Dynamic Asset Allocation Modeling for International Investment: A Comparison of Information-Based Active Strategies Versus Passive Strategies for the EAFE and S&P 500 Portfolios

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ABSTRACT

Dynamic Asset Allocation Modeling for International Investment: A Comparison of Information-Based Active Strategies Versus Passive Strategies for the EAFE and S&P 500 Portfolios

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Tactical asset allocation has become popular in asset management since the stock market crash in October 1987. Researchers and practitioners have always promoted the benefits of international diversification. Much research has been done in domestic asset allocation and global asset allocation. However, a portfolio mix between the S&P 500 Index and the MSCI EAFE Index is a novel combination for tactical asset allocation. The objective of this study is to develop a dynamic asset allocation strategy dealing with such an asset mix. A rolling binary logit model is built using the preceding sixty months of data and is used to forecast the next month's movements of these two indices. Forty-eight trading strategies are implemented to validate the forecastability of the prediction model using the out-of-sample data from January 1978 to September 1999.

This study affirms that a dynamic asset allocation strategy can be established to time the market and generate a superior abnormal return on a portfolio investing in these two assets. A prediction model can be built on public information variables to successfully forecast the upcoming movements of these two indices. Even with transaction costs, an investor can rely on the signals to make asset allocation between these two indices and produce a terminal wealth significantly larger than the passive portfolios invested in either one of the indices alone.

To T.P., Y.P. and my parents

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1 Introduction

Tactical asset allocation has become a popular strategy in asset management since the October 1987 market crash. The value added by a successful tactical asset allocation strategy relies on the manager's market-timing ability, since the portfolio weights in different asset classes are altered according to the manager's perfect foresight. The driving force behind tactical asset allocation strategy is the recent evidence on the predictability of stock returns using fundamental, technical, or sentiment indicator variables.

There is an extensive body of literature that covers the predictability of stock returns. For example, Rozeff (1984) suggests dividend yield is an estimate of the equity risk premium. Fama and French (1993), MacBeth and Emanuel (1993), and Chan, Karceski, and Lakonishok (1998) claim that macroeconomic variables such as the default premium and the term premium, and fundamental variables such as dividend yield, size, and book-to-market, are able to do a good job in explaining stock returns. Breen, Glosten, and Jagannathan (1989), and Pesaran and Timmermann (1995) confirm that short-term interest rates can predict stock excess returns. Sung and Urrutia (1995) show that there is a long-term and short-term causal relation between dividends and stock prices. Wu and Wang (2000) conclude that both dividend and earnings yields have predictive power on future stock returns. Jensen, Mercer, and Johnson (1996), Thorbecke, W. (1997), Johnson and Jensen (1998), Conover, Jensen, and Johnson (1999), and Park and Ratti (2000) find that monetary policy has a significant impact on expected stock returns. Patelis (1997) emphasizes that monetary policy variables are valuable predictors of excess stock returns. Brocato and Steed (1998) and Erb, Harvey, and Viskanta (1994) assert that business cycles affect stock prices.

Research in domestic asset allocation usually focuses on an asset mix among stocks, bonds, and Treasury bills, while research in global asset allocation usually deals with the largest stock markets in the world. Much research has been done in searching for the best forecasting models using different model selection criteria, and in determining the predictability of explanatory variables.

Nam and Branch (1994) develop a tactical asset allocation strategy between the one-month U.S. Treasury bills and the S&P 500 Index. They use publicly available information such as the dividend-price ratio, previous month Treasury bill rate, change in the Treasury bill rate, and growth in earnings per share in their logit model to estimate the probabilities of the two states of the upcoming market month: bullish or bearish. The allocation between the two assets is then adjusted according to the forecasts. Their results reveal that the active strategies outperform the control strategies for both the in-sample period and the out-of-sample period. However, the gains from the active strategies are substantially reduced when transaction costs are accounted for. They suggest that frequent rebalances of the portfolio mix is not beneficial when the market risk environment only changes modestly. Furthermore, they found that the logit model provides a result superior to a comparative model using ordinary least squares.

Larsen and Wozniak (1995) establish a two-month sequential trading rule, based on the current and the past two months' forecasts generated by a logit model, to invest in either assets: stocks or bonds, and stocks or Treasury bills. They use nine explanatory variables in their prediction model, which include three bond-market factors, four stock-market factors, and two macroeconomic factors. For most of the explanatory variables, they include the first two lagged values in the regression. Their out-of-sample results indicate that active asset allocation strategies produce a superior risk-adjusted return to the passive strategies. Furthermore, the active strategies require making fewer transactions than the fixed-weight strategies, which require monthly rebalancing.

Breen, Glosten, and Jagannathan (1989) confirm the forecasting power of one-month Treasury bill returns in predicting the stock excess returns. Their prediction model uses Treasury bill returns as the only explanatory variable and a three-year rolling estimation period to forecast the stock excess returns. They assess the model's market timing ability using the Cumby-Modest (1987) test and the Henriksson-Merton (1981) test. The portfolio formed by trading strategy using the forecasted signals to invest fully in either stocks or Treasury bills produces an economically significant result during the out-of-sample period from April 1954 to December 1986. They explain that the active strategy is useful partly due to the stock excess return being relatively less volatile during forecasted up markets than during forecasted down markets.

