following eight investment assets are used for simulation programs for Tables 6.14, 6.15, 6.16, and 6.17:
  ii. CRSP: equally-weighted return for individual stock in Portfolio Decile 10.

(2) The simulation results are obtained by the following procedures.

- Step one: Each household’s minimum-variance efficient portfolio is obtained when the same parameters for each household are included in the simulation programs. The parameters include the same human wealth ratios as the respondent’s, the same net primary residence ratio as the respondent’s, the same industry and then the same perceived stability in human wealth as the respondent’s, the same planned investment time horizon as the respondent’s, and the same weighted expected return as that of each household's current asset allocations.

- Step two: The simulation results from Step one are grouped by time and then by human wealth ratios.

- Step three: The mean values of asset allocations and Sharpe ratios within each group are presented in corresponding tables.
<table>
<thead>
<tr>
<th>Human Wealth / Total Wealth</th>
<th>Age</th>
<th>Stock</th>
<th>Bond</th>
<th>Business Ownership</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>47</td>
<td>0%</td>
<td>4%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>56</td>
<td>0%</td>
<td>10%</td>
<td>6%</td>
<td>20%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>61</td>
<td>0%</td>
<td>5%</td>
<td>9%</td>
<td>25%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>57</td>
<td>0%</td>
<td>4%</td>
<td>7%</td>
<td>18%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>58</td>
<td>0%</td>
<td>5%</td>
<td>8%</td>
<td>18%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>58</td>
<td>0%</td>
<td>2%</td>
<td>8%</td>
<td>18%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>57</td>
<td>0%</td>
<td>2%</td>
<td>9%</td>
<td>22%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>55</td>
<td>0%</td>
<td>2%</td>
<td>6%</td>
<td>12%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>51</td>
<td>0%</td>
<td>2%</td>
<td>6%</td>
<td>11%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>49</td>
<td>0%</td>
<td>1%</td>
<td>7%</td>
<td>14%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>44</td>
<td>0%</td>
<td>1%</td>
<td>5%</td>
<td>9%</td>
</tr>
</tbody>
</table>

Table 6.10 (Simulation Results)
The Mean Optimal Portfolios for Households with a One-Year Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (for four types of investment assets)
Table 6.11 (Simulation Results)
The Mean Optimal Portfolios for Households with a **Five-Year** Investment Time Horizon by the Ratios of Human Wealth to Total Wealth, Given the Household’s Expected Return Estimated from SCF (**for four types of investment assets**)
<table>
<thead>
<tr>
<th>Human Wealth / Total Wealth</th>
<th>Age</th>
<th>Stock</th>
<th>Bond</th>
<th>Business Ownership</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>50</td>
<td>13%</td>
<td>37%</td>
<td>18%</td>
<td>32%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>61</td>
<td>15%</td>
<td>36%</td>
<td>20%</td>
<td>29%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>58</td>
<td>13%</td>
<td>19%</td>
<td>34%</td>
<td>34%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>60</td>
<td>18%</td>
<td>19%</td>
<td>26%</td>
<td>38%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>58</td>
<td>20%</td>
<td>20%</td>
<td>17%</td>
<td>43%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>56</td>
<td>18%</td>
<td>19%</td>
<td>19%</td>
<td>44%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>57</td>
<td>14%</td>
<td>33%</td>
<td>17%</td>
<td>36%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>54</td>
<td>15%</td>
<td>29%</td>
<td>17%</td>
<td>40%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>51</td>
<td>14%</td>
<td>28%</td>
<td>18%</td>
<td>41%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>49</td>
<td>14%</td>
<td>29%</td>
<td>17%</td>
<td>40%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>45</td>
<td>7%</td>
<td>47%</td>
<td>13%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Table 6.12 (Simulation Results)
The Mean Optimal Portfolios for Households with a Ten-Year Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (for four types of investment assets)
<table>
<thead>
<tr>
<th>Human Wealth / Total Wealth</th>
<th>Age</th>
<th>Stock</th>
<th>Bond</th>
<th>Business Ownership</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>44</td>
<td>2%</td>
<td>19%</td>
<td>29%</td>
<td>50%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth &lt;= 0.1</td>
<td>59</td>
<td>1%</td>
<td>15%</td>
<td>37%</td>
<td>47%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth &lt;= 0.2</td>
<td>55</td>
<td>1%</td>
<td>9%</td>
<td>46%</td>
<td>44%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth &lt;= 0.3</td>
<td>55</td>
<td>2%</td>
<td>2%</td>
<td>35%</td>
<td>62%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth &lt;= 0.4</td>
<td>60</td>
<td>2%</td>
<td>8%</td>
<td>29%</td>
<td>62%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth &lt;= 0.5</td>
<td>52</td>
<td>2%</td>
<td>10%</td>
<td>38%</td>
<td>50%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth &lt;= 0.6</td>
<td>57</td>
<td>2%</td>
<td>24%</td>
<td>14%</td>
<td>59%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth &lt;= 0.7</td>
<td>54</td>
<td>2%</td>
<td>16%</td>
<td>19%</td>
<td>64%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth &lt;= 0.8</td>
<td>47</td>
<td>1%</td>
<td>13%</td>
<td>23%</td>
<td>63%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth &lt;= 0.9</td>
<td>43</td>
<td>1%</td>
<td>12%</td>
<td>29%</td>
<td>59%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth &lt;= 1.0</td>
<td>41</td>
<td>1%</td>
<td>26%</td>
<td>18%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Table 6.13 (Simulation Results)
The Mean Optimal Portfolios for Households with a **Fifteen-Year** Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (for four types of investment assets)
<table>
<thead>
<tr>
<th>Human Wealth / Total Wealth</th>
<th>Age</th>
<th>VW Index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0 = Human Wealth / Total Wealth</td>
<td>47</td>
<td>0%</td>
<td>4%</td>
<td>4%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
<td>54%</td>
<td>29%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>56</td>
<td>0%</td>
<td>10%</td>
<td>6%</td>
<td>20%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>12%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>61</td>
<td>0%</td>
<td>5%</td>
<td>9%</td>
<td>25%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>24%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>57</td>
<td>0%</td>
<td>4%</td>
<td>7%</td>
<td>18%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>33%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>58</td>
<td>0%</td>
<td>5%</td>
<td>8%</td>
<td>18%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>29%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>58</td>
<td>0%</td>
<td>2%</td>
<td>8%</td>
<td>18%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>34%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>57</td>
<td>0%</td>
<td>2%</td>
<td>9%</td>
<td>22%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>26%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>55</td>
<td>0%</td>
<td>2%</td>
<td>6%</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>31%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>51</td>
<td>0%</td>
<td>2%</td>
<td>6%</td>
<td>11%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
<td>32%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>49</td>
<td>0%</td>
<td>1%</td>
<td>7%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>30%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>44</td>
<td>0%</td>
<td>1%</td>
<td>5%</td>
<td>9%</td>
<td>0%</td>
<td>1%</td>
<td>37%</td>
<td>48%</td>
</tr>
</tbody>
</table>