Kairys (1993) test the predictive ability of three forecasting models using the ex ante commercial paper rates and a regression window of sixty months to predict the direction of the stock market: bullish or bearish. The three models include two linear probability models, one regressing on the level of commercial paper rates and the other regressing on the change in commercial paper rates, and a third model based on Van Strum (1927) using only the directional changes in commercial paper rate to classify the upcoming market direction. A trading strategy is formed to invest in the stock index when a forecast calls for a bull market and in the risk-free asset when a forecast indicates a bear market. The Jensen (1968) test, the Henriksson-Merton (1981) test, and the Cumby and Modest (1987) test are performed to assess the forecasting ability of the models. All three tests confirm the Van Strum (1927) model has strong forecasting power. Furthermore, even with 1 percent transaction costs, trading strategies formed on the three models are able to generate a return superior to the buy-and-hold strategy.

Klemkosky and Bharati (1995) use Mallow's criterion to identify the best prediction models to forecast the returns on the S&P 500 Index and a corporate bond index at the beginning of every month. They base their linear regression models on eleven publicly known predictor variables, which include four term-structure factors, four stock-market factors, and three bond-market factors. An all-possible-regressions approach using a five-year rolling estimation period is employed for the model selection process. The portfolio with the highest Sharpe ratio is chosen as the optimal portfolio, and its ex post performance is then calculated using the actual asset returns. They invest in one-month Treasury bills when the expected returns of both assets are less than the one-month Treasury bill rate. Their results disclose that active portfolio outperforms the comparative portfolios in return and risk, with and without transaction costs

Pesaran and Timmermann (1995) use the all possible combinations of nine predictor variables: the first lag of dividend yield and earnings-price ratio, the first two lags of one-month Treasury bill and twelve-month Treasury bond rates, the second lag of the yearly rate of change of inflation, industrial production and money stock, and a six-year estimation window in their regression models to forecast the asset returns. The optimal models are selected using four predetermined model selection criteria to generate forecasts each month. Accordingly, trading strategies are established to switch a portfolio to either stocks or bonds. They use the Sharpe ratio to evaluate the performance of various portfolios. Their results indicate that the predictor variables included in a forecasting model change with the business cycle. As a result, the forecasting model also changes with time. They suggest that this reflects learning in the marketplace, which is a continuous process. The only predictor variable that is included in the forecasting models throughout the whole sample period is the first lag of one-month Treasury bill rate. And, the dividend yield has become significant around 1970. Furthermore, the active portfolio can generate a superior return to the market return when the markets are volatile but not when the markets are relatively calm.

Bossaerts and Hillion (1999) use seven statistical model selection criteria to choose the models with the maximum external validity for the prediction of excess returns in fourteen international stock markets, and the essential predictors among ten publicly known variables: a January dummy, the first two lags of the monthly excess stock return, the first two lags of the monthly bond excess return, a Treasury bond yield, a three-month Treasury bill yield, the stock index price level, the stock index dividend yield, the market index price-earnings ratio. Their results confirm predictability in the five-year in-sample period, however no such ability is found in the out-of-sample dataset. They attribute the model's inability to predict partly to model nonstationarity and partly to the use of only linear models. They claim that the "true" prediction model may be nonlinear.

Hardy (1990) implements a global asset allocation strategy using the forecasts of a prediction model for the U.S. stock market and five foreign stock markets. The prediction model includes four basic explanatory variables: a January dummy, the short-term rate, the spread between long and short rates, and the historical dividend yield, to forecast the excess stock returns of the U.S. stock market. For the foreign markets, the regression model incorporates two more explanatory variables: the U.S. short rate and the U.S. dividend yield, to reflect the importance of the U.S. market. The regression model uses an eighty-four-month rolling estimation window to generate forecasts for the out-of-sample period. The results reveal that the same explanatory variables can be used to forecast the dollar excess returns on stock indexes for all six countries. Also, a tactical asset allocation strategy using the forecasts to make investment decisions across markets can generate an excellent portfolio performance.

Kahn, Roulet, and Tajbakhsh (1996) propose a three-step approach to develop global asset allocation strategies. They first build a linear regression model using the same five explanatory variables: the predicted dividend yield, the short-term interest rate, the spread between the country's and the U.S. short rate, the exchange rate to U.S.

dollars, and a January dummy, to forecast the expected excess returns of the U.S. and twenty international stock markets. The regression window begins with the first thirty-month data and is progressively expanded until it reaches sixty months. They then form a mean-variance optimal portfolio based on the expected returns and variations provided by step one. Finally, they use the Sharpe ratio and information ratio to measure the out-of-sample portfolio performance from January 1993 to March 1995. They find that their model has a better out-of-sample performance than the Solnik (1993) model.

Researchers and practitioners have always promoted the benefits of international diversification. For instance, Odier and Solnik (1993) state that investing internationally enhances portfolio return and reduces portfolio risk. The risk-diversification provided by international investments can be explained by the low cross-country correlations. De Santis and Gerard (1997) reveal that severe market declines are contagious, however the increasing integration among international markets has not significantly affected the expected gains from international diversification. Hardy (1990) confirms that international diversification is advantageous.

Much research has been done in global asset allocation. To the best of our knowledge, there has not been any study on a two-way asset mix between the S&P 500 Index and the Morgan Stanley Capital International Europe, Australia and the Far East (MSCI EAFE) Index. Our research will be the first paper on a tactical asset allocation strategy dealing with such a novel combination. Apparently, it would be more financially feasible for an investor to invest in two equity indices than in all the countries involved to achieve the same diversification effect. Moreover, the savings in transaction costs would be substantial. Hence, the results of this research will provide a significant contribution to the tactical asset allocation and global diversification literature.

The primary objective of this research is to develop a dynamic asset allocation strategy to enhance an investor's international investment return, without incurring a higher risk. In this paper, we focus on a two-way asset allocation between the S&P 500 Index and the MSCI EAFE Index. Initially, twenty three times series are chosen as possible candidates to construct the prediction model. To safeguard for the presence of nonstationarity in the candidate time series, we employ the Augmented Dickey-Fuller test to check for unit roots, and the first-differencing technique to convert a nonstationary series into a stationary series. To select explanatory variables for the prediction model, we use the results of the pairwise Granger causality tests on the relation between the candidate time series and the return spread between the two indices. We then analyze the long-run relationship between the two indices. Subsequently, we use binary logit regression to construct the base model to predict the upcoming movements of these two assets using an in-sample dataset. The model is then validated for its predictive ability through the use of an out-of-sample dataset. Following the forecasts, the portfolio's exposure in these two assets is adjusted accordingly over time, using forty-eight trading strategies. We evaluate the performance of the active portfolios against several control portfolios. To check the robustness of the model's predictive ability, we perform three different market-timing tests. Furthermore, we investigate the effect of transaction costs on the actively managed portfolios.

Our study concludes that a tactical asset allocation strategy can be developed to time the market and generate a consistent and superior return on a portfolio investing in the S&P 500 Index and the MSCI EAFE Index. A logit model can be built on public information variables to successfully forecast the upcoming movements of these two indices. Even with transaction costs, an investor can rely on the signals provided by the model to make asset allocation between these two assets and produce a terminal wealth significantly larger than the portfolios invested in either index alone. However, an investor should not neglect the adverse effect of transaction costs, especially when the costs involved are high and the market expectations are weak.

The paper is organized as follows. Section II describes the data and methodology. Section III explains the model construction and validation procedures. Section IV presents the trading strategies and results. Section V discusses the tests of market timing ability. Section VI examines the effect of transaction costs on the active portfolios. Section VII concludes the paper and suggests future research that could extend this work.

2 Data and Methodology

2.1 Data

The monthly data used in this study are from five different sources, namely Ibbotson Associates, DataStream, International Monetary Fund (International Financial Statistics), The Federal Reserve Board, and Standard and Poor's. In total, twenty-six time series (eleven EAFE and fifteen U.S.) are used in this research. Twenty-three of the series (eleven EAFE and twelve U.S.) are engaged as possible candidates for the prediction model (see Appendix I).

The MSCI EAFE Index starts in January 1970. However, some of the EAFE data series have no data for the first three years following the start of the Index, the sample begins in January 1973.

The sample covers the period January 1973 to September 1999. The first sixty months (i.e., January 1973 to December 1977) are used as the in-sample period for model construction, and the subsequent two hundred and sixty one months (i.e., January 1978 to September 1999) are used as the out-of-sample period for model validation.

2.1.1 Compilation of the EAFE Data

Because some data are not available for some of the twenty countries in the MSCI EAFE Index, ten countries, namely United Kingdom, Germany, France, Netherlands, Switzerland, Italy, Spain, Sweden, Australia and Japan, are chosen to compile the EAFE series used in this paper.

The EAFE data are calculated as the GDP-weighted average of the ten selected countries, of which the GDP total represents 85.18 percent of the GDP total of the twenty countries in the index. Hence, the compiled data series should offer a good representation of the EAFE Index.

2.1.2 Missing Observations

Even though only ten countries are used to compile the EAFE data, the problem of missing observations still exists for some of the EAFE variables. Such problem is dealt with in one of the following ways: (a) previous values are used if only one or two observations are missing; (b) the ranges of missing values for one or more countries are dropped and the GDP weights for the remaining countries are adjusted to 100 percent for the calculation of the EAFE data; or (c) a proxy variable, which is highly correlated with the variable that has missing observations, is used to calculate the values of the missing observations, if such proxy can be found. Also, if monthly data is unavailable for a country, for example the Australian Consumer Price Index is a quarterly series, linear interpolation is used to convert the available series to a monthly series.

The U.S. data are complete and, therefore, the problem of missing observations does not exist.