Table 6.14 (Simulation Results)
The Mean Optimal Portfolios for Households with a One-Year Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (for eight types of investment assets)
<table>
<thead>
<tr>
<th>Age = Human Wealth / Total Wealth</th>
<th>1.0</th>
<th>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</th>
<th>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</th>
<th>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</th>
<th>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</th>
<th>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</th>
<th>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</th>
<th>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</th>
<th>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</th>
<th>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</th>
<th>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>56</td>
<td>61</td>
<td>62</td>
<td>58</td>
<td>59</td>
<td>56</td>
<td>56</td>
<td>51</td>
<td>49</td>
<td>43</td>
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</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>16%</td>
<td>19%</td>
<td>19%</td>
<td>17%</td>
<td>16%</td>
<td>15%</td>
<td>17%</td>
<td>13%</td>
<td>13%</td>
<td>16%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>6%</td>
<td>15%</td>
<td>18%</td>
<td>12%</td>
<td>15%</td>
<td>10%</td>
<td>13%</td>
<td>10%</td>
<td>15%</td>
<td>16%</td>
<td>8%</td>
<td></td>
</tr>
<tr>
<td>2%</td>
<td>14%</td>
<td>20%</td>
<td>7%</td>
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<td>5%</td>
<td>7%</td>
<td>3%</td>
<td>12%</td>
<td>12%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>56%</td>
<td>22%</td>
<td>12%</td>
<td>36%</td>
<td>26%</td>
<td>40%</td>
<td>31%</td>
<td>43%</td>
<td>33%</td>
<td>34%</td>
<td>55%</td>
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</tr>
<tr>
<td>20%</td>
<td>30%</td>
<td>31%</td>
<td>29%</td>
<td>30%</td>
<td>29%</td>
<td>32%</td>
<td>30%</td>
<td>32%</td>
<td>33%</td>
<td>25%</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.15 (Simulation Results)
The Mean Optimal Portfolios for Households with a **Five-Year** Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (for **eight types of investment assets**)
### Table 6.16 (Simulation Results)
The Mean Optimal Portfolios for Households with a **Ten-Year** Investment Time Horizon by the Ratios of Human Wealth to Total Wealth (**for eight types of investment assets**)
Table 6.17 (Simulation Results)
The Mean Optimal Portfolios for Households with a **Fifteen-Year** Investment Time Horizon by the Ratios of Human Wealth to Total Wealth **(for eight types of investment assets)**

<table>
<thead>
<tr>
<th>Human Wealth / Total Wealth</th>
<th>Age</th>
<th>VW Index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 = Human Wealth / Total Wealth</td>
<td>44</td>
<td>0%</td>
<td>34%</td>
<td>1%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
<td>23%</td>
<td>32%</td>
</tr>
<tr>
<td>0.0 &lt; Human Wealth / Total Wealth =&lt; 0.1</td>
<td>59</td>
<td>0%</td>
<td>39%</td>
<td>2%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>17%</td>
<td>28%</td>
</tr>
<tr>
<td>0.1 &lt; Human Wealth / Total Wealth =&lt; 0.2</td>
<td>55</td>
<td>0%</td>
<td>23%</td>
<td>2%</td>
<td>31%</td>
<td>0%</td>
<td>0%</td>
<td>9%</td>
<td>34%</td>
</tr>
<tr>
<td>0.2 &lt; Human Wealth / Total Wealth =&lt; 0.3</td>
<td>55</td>
<td>0%</td>
<td>37%</td>
<td>2%</td>
<td>13%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>46%</td>
</tr>
<tr>
<td>0.3 &lt; Human Wealth / Total Wealth =&lt; 0.4</td>
<td>60</td>
<td>0%</td>
<td>34%</td>
<td>2%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>46%</td>
</tr>
<tr>
<td>0.4 &lt; Human Wealth / Total Wealth =&lt; 0.5</td>
<td>52</td>
<td>0%</td>
<td>22%</td>
<td>2%</td>
<td>24%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
<td>38%</td>
</tr>
<tr>
<td>0.5 &lt; Human Wealth / Total Wealth =&lt; 0.6</td>
<td>57</td>
<td>0%</td>
<td>17%</td>
<td>1%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>31%</td>
<td>45%</td>
</tr>
<tr>
<td>0.6 &lt; Human Wealth / Total Wealth =&lt; 0.7</td>
<td>54</td>
<td>0%</td>
<td>27%</td>
<td>1%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>21%</td>
<td>48%</td>
</tr>
<tr>
<td>0.7 &lt; Human Wealth / Total Wealth =&lt; 0.8</td>
<td>47</td>
<td>0%</td>
<td>28%</td>
<td>1%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>17%</td>
<td>47%</td>
</tr>
<tr>
<td>0.8 &lt; Human Wealth / Total Wealth =&lt; 0.9</td>
<td>43</td>
<td>0%</td>
<td>34%</td>
<td>2%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>15%</td>
<td>41%</td>
</tr>
<tr>
<td>0.9 &lt; Human Wealth / Total Wealth =&lt; 1.0</td>
<td>41</td>
<td>0%</td>
<td>22%</td>
<td>1%</td>
<td>5%</td>
<td>0%</td>
<td>1%</td>
<td>32%</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>VW index</td>
<td>Large Stock</td>
<td>Small Stock</td>
<td>Business Ownership</td>
<td>Corp. Bond</td>
<td>Long-Term Gov. Bond</td>
<td>Inter. Gov. Bond</td>
<td>Real Estate</td>
<td></td>
</tr>
<tr>
<td>---------------</td>
<td>----------</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>-----------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>VW index</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Stock</td>
<td>0.99</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Stock</td>
<td>0.81</td>
<td>0.74</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Ownership</td>
<td>0.95</td>
<td>0.93</td>
<td>0.81</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate Bond</td>
<td>0.38</td>
<td>0.41</td>
<td>0.15</td>
<td>0.35</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term Gov. Bond</td>
<td>0.32</td>
<td>0.35</td>
<td>0.08</td>
<td>0.29</td>
<td>0.97</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter. Gov. Bond</td>
<td>0.27</td>
<td>0.29</td>
<td>0.05</td>
<td>0.23</td>
<td>0.96</td>
<td>0.96</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Estate</td>
<td>-0.06</td>
<td>-0.06</td>
<td>-0.01</td>
<td>-0.05</td>
<td>-0.07</td>
<td>-0.08</td>
<td>-0.12</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.18
Correlation Matrix for 1-Year Inflation-Adjusted Return
<table>
<thead>
<tr>
<th></th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW index</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Stock</td>
<td>0.99</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Stock</td>
<td>0.82</td>
<td>0.74</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Ownership</td>
<td>0.95</td>
<td>0.93</td>
<td>0.81</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate Bond</td>
<td>0.35</td>
<td>0.37</td>
<td>0.16</td>
<td>0.33</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term Gov. Bond</td>
<td>0.28</td>
<td>0.31</td>
<td>0.08</td>
<td>0.27</td>
<td>0.95</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter. Gov. Bond</td>
<td>0.19</td>
<td>0.21</td>
<td>0.03</td>
<td>0.17</td>
<td>0.94</td>
<td>0.94</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Real Estate</td>
<td>-0.06</td>
<td>-0.07</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.22</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.19
Correlation Matrix for 5-Year Inflation-Adjusted Return
<table>
<thead>
<tr>
<th></th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VW index</strong></td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Large Stock</strong></td>
<td>0.99</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Small Stock</strong></td>
<td>0.79</td>
<td>0.70</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Business Ownership</strong></td>
<td>0.95</td>
<td>0.92</td>
<td>0.80</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Corporate Bond</strong></td>
<td>0.38</td>
<td>0.41</td>
<td>0.15</td>
<td>0.34</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Long-Term Gov. Bond</strong></td>
<td>0.32</td>
<td>0.35</td>
<td>0.09</td>
<td>0.29</td>
<td>0.96</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Inter. Gov. Bond</strong></td>
<td>0.25</td>
<td>0.27</td>
<td>0.06</td>
<td>0.21</td>
<td>0.94</td>
<td>0.95</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Real Estate</strong></td>
<td>-0.07</td>
<td>-0.09</td>
<td>0.03</td>
<td>-0.04</td>
<td>-0.21</td>
<td>-0.23</td>
<td>-0.27</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.20
Correlation Matrix for 10-Year Inflation-Adjusted Return
<table>
<thead>
<tr>
<th></th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>VW index</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large Stock</td>
<td>0.99</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small Stock</td>
<td>0.78</td>
<td>0.70</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Ownership</td>
<td>0.93</td>
<td>0.91</td>
<td>0.77</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corporate Bond</td>
<td>0.38</td>
<td>0.40</td>
<td>0.16</td>
<td>0.34</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-Term Gov. Bond</td>
<td>0.30</td>
<td>0.32</td>
<td>0.08</td>
<td>0.26</td>
<td>0.96</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter. Gov. Bond</td>
<td>0.24</td>
<td>0.25</td>
<td>0.05</td>
<td>0.19</td>
<td>0.94</td>
<td>0.95</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Real Estate</td>
<td>-0.14</td>
<td>-0.15</td>
<td>-0.08</td>
<td>-0.11</td>
<td>-0.20</td>
<td>-0.21</td>
<td>-0.26</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 6.21
Correlation Matrix for 15-Year Inflation-Adjusted Return
### Table 6.22 (Efficiency Descriptive Summary)