2.2 Methodology

2.2.1 Stationarity Test

There are many studies showing that macroeconomic time series follow random walks, i.e., they are nonstationary time series. The coefficients generated by a regression model using nonstationary series cannot be used for forecasting because the structural relationships between the dependent and independent variables described by the model change over time (Pindyck and Rubinfeld, 1991).

Therefore, every candidate time series is tested for unit root using the Augmented Dickey-Fuller unit root test at a critical value of 5 percent (Arshanapalli and Doukas, 1993; Sung and Urrutia, 1995). Out of the twenty-three selected series, ten series are found to be following random walks. The nonstationary series are then transformed into stationary series using first-differencing technique, i.e., $\Delta X_t = X_t - X_{t-1}$.

2.2.2 Selection of Predictor Variables

Granger causality tests have been used in different research projects to examine the relationship between two time series. Sung and Urrutia (1995) employ the error correction model to examine the long-term and short-term relations between the S&P 500 index prices and dividends. Arshanapalli and Doukas (1993) use the theory of cointegration and error correction model to study the linkages and dynamic interactions among the world's five largest stock markets. Gallinger (1994) uses Granger causality tests to analyze the relation between real stock returns and real activity.

To test if there is any relation between the candidate variables and the spread (SP500EAFE) between the S&P 500 Index total return (SP500TR) and the MSCI EAFE Index total return (EAFETR), i.e., SP500TR – EAFETR, pairwise Granger causality tests are conducted to examine which variables, in the original or first-differenced series, cause changes in the spread.

As in Arshanapalli and Doukas (1993), two regressions are run to test whether X causes Y. First, Y is regressed on its own lagged values to find the optimal lag length P for Y. Then, Y is regressed on its own optimal lag length P and the lagged values of X to find the optimal lag length Q for X. The two regressions are

$$Y_t = \delta_0 + \sum_{x=1}^{P} \delta_x Y_{t-x}$$

$$Y_t = \alpha_0 + \sum_{i=1}^{P} \alpha_i Y_{t-i} + \sum_{j=1}^{Q} \beta_j X_{t-j}.$$

$\sum_{j=1}^{Q} \beta_j X_{t-j}$ =0 is tested. If they are, the null hypothesis that "X does not cause Y" is accepted. The Akaike Information Criterion (AIC) (Akaike 1973) is employed to determine the optimal lag length P and Q. A maximum of three lags is used in the AIC process because the public should not take more than three months to respond to the new information. According to the semi-strong form efficient market hypothesis, all publicly available information is fully and immediately reflected in the market prices. The AIC is calculated as

$$AIC = T \log(RSS) + 2K,$$

where T is the number of observations, RSS is the residual sum of squares, and K is the number of explanatory variables.

As a result, nine series are found to cause changes in SP500EAFE at a significance level of 15 percent (see Appendix II), and, therefore, are used as explanatory variables in the model construction.

2.2.3 Logit Model

The objective of this research is to develop a dynamic asset allocation strategy between the S&P 500 Index and the MSCI EAFE Index; a model able to predict the direction of the upcoming states of these two assets is therefore essential.

Since the dependent variable is qualitative with two possible outcomes: SP500EAFE > 0 (i.e., SP500TR > EAFETR) or SP500EAFE < 0 (i.e., SP500TR < EAFETR), a binary logit model is used to make forecasts for the outcome of SP500EAFE, given a set of explanatory variables. A logit model is chosen over a linear probability model because the predicted probabilities of a logit model lie within an (0, 1) interval (Pindyck and Rubinfeld, 1991). The logit model is specified as:

$$P_t = P(Y_t = 1 \mid X_t) = F(Z_t) = F(\alpha + \beta X_t) = \exp(\alpha + \beta X_t)/(1 + \exp(\alpha + \beta X_t))$$

where P_i = the conditional probability that SP500EAFE > 0, given X_i, Y_i = 1 if SP500EAFE > 0, 0 otherwise, X_i = the set of explanatory variables, and $F(Z_i)$ = the cumulative logistic probability distribution function of Z_i.

3 Model Construction and Validation

The base models are built upon the data from January 1973 to December 1977. An all-possible-regressions approach is used in model construction. Altogether, five hundred and eleven logit models are formed on all possible combinations of the nine explanatory variables.

Since the base models are built upon the in-sample data, it is important to validate the model and its predictive ability through the use of a holdout sample. Hence, each model is tested for its predictive ability using a five-year rolling estimation window and the two-hundred-and-sixty-one-month out-of-sample data from January 1978 to September 1999.

Erb, Harvey, and Viskanta (1994) state that correlation involves returns on two assets. The long-run relation between the SP500TR and the EAFETR has been stable with an average correlation coefficient of approximately 0.47. However, the five-year correlation has a somewhat wider variation range of 0.26–0.71 than the longer-term correlations such as the twenty-year's 0.41–0.50, the fifteen-year's 0.42–0.52, and the ten-year's 0.35–0.55 (see Figure I). As a result, a five-year rolling estimation window is used in the logit regression to exploit such variations in the correlation spread.