Descriptive Summary of Comparison between Sharpe Ratio from Simulation Results and Sharpe Ratio from Empirical Results

<table>
<thead>
<tr>
<th>Stated Investment Time Horizon</th>
<th>Inefficient Portfolio</th>
<th>Efficient Portfolio</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of households</td>
<td>%</td>
<td># of households</td>
</tr>
<tr>
<td>&lt;= 1 year</td>
<td>1645</td>
<td>49%</td>
<td>1684</td>
</tr>
<tr>
<td>1 year &lt; t &lt;= 5 years</td>
<td>2188</td>
<td>57%</td>
<td>1642</td>
</tr>
<tr>
<td>5 years &lt; t &lt;= 10 years</td>
<td>1589</td>
<td>35%</td>
<td>2948</td>
</tr>
<tr>
<td>10 years &lt; t &lt;= 15 years</td>
<td>2660</td>
<td>77%</td>
<td>806</td>
</tr>
</tbody>
</table>

**Panel A**

Four Investment Assets in Simulation Program

**Panel B**

Eight Investment Assets in Simulation Program

1. The Sharpe ratio from the simulation result is larger than the Sharpe ratio from the empirical result.
2. The Sharpe ratio from the simulation result is no larger than the Sharpe ratio from the empirical result.
3. Households with no investment assets are not included in the calculation of efficiency tests.
The Efficiency Tests of U.S. Household Investors' Portfolios (Four Investment Assets in Simulation Program)

<table>
<thead>
<tr>
<th>Investment Time Horizon</th>
<th>No of households</th>
<th>%</th>
<th>Total</th>
<th>No of households</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>995</td>
<td>30%</td>
<td>3329</td>
<td>919</td>
<td>28%</td>
<td>3329</td>
</tr>
<tr>
<td>5 years</td>
<td>1404</td>
<td>37%</td>
<td>3830</td>
<td>1034</td>
<td>27%</td>
<td>3830</td>
</tr>
<tr>
<td>10 years</td>
<td>1442</td>
<td>32%</td>
<td>4537</td>
<td>1405</td>
<td>31%</td>
<td>4537</td>
</tr>
<tr>
<td>15 years</td>
<td>1113</td>
<td>32%</td>
<td>3466</td>
<td>945</td>
<td>27%</td>
<td>3466</td>
</tr>
</tbody>
</table>

1. Test Statistic: \( W = \left[ \frac{1}{1+\sigma_i^2} \div \sqrt{1+\sigma_j^2} \right]^2 - 1 \), \( F = \left[ \frac{T*(T-N-1)}{N*(T-2)} \right] W \).
2. The Degrees of Freedom N and (T-N-1). There are 4 investment assets under analysis, and the number of observations in a time series used to estimate mean and standard deviation is 150. Therefore, the degree of freedom is 4 and 145.
<table>
<thead>
<tr>
<th>Investment Time Horizon</th>
<th>$F^1 &gt; F^*_{(0.05,8,141)}$</th>
<th>$F =&lt; F^*_{(0.05,8,141)}$</th>
<th>Total</th>
<th>$F^1 &gt; F^*_{(0.01,8,141)}$</th>
<th>$F =&lt; F^*_{(0.01,8,141)}$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># of households</td>
<td>%</td>
<td># of households</td>
<td>%</td>
<td># of household</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 year</td>
<td>1093</td>
<td>33%</td>
<td>2236</td>
<td>67%</td>
<td>3329</td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>1908</td>
<td>50%</td>
<td>1922</td>
<td>50%</td>
<td>3830</td>
<td></td>
</tr>
<tr>
<td>10 years</td>
<td>1531</td>
<td>34%</td>
<td>3006</td>
<td>66%</td>
<td>4537</td>
<td></td>
</tr>
<tr>
<td>15 years</td>
<td>1529</td>
<td>44%</td>
<td>1937</td>
<td>56%</td>
<td>3466</td>
<td></td>
</tr>
</tbody>
</table>

1. Test Statistic: $W = \sqrt{1 + \frac{S_i^2}{1 + S_j^2} \frac{N}{T}}$, $F = \frac{T(N-1)}{N(T-2)} W$.  
2. The Degrees of Freedom $N$ and $(T-N-1)$. There are 4 investment assets under analysis, and the number of observations in a time series used to estimate mean and standard deviation is 150. Therefore, the degree of freedom is 8 and 141.

Table 6.24 (Efficiency Tests)  
The Efficiency Tests of U.S. Household Investors’ Portfolios (Eight Investment Assets in Simulation Program)
<table>
<thead>
<tr>
<th>Age Range</th>
<th>Expected Investment Horizon</th>
<th>Expected Target Real Accumulations</th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>30-40 years old</strong></td>
<td>1 year</td>
<td>High</td>
<td>1.10</td>
<td>0%</td>
<td>0%</td>
<td>21%</td>
<td>56%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>1.07</td>
<td>0%</td>
<td>7%</td>
<td>5%</td>
<td>17%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>1.04</td>
<td>0%</td>
<td>1%</td>
<td>4%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td>5 years</td>
<td>High</td>
<td>1.65</td>
<td>0%</td>
<td>0%</td>
<td>14%</td>
<td>63%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>1.40</td>
<td>0%</td>
<td>27%</td>
<td>5%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>1.15</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>10 years</td>
<td>High</td>
<td>2.80</td>
<td>0%</td>
<td>2%</td>
<td>24%</td>
<td>57%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>2.10</td>
<td>0%</td>
<td>26%</td>
<td>4%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>1.45</td>
<td>0%</td>
<td>7%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>15 years</td>
<td>High</td>
<td>5.00</td>
<td>0%</td>
<td>10%</td>
<td>27%</td>
<td>45%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Median</td>
<td>3.45</td>
<td>0%</td>
<td>13%</td>
<td>8%</td>
<td>14%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
<td>2.10</td>
<td>0%</td>
<td>3%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

- Human Wealth / Total Wealth = 0.72954 (Mean value for household investors with age between 30 and 40 years old);
- Pre-Retirement HW / Total HW =0.69063 (Mean value for household investors with age between 30 and 40 years old);
- Net primary residence ratio = 0.12833 (Mean value for household investors with age between 30 and 40 years old);

Table 6.25 (Efficient Frontier)
Efficient Frontier for Household Investors with Age Between 30 and 40 Years Old
<table>
<thead>
<tr>
<th>Age Range</th>
<th>Expected Investment Horizon</th>
<th>Expected Target Real Accumulations</th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-50 years old</td>
<td>1 year High</td>
<td>1.10</td>
<td>0%</td>
<td>19%</td>
<td>19%</td>
<td>45%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.07</td>
<td>0%</td>
<td>32%</td>
<td>12%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>32%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.03</td>
<td>0%</td>
<td>6%</td>
<td>8%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>76%</td>
</tr>
<tr>
<td></td>
<td>5 years High</td>
<td>1.65</td>
<td>0%</td>
<td>1%</td>
<td>15%</td>
<td>62%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.40</td>
<td>0%</td>
<td>29%</td>
<td>5%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.15</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>75%</td>
</tr>
<tr>
<td></td>
<td>10 years High</td>
<td>2.85</td>
<td>0%</td>
<td>1%</td>
<td>26%</td>
<td>59%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>2.15</td>
<td>0%</td>
<td>25%</td>
<td>5%</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.45</td>
<td>0%</td>
<td>7%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>67%</td>
</tr>
<tr>
<td></td>
<td>15 years High</td>
<td>5.10</td>
<td>0%</td>
<td>11%</td>
<td>29%</td>
<td>46%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>3.60</td>
<td>0%</td>
<td>14%</td>
<td>10%</td>
<td>16%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.15</td>
<td>0%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>38%</td>
</tr>
</tbody>
</table>

- Human Wealth / Total Wealth = 0.65527 (Mean value for household investors with age between 40 and 50 years old);
- Pre-Retirement HW / Total HW = 0.65151 (Mean value for household investors with age between 40 and 50 years old);
- Net primary residence ratio = 0.15433 (Mean value for household investors with age between 40 and 50 years old);

Table 6.26 (Efficient Frontier)
Efficient Frontier for Household Investors with Age Between 40 and 50 Years Old
<table>
<thead>
<tr>
<th>Age Range</th>
<th>Expected Investment Horizon</th>
<th>Expected Target Real Accumulations</th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-60 years old</td>
<td>1 year High</td>
<td>1.10</td>
<td>0%</td>
<td>0%</td>
<td>22%</td>
<td>55%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.07</td>
<td>0%</td>
<td>11%</td>
<td>7%</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
<td>5%</td>
<td>65%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.04</td>
<td>0%</td>
<td>3%</td>
<td>5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>45%</td>
<td>47%</td>
</tr>
<tr>
<td></td>
<td>5 years High</td>
<td>1.65</td>
<td>0%</td>
<td>1%</td>
<td>15%</td>
<td>61%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.40</td>
<td>0%</td>
<td>29%</td>
<td>5%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>19%</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.15</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>74%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>10 years High</td>
<td>2.80</td>
<td>0%</td>
<td>2%</td>
<td>24%</td>
<td>57%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>17%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>2.10</td>
<td>0%</td>
<td>27%</td>
<td>4%</td>
<td>7%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.45</td>
<td>0%</td>
<td>7%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>66%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>15 years High</td>
<td>5.10</td>
<td>0%</td>
<td>11%</td>
<td>29%</td>
<td>46%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>3.60</td>
<td>0%</td>
<td>14%</td>
<td>10%</td>
<td>16%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.15</td>
<td>0%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>38%</td>
<td>57%</td>
</tr>
</tbody>
</table>