The estimated regression coefficients derived from the base model using data from January 1973 to December 1977 are fitted in with the actual lagged values of the independent variables to predict the conditional probability of the outcome of SP500EAFE for January 1978. Then, January 1973 is dropped and January 1978 is added to the estimation period to reestimate the regression coefficients for the base model for use in predicting the conditional probability for February 1978. That is, the regression coefficients for the base model are reestimated monthly using the five-year period immediately preceding the prediction month for use with the actual lagged values of the independent variables to make forecast for the prediction month. The same procedure is then repeated forward through the two-hundred-and-sixty-one-month out-of-sample period.

4 Trading Strategies and Results

4.1 Trading Strategies

Primarily, forty-eight trading strategies are established to check the predictability of the base models using the two-hundred-and-sixty-one-month out-of-sample data. The estimated conditional probabilities generated by the model form the base of a trading rule. Depending on the criteria set by the filter rule, all strategies require 100 percent invested in one of the two assets.

Nineteen of the strategies use a cutoff probability to classify the two states of the outcome. That is, if the estimated probability for a particular month is greater than the selected cutoff point, that month is categorized as SP500EAFE > 0, otherwise it is considered as SP500EAFE < 0. The strategy commands investing in the S&P 500 Index when the model signals SP500EAFE > 0 and in the MSCI EAFE Index when the model signals SP500EAFE < 0.

The other twenty-nine strategies assume a probability range as a neutral zone. That is, if the estimated probability for a particular month falls above the neutral range, that month is categorized as SP500EAFE > 0 and investing in the S&P 500 Index is required. And, if the estimated probability for a particular month falls below the neutral range, that month is categorized as SP500EAFE < 0 and investing in the MSCI EAFE Index is required. If the estimated probability falls within the neutral range, the direction of the asset movements for that month is too close to call or not clear. Thus, it will require the investor to stay invested in the same asset of the preceding month rather than making a change for that particular month. Doing so, an investor would have at least saved the transaction costs involved in changing the asset mix of a portfolio.

In sum, a trading strategy works as follows. First, they are all prefixed with an "R", which stands for "rule". Second, a one- or two-digit rule (i.e., R5 to R95) is the strategy using a cutoff probability to categorize the outcome. The numeral(s) represents the cutoff point used in that rule. Third, a four-digit rule (i.e., R5025 to R7545) is the strategy using a probability neutral zone. The first and last two digits of the trading rule stands for the upper and lower bound of the neutral range, respectively. The forty-eight trading strategies are listed in Appendix III.

As a check on the efficacy of the twenty nine strategies that assuming a probability neutral zone, another twenty nine strategies of the same name but suffixed with an "A" are developed. They adopt the same asset allocation strategy for an estimated probability falling above or below the neutral zone, but a different approach when an estimated probability falls within the neutral zone. When a forecast falls within the neutral range, it will require the investor to do a 50-50 split between the two assets instead of 100 percent invested in one of the two assets.

4.2 Control Portfolio

Six control portfolios, which consist of one active and five passive portfolios, are formed for comparative purposes. The active portfolio (3-ASSET) is composed of 40 percent in the S&P 500 Index, 40 percent in the MSCI EAFE Index, and 20 percent in U.S. long-term government bond, and is rebalanced monthly to maintain the fixed percentages in the asset mix. The five passive portfolios are invested separately in the S&P500 Index (SP500), the MSCI EAFE Index (EAFE), U.S. long-term government bond (USLTGVTBD), U.S. long-term corporate bond (USLTCORPBD), and U.S. one-month Treasury bill (USTB1M), respectively, using a buy-and-hold strategy throughout the holding period.

4.3 Trading Results

Using the forty eight predetermined trading strategies, two hundred and two of the five hundred and eleven logit models are able to provide a terminal wealth of more than

\$60, based on an initial investment of \$1, over a two-hundred-and-sixty-one-month holding period. Terminal wealth of \$60 is double the wealth of \$29.46 yielded by the SP500 portfolio, the best-performing control portfolio. Sixty dollars is arbitrarily chosen to demonstrate the effectiveness of the models formed on the nine selected variables. Furthermore, ninety-three of the models generate a terminal wealth greater than \$70, out of which twenty-three models create a terminal wealth greater than \$80.