- Human Wealth / Total Wealth = 0.58320 (Mean value for household investors with age between 50 and 60 years old);
- Pre-Retirement HW / Total HW = 0.46721 (Mean value for household investors with age between 50 and 60 years old);
- Net primary residence ratio = 0.16155 (Mean value for household investors with age between 50 and 60 years old);

**Table 6.27 (Efficient Frontier)**

Efficient Frontier for Household Investors with Age Between 50 and 60 Years Old
### Table 6.28 (Efficient Frontier)

**Efficient Frontier for Household Investors with Age Between 60 and 70 Years Old**

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Expected Investment Horizon</th>
<th>Expected Target Real Accumulations</th>
<th>VW index</th>
<th>Large Stock</th>
<th>Small Stock</th>
<th>Business Ownership</th>
<th>Corp. Bond</th>
<th>Long-Term Gov. Bond</th>
<th>Inter. Gov. Bond</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>60-70 years old</strong></td>
<td>1 year</td>
<td>High</td>
<td>1.10</td>
<td>0%</td>
<td>20%</td>
<td>21%</td>
<td>42%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.07</td>
<td>0%</td>
<td>35%</td>
<td>13%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>31%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.03</td>
<td>0%</td>
<td>5%</td>
<td>9%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>75%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>5 years</td>
<td>High</td>
<td>1.65</td>
<td>0%</td>
<td>2%</td>
<td>16%</td>
<td>60%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>1.40</td>
<td>0%</td>
<td>29%</td>
<td>5%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>19%</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.15</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>73%</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>10 years</td>
<td>High</td>
<td>2.80</td>
<td>0%</td>
<td>2%</td>
<td>24%</td>
<td>56%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>2.10</td>
<td>0%</td>
<td>27%</td>
<td>4%</td>
<td>7%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>52%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>1.45</td>
<td>0%</td>
<td>7%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>66%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>15 years</td>
<td>High</td>
<td>5.05</td>
<td>0%</td>
<td>12%</td>
<td>29%</td>
<td>45%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>3.60</td>
<td>0%</td>
<td>14%</td>
<td>10%</td>
<td>15%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.25</td>
<td>0%</td>
<td>5%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>32%</td>
<td>61%</td>
</tr>
</tbody>
</table>

- Human Wealth / Total Wealth = 0.50683 (Mean value for household investors with age between 60 and 70 years old);
- Pre-Retirement HW / Total HW = 0.10144 (Mean value for household investors with age between 60 and 70 years old);
- Net primary residence ratio = 0.25933 (Mean value for household investors with age between 60 and 70 years old);
CHAPTER 7

SUMMARY, CONCLUSIONS, LIMITATIONS, AND IMPLICATIONS

7.1 Summary and Conclusions

The purpose of this paper is to analyze the rationality of asset allocation among U.S. households, based on inclusion of human wealth in the model, taking household’s net primary residence ratio as an exogenous variable, consideration of different planned horizons for investments for household investors, and inclusion of proxies for real estate return and for small business ownership in the market portfolio.

Descriptive data about household investors’ actual portfolios were obtained from the 1998 SCF. Prescriptive data about the efficient portfolios were obtained from simulation. Descriptive data were then compared to prescriptive data and statistic tests were applied to test the efficiency of household investors’ portfolios.

In empirical results, the mean of the annualized expected return is 5.37%, while the median is 6.41%. Compared to the annualized return data calculated from the 1948-
1998 Ibboston Associate, both the mean value of 5.37% and median value of 6.41% are close to the annualized real estate return data. In addition, about 9.3% of the total population will expect to earn an annualized expected return equal to 0. All these respondents are households with no investment assets. Furthermore, the distribution of U.S. household investors’ annualized expected returns for their investment portfolios is widely spread and asymmetric. There are two possible reasons to explain the shape of this kind of distribution. One is that there are extreme differences in the wealth values of the total population in the U.S. The other possible reason is that some household investors are too conservative in their investment decisions. Both of these explanations are documented by economists. Some further decomposition should be done before further conclusions can be made.

The following conclusions can be drawn from the simulation results. The resulting efficient portfolios have expected returns equal to those of the households’ current portfolios while the risk of the portfolios is lower.

1. The simulation results show that the prescriptive investment percentages in real estate-related assets should be above 30% when the households’ investment horizons are larger than 5 years. In addition, the longer the expected time horizons, the higher percentages one had better to invest ones money in some real estate-related assets. This result is consistent with the recommendation from the investment industry that “REITs are conservative, and are good long-term holdings on the seven-year horizon.” (Smart Money, p.71, 1/ 2003). On the other hand, although there are some exceptions, the prescriptive investment percentages in business ownership should decrease while human wealth ratios increase.
2. Value-weighted index, corporate bonds, and long-term government bonds will not be optimal investment assets for household investors no matter what their investment time horizons are.

3. Intermediate government bonds will be a good investment to be included in the household investors’ portfolios especially when household investors’ investment time horizons are within 10 years.

4. Investors would be better off reallocating more of their assets among intermediate government bonds, real estate and business ownership (in terms of the equally-weighted smallest-size stocks in the CRSP data set), especially household investors with investment time horizons larger than 5 years.

In regard to the investment in business ownership, an individual could invest in microcap stocks to achieve a similar expected result to business ownership, instead of running a business himself/herself.