This paper focuses on the performance of Model 498, which is the "best" model among all the models formed. Seven time series, in the original series or first-differenced series, and their lagged values chosen by the AIC are included in the model, namely the SP500TR, ΔEAFEDY, ΔSP500DY, ΔUSTB1MR, USDEFAULTPREM, USHORIZONPREM, and USEQRSKPREM[1]. Model 498 is:

$$\begin{aligned} Z_t &= \alpha + \beta_1 SP500TR_{t-1} + \beta_2 \Delta EAFEDY_{t-1} + \beta_3 \Delta SP500DY_{t-1} + \beta_4 \Delta SP500DY_{t-2} + \\ &\beta_5 \Delta USTB1MR_{t-1} + \beta_6 \Delta USTB1MR_{t-2} + \beta_7 \Delta USTB1MR_{t-3} + \beta_8 USDEFAULTPREM_{t-1} + \\ &\beta_9 USHORIZONPREM_{t-1} + \beta_{10} USHORIZONPREM_{t-2} + \beta_{11} USEQRSKPREM_{t-1} + \\ &\beta_{12} USEQRSKPREM_{t-2} + \beta_{13} USEQRSKPREM_{t-3} \end{aligned}$$

Some of the explanatory variables are found highly correlated, as noted in the correlation matrix (see Appendix IV). The high correlation among the explanatory variables implies that multicollinearity exists, which is a common problem in many

[1] SP500TR: Standard and Poor's 500 (S&P 500) Index total return; ΔEAFEDY: the first difference of EAFE dividend yield; ΔSP500DY: the first difference of S&P 500 dividend yield, ΔUSTB1MR: the first difference of U.S. one-month Treasury bill rate; USDEFAULTPREM: U.S. bond default premium (the geometric difference between total returns on long-term corporate bonds and long-term government bonds); USHORIZONPREM: U.S. bond horizon premium (the geometric difference between total returns on long-term government bonds and U.S. thirty-day Treasury bills); USEQRSKPREM: "fundamental based" equity risk premium (E/P ratio for the S&P 500 minus the one-month Treasury bill rate).

economic time series. The presence of multicollinearity may prevent making inferences about the estimated regression coefficients, however it does not affect the model's ability to predict (Klemkosky and Bharati, 1995; Neter, Kutner, Nachtsheim, and Wasserman, 1996).

Table I reports the terminal wealth, and the monthly and annualized rates of returns of the six control portfolios and the forty eight portfolios formed by trading strategies using the forecasts of Model 498. Out of all the trading strategies, eighteen strategies provide a terminal wealth of more than $60; five strategies generate a terminal wealth of more than $80 and two strategies generate a terminal wealth of more than $100.

Only three strategies (i.e., R5 - $27.90, R10 - $27.48, and R95 - $27.78) create a terminal wealth slightly inferior to the $29.46 provided by the SP500 portfolio. All forty-eight trading strategies produce more wealth than the EAFE portfolio ($19.22) and the 3-ASSET portfolio ($20.90).

Strategy R6040 yields the largest terminal wealth among the forty-eight trading rules, followed by Strategy R6045 and R6540. R6040 is the best trading strategy. Employing this filter rule, an investment of $1 made at the beginning of January 1978 produces a terminal wealth of $113.59 at the end of September 1999, which is one hundred and thirteen times of the original investment and almost four times of the terminal wealth provided by the SP500 portfolio. It represents an average monthly return of 1.83 percent (or an annualized return of 21.96 percent) for almost twenty-two years, which is significantly higher than the return of 1.30 percent per month (or 15.66 percent per year) of the SP500 portfolio, the best control portfolio.

Furthermore, the two portfolios formed by R6045 and R6540 provide the second and third largest terminal wealth of $100.58 and $85.75, which represent an average monthly return of 1.78 percent and 1.72 percent (or annualized return of 21.39 percent and 20.64 percent), respectively.

Among the nineteen trading strategies that use a cutoff probability, R60 has the highest terminal wealth. In fact, the performance of strategy R60 ranks the fifth among the forty-eight strategies tested. Portfolio R60 provides an average monthly return of 1.69 percent (or an annualized return of 20.32 percent). It creates a terminal wealth of $80.10, which is more than double of the wealth provided by the S&P 500 portfolio. Figure II depicts the wealth generated by R6040, R6045, R6540, R60 and the six control portfolios over the two-hundred-and-sixty-one-month holding period.

Table II shows the year-to-year portfolio value of the six control portfolios and the forty-eight portfolios formed by trading strategies. The superior performance of R6040 has been very consistent throughout the entire two-hundred-and-sixty-one-month holding period. Portfolio R6040 produces the largest wealth year after year, with the exception of the first year at $1.24, which is inferior to the $1.34 of the EAFE portfolio, the best-performing control portfolio of that year, and three other trading rules (i.e., R85, R90 and R95).

In addition, the year-to-year performance of R60 has been quite stable throughout the holding period. Except for the first two years, the yearend wealth generated by R60 has been or very close to the largest wealth generated by strategies that use a cutoff percentage. In fact, it has the greatest yearend wealth from 1986 and onwards.

The outstanding performance of R6040, R6045 and R60 indicates that 60 percent is the optimal cutoff probability to classify the two states of outcome of SP500EAFE forecasted by Model 498. An asset allocation strategy based on this cutoff point should be able to enhance the performance of a portfolio significantly.

Table III presents a comparison of the terminal wealth created by strategies R5025 – R7545 with strategies R5025A – R7545A, i.e., strategies commanding 100 percent invested in one of the two assets versus strategies commanding a 50-50 split between the two assets when a forecast falls within the probability neutral zone. In general, strategies R5025 – R7545 perform better than strategies R5025A – R7545A. For example, R6040's $113.59 is 52 percent more than R6040A's $74.79; R6045's $100.58 is 40 percent more than R6045A's $71.74; and R6540's $85.75 is 26 percent more than R6540A's $68.18. Strategies R6035, R5540 and R5040 also provide a much larger terminal wealth than R6035A, R5540A and R5040A. To the contrary, only five of the "A" strategies have a better performance than their counterparts, yet by a few cents to a few dollars. The relative performance of these two classes of strategy is portrayed in Figure III. Evidently, a trading strategy demanding 100 percent invested in one of the two assets is preferred in terms of terminal wealth to a trading strategy demanding a 50-50 split between the two assets.

5 Market-Timing Tests

How to evaluate the performance of a portfolio manger has always been a problem and remains mostly unresolved by academics and practitioners (Cumby and Modest, 1987; Ferson and Schadt, 1996). One-parameter measures such as the Sharpe ratio, the Treynor measure, and the Jensen's alpha are the conventional methods for portfolio performance evaluation. Merton (1981) and Henriksson and Merton (1981) propose a nonparametric test of market timing, which requires a forecast to rank the alternative investments in ordinal numbers without making reference to the level of the realized excess return. The Henriksson-Merton test confirms market-timing ability when the sum of conditional probabilities of correct forecasts exceeds one. Cumby and Modest (1987) suggest a regression model to test market timing, which requires the conditional expected return to be regressed on the states of the forecasts: X = 1 for a correct forecast and X = 0 for an incorrect forecast. They state that a positive slope coefficient implies forecasting power.

As a check on the robustness of Model 498, in particular strategy R6040, R6045, R6540 and R60, we implement three different market-timing tests, namely the Henriksson-Merton (1981) test, the Cumby and Modest (1987) regression test, and the Sharpe ratio, to assess the forecastability of the model.

5.1 The Henriksson-Merton Test

The Henriksson-Merton (1981) test is employed to evaluate the reliability of the forecasts on the direction of the upcoming states of SP500EAFE generated by Model 498. According to Henriksson-Merton (1981) and Merton (1981), for a forecast to have value the sum of the probability of a correct prediction given SP500EAFE > 0 and the probability of a correct prediction given SP500EAFE < 0 exceeds one. The Henriksson-Merton test statistics (*p*-stat) are calculated as:

$$p - stat = \frac{n_1}{N_1} + \frac{n_2}{N_2},$$

where n_1 = number of correct predictions that SP500EAFE > 0, N_1 = number of observations that SP500EAFE > 0, n_2 = number of correct predictions that SP500EAFE < 0, N_2 = number of observations that SP500EAFE < 0, n_3 = number of incorrect predictions that SP500EAFE > 0.

The *p*-value of a *p*-stat is calculated as in Park and Switzer (1996):

$$p\text{-value} = \sum_{x=n_1}^{\min(N_1,n)} \binom{N_1}{x}\binom{N_2}{n-x} / \binom{N}{n}, \text{ where } N = N_1 + N_2 \text{ and } n = n_1 + n_3.$$

Table IV presents the *p*-stats and their corresponding *p*-values for all the trading strategies. Out of the forty-eight trading strategies, forty-six strategies have a *p*-stat greater than one, and forty-one of them have a minimum significance level of 10 percent. Specifically, there are seventeen strategies at the significance level of 1 percent, eighteen strategies at a significance level of 5 percent, and six strategies at a significance level of 10 percent.

Apparently, strategy R6040, R6045 and R6540 are proved the best-performing strategies by their highest *p*-stats of 1.2646,1.2265 and 1.2265, and the lowest *p*-values of 1.4560e-05, 1.7747e-04 and 1.7221e-04, respectively. Strategy R60 also has a high *p*-stat of 1.1732 at a significance level of 1 percent (*p*-value = 0.0030).

The Henriksson-Merton (1981) test results clearly support the hypothesis that Model 498 has predictive ability. For the most part, an investor can depend on the signals provided by the model to invest in either the S&P 500 Index or the MSCI EAFE Index and make a superior return on the investment.

5.2 The Cumby and Modest Test

To further explore the forecastability of Model 498, a regression test proposed by Cumby and Modest (1987) is performed for each of the forty-eight trading strategies. The regression model is:

$$Y_t = \alpha + \beta X_t$$

where Y_i = SP500TR – EAFETR for a prediction of SP500EAFE > 0, or Y_i = EAFETR – SP500TR for a prediction of SP500EAFE < 0, X_i = 1 for a correct prediction, 0 otherwise.

From the regression model, the conditional expectation of Y, the expected return, relies linearly on X, the forecast. If a filter rule is able to make correct forecasts, the regression coefficient, β, should be greater than zero. According to Cumby and Modest (1987), testing $\beta = 0$ is a test of forecasting ability of the filter rules. The intercept, α, represents the decrease in mean monthly return pertaining to the incorrect predictions and the slope coefficient, β, represents the increase in mean monthly return pertaining to the correct predictions.