Real estate is a good asset in an efficient portfolio because it provides rates of return that compare favorably with those of common stocks and bonds, but at remarkably low levels of risk. Furthermore, real estate typically does not have substantial positive correlation with common stocks or bonds (most of these correlations are negative), a characteristic that allows diversification without sacrificing much return. The diversification advantages of real estate related assets especially benefit those respondents with high human wealth. This is because people who have high human wealth will be sensitive to the business cycle. The risk characteristic of household
investors with high human wealth can be further diversified when real estate assets are included in the portfolios.

In the formal efficiency test of households’ current portfolios, 28% of respondents who have investment time horizons less than or equal to 1 year hold statistically significant inefficient portfolios when the probability associated with the F cumulative distribution is equal to 0.01. In addition, 27% of respondents who have investment time horizons equal to 5 years and 31% of respondents who have investment time horizons equal to 10 years hold inefficient portfolios (statistically significant). Furthermore, 27% of respondents who have investment time horizons equal to 15 years hold inefficient portfolios based on the probability of 0.01.

By analyzing the additional expected risk premium (expected return minus the risk free rate) that can be achieved by moving from the actual to the minimum-variance efficient portfolios, it is found that the expected risk premium can be improved by 0.60 units per units of risk (in terms of standard deviation) for households who hold statistically significant inefficient portfolios. This additional expected risk premium can be achieved by reallocating investment assets from current portfolios to some real-estate related assets (such as REIT), intermediate government bonds, or business ownership-related assets.
7.2 Limitations of This Study

The test results presented in this study may be sensitive to the assumptions made about expected returns and risks. In this study, it is assumed that investors could choose efficient portfolios based on historical returns and covariance data, but could not successfully engage in market timing. Under this assumption, the resampling procedure can be applied to historical observed inflation-adjusted annual return data in this study to generate future holding-period return distributions. As an alternative, a model of how individual investors predict future return should be specified in order to generate ex ante expected return and risk of portfolios.

In addition, the analyses and tests in this study are based on the following assumptions about proxy to return on real estate and financial assets:

1. Each household's real estate holdings (except primary residence) match the corresponding category in terms of expected return and variance. In this study when return and risk of real estate are calculated (in both empirical and simulation sections), some adjustment have been made to deal with the problem that investment in real estate often has little geographic and type diversification. This problem might not have been eliminated totally due to the limitations of no long-term time series data and no large-scale cross sectional individual return data for real estate.

2. Each household's financial asset holdings match the corresponding category in terms of expected return and variance. For those who invest largely in mutual funds, for instance, in retirement accounts, this may be a reasonable assumption, but for others, it might be unreasonable.
Further research can attempt to make adjustment for lack of diversification within households if some new data sets can be obtained.

7.3 Implications

7.3.1 Implications for Further Research

In basic economic theory, an individual investor’s utility curves specify the trade-offs he or she is willing to make between expected return and risk. In addition, the efficient frontier represents that set of portfolios that has the minimum risk for every level of return. In conjunction with the efficient frontier these utility curves determine which particular efficient portfolio, as defined as an optimal portfolio, best suits an individual investor. This optimal portfolio is the efficient portfolio that has the highest utility for a given investor. It lies at the point of tangency between the efficient frontier and the curve with the highest possible utility. If one wants to know the optimal portfolio for a particular investor, some assumptions about utility function and the measure of risk tolerance for an individual investor should be made.

There is a self-reported risk tolerance measure in the 1998 SCF. This is a measure of an individual’s willingness to accept risk. Respondents are asked whether or not they are (1) willing to take substantial risks on investments in order to make a substantial return, or (2) willing to take about average risks to make an above average return on investments, or (3) willing to take average risks to make an average return on
investments, or (4) not willing to take any financial risks. However, Hanna, Gutter and Fan (2001) present an improved measure of subjective risk tolerance based on economic theory and discuss its link to relative risk aversion. Results from a web-based survey are presented and compared with the answers to the SCF risk tolerance measure; they found no statistically significant correlations for this self-reported measure in the SCF.

Although some other researchers have different results (e.g., Schooley and Worden 1996), the problem related to the usefulness of the self-reported risk attitude measure is unsolved. Further research to estimate the risk tolerance of household investors from SCF should be done before the optimal portfolio for each household can be calculated.

7.3.2 Implications for Policymakers and Financial Planners

Popular Advice on Portfolio Allocation

Table 7.1 shows the recommendations of four financial advisors. The recommendations in part A come from the recommendations made by Fidelity Investment (Larry Mark, 1993). Those in part B come from a book promoted by Merrill Lynch (Don Underwood and Paul B. Brown, 1993). Those in part C come from a book by Jane Bryant Quinn (1991), a prominent journalist who writes on personal financial planning. Those in part D come from an article in the New York Times (Mary Rowland, 1994). Each of the advisors presents recommended allocations among stocks, bonds, and cash for three investors with different preferences toward risk. The last column is the ratio of bonds to stocks, which is used to measure the composition of risky assets. For all
of the advisors, the recommended ratio of bonds to stocks falls as the investor becomes more willing to take the risk.

In addition to willingness to take risk, many advisors suggest that investors should vary their mix of assets depending on how long they plan to invest. The further investors are from their investment goal, the more they should have in stocks. The closer they get, the more they should lean toward bonds and money-market instruments, such as Treasury Bills. Bonds and money-market instruments may generate lower returns than stocks. But for those who need money in the near future, conservative investments make more sense, because there is less chance of suffering a devastating short-term loss.

Some investment advisors consider gold and real estate in addition to the usual trio of stocks, bonds, and money-market instruments. Gold and real estate are said to give “a hedge against hyperinflation, and the real estate is better than gold, because one will get better long-run returns.” However, no investment advisors give the specific percentages about asset allocation in real estate-related assets.
<table>
<thead>
<tr>
<th>Advisor and investor type</th>
<th>Cash</th>
<th>Bond</th>
<th>Stocks</th>
<th>Ratios of bonds to stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Fidelity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservative</td>
<td>50</td>
<td>30</td>
<td>20</td>
<td>1.5</td>
</tr>
<tr>
<td>Moderate</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>1</td>
</tr>
<tr>
<td>Aggressive</td>
<td>5</td>
<td>30</td>
<td>65</td>
<td>0.46</td>
</tr>
<tr>
<td>B. Merrill Lynch</td>
<td></td>
<td></td>
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<td>35</td>
<td>45</td>
<td>0.78</td>
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<tr>
<td>Moderate</td>
<td>5</td>
<td>40</td>
<td>55</td>
<td>0.73</td>
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<tr>
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<td>20</td>
<td>75</td>
<td>0.27</td>
</tr>
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<td>C. Jane Bryant Quinn</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>50</td>
<td>30</td>
<td>20</td>
<td>1.50</td>
</tr>
<tr>
<td>Moderate</td>
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<td>40</td>
<td>50</td>
<td>0.80</td>
</tr>
<tr>
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<td>100</td>
<td>0.00</td>
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<tr>
<td>D. The New York Times</td>
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<tr>
<td>Conservative</td>
<td>20</td>
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<td>1.00</td>
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<tr>
<td>Moderate</td>
<td>10</td>
<td>30</td>
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<td>0.50</td>
</tr>
<tr>
<td>Aggressive</td>
<td>0</td>
<td>20</td>
<td>80</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Table 7.1 Asset Allocation Recommended by Financial Advisors

*Advice on Portfolio Allocation in This Study*

In this study, the real estate-related assets are included in the model to obtain the mean-variance efficient portfolios for household investors. Furthermore, most of the recommended allocations from advisors are among stocks, bonds, and cash. However, there are different types of stocks and bonds, such as small stocks, large stocks, intermediate government bonds, or corporate bonds, and the performance of these securities are quietly different. Most of the investment advisors do not give specific...
recommendations within one category, such as small or large stocks in the category of stocks. This study tries to give a more detailed analysis on this issue. Not only the broad categories of securities, such as stocks and bond, are studied, but also different types of stocks and bonds, such as small stocks and intermediate government bonds, are included in the model to obtain the efficient portfolios.

Furthermore, this study also provides efficient portfolios based on individual investors’ ex ante expected investment horizons, and individual investors’ “risk capacity”. In “A Random Walk Down Wall Street”, Burton Malkiel (1996) assets that risk tolerance is a function of both an individual’s attitude toward risk as well as his or her risk capacity. Risk attitude is a purely subjective matter and are usually measured in terms of risk aversion, but risk capacity, according to Malkiel, tends to be related to an investor’s place in the life cycle. In this study, the content of risk capacity is extended. In addition to stages in life cycle of household investors, the size of household’s expected future labor income, expected labor income growth, perceived stability of labor income, and the correlation of labor income with other financial assets are all considered in the measure of human wealth ratio and the modified mean-variance efficient portfolio model.

The efficient frontiers are presented in Tables 6.25, 6.26, 6.27, 6.28. Table 6.25 represents the efficient portfolios for a household investor with age between 30 and 40 years old. The mean value of the household investor’s human wealth ratios is 0.72954 for this group and he/she earns an industry-averaged labor income growth. In addition, the industry-averaged unemployment rates and industry-averaged unemployment durations are used for the calculation of stability of future labor income. A household investor can find the mean-variance efficient portfolios in this table based on his/her
expected investment horizon and expected target real accumulation. For example, for a household investor with age between 30 and 40 years old and with expected investment horizon equal to 15 years, the efficient portfolio will be 10% in large stock-related assets, 27% in small stock-related assets, 45% in business ownership-related assets (in terms of the equally-weighted smallest-size stocks in the CRSP data set) and 18% in real estate-related assets. This portfolio will expect to result in $5 of real accumulation in 15 years for $1 initial investment.

Tables 6.25 to Table 6.28 show that the efficient frontiers are composed of small stock companies, business ownership (the smallest-size companies in the CRSP dataset), intermediate government bonds, real estate and large stock companies. Table 6.25 to Table 6.28 in this study present that rational people with high risk aversion should invest in intermediate government bonds and real-estate-related assets. Those who have low risk aversion should invest high proportion of investment assets in a small stock fund and business ownerships. Those who have risk aversion between these two points should choose a combination on the order of intermediate government bonds, real estate, large stock funds, small stock funds and business ownership. The expected return and risk that household investors should choose will depend on their utility functions, but will be on the frontier between these two points.

Table 6.25 to Table 6.28 can serve as guidelines for household investors for their asset allocation decisions, when their ages, and planned investment time horizons are matched to the corresponding classes.
REFERENCES