Table V reports the regression results, namely the R Sq., R Bar Sq., α and β together with their *t*-statistics and *p*-values, for all the trading strategies. The high value of R Sq. and R Bar Sq. (55 percent - 58 percent) implies the model has a good fit. It also suggests that X has good explanatory power and is a driving force of Y. In addition, the positive values of β and their significant *t*-statistics confirm that the trading rules have forecasting power.

The "Net Forecast Result", as shown on Column 9 of Table V, is obtained by subtracting the total decrease in returns caused by incorrect forecasts (i.e., α times the number of incorrect forecasts) from the total increase in returns caused by correct forecasts (i.e., β times the number of correct forecasts). This simple calculation of the holding period return, without accounting for any compounding effects over the holding period, could provide a notion of which trading strategies offer a positive result.

Intuitively, a positive value of "Net Forecast Result" indicates that the trading strategy is capable of providing a positive return to an investor. This is supported by the fact that all trading strategies have a positive "Net Forecast Result" do have a positive terminal wealth (see Table I). Furthermore, the higher the positive value of "Net Forecast Result", the better the strategy performs. Evidently, R6040, R6045 and R6540 are the three best-performing strategies bearing the largest values of 8.6935, 8.2099 and 8.1441, respectively. R60 also has a high value of 7.5164 among the strategies using a cutoff probability.

The Cumby and Modest (1987) regression test results again vouch for the forecasting ability of Model 498. Essentially, an investor can employ any one of the trading strategies to obtain a positive return on an investment.

5.3 Sharpe Ratio

The Sharpe ratio is a common tool used to assess the performance of a portfolio in terms of its risk-adjusted excess return. It is calculated as the excess mean monthly return of a portfolio over U.S. one-month Treasury bills divided by the standard deviation of the portfolio.

Table VI presents the Sharpe ratios for the forty-eight active portfolios as well as the six control portfolios. Among all the trading strategies, R6040 has the highest Sharpe ratio of 0.2720, followed by R6045's 0.2607. Although, R6540 has a higher monthly return of 1.72 percent than R5540's 1.70 percent and R6035's 1.69 percent, it has a higher standard deviation, which causes its Sharpe ratio (0.2456) to fall below those of R5540 and R6035 (both of 0.2466). R60 has a Sharpe ratio of 0.2410, which is the highest among all the strategies that use a cutoff probability.

The Sharpe Ratios of 0.1148, 0.1698 and 0.1747 of EAFE, SP500 and 3-ASSET, respectively, are significantly lower than those of R6040, R6045, R6540 and R60. In fact, forty-three active portfolios have a higher Sharpe ratio than those of the SP500 and 3-ASSET portfolios. And, all forty-eight trading strategies yield a Sharpe ratio superior to that of the EAFE portfolio.

Apparently, the higher Sharpe ratios of the active portfolios indicate that the risk-adjusted returns generated by the trading strategies are superior to those of the control portfolios. As a result, the active strategies are worth pursuing to improve the return of an investment without increasing the portfolio risk. Hence, Model 498 has once again stood to the test of market timing ability by the high Sharpe Ratios of the portfolios formed by trading strategies, upon which the estimated probability generated by the model is based.

Table VII compares the Sharpe ratios for strategies R5025 – R7545 to strategies R5025A – R7545A. The results are mixed. Only seventeen strategies of R5025 – R7545 have a higher Sharpe ratio than strategies R5025A – R7545A. In other words, twelve of the "A" strategies have a higher Sharpe ratio. The Sharpe ratios of R6040 (0.2720), R6045 (0.2607), R6035 (0.2466), R6540 (0.2456), R5540 (0.2466) and R5040 (0.2366) are significantly higher than the Sharpe ratios of their counterparts. Ironically, the Sharpe ratios of strategy R7545A (0.2173), R7525A (0.2044), R7530A (0.2031), and R7535A (0.2030) are superior to their counterparts' by a considerable margin, though the terminal wealth they produce are greater than their counterparts' by only a few cents to a few dollars. However, their return risks (standard deviation) are relatively lower. Figure IV presents a clear picture of the Sharpe ratios of these two classes of strategy.

Consequently, an estimated probability of 60 percent and 40 percent appear to be a good choice for the upper and lower bound of a probability neutral zone for Model 498, respectively. In fact, this is clearly shown by the superior performance of R6040. Furthermore, a neutral range of fifteen to twenty five points seems to be proper for strategies demanding 100 percent invested in one of the two assets to obtain a favourable risk-adjusted return. Conversely, an estimated probability of 75 percent and 35 percent or below for the upper and lower bound of a probability neutral zone, respectively, or a neutral range of thirty to fifty points are not recommended for such strategies. Even though, they still provide a positive return on the investment, the return volatility is significantly higher.

6 Effect of Transaction Costs

Transaction costs have always been a detrimental factor to the performance of a portfolio. The adverse effect of transaction costs on the value of a portfolio is investigated using commission ceilings of 1 percent, 2 percent and 3 percent per annum. Different commission rates are used to show the degree of "churning" effect as the cost increases. Portfolios formed by R60, R6040, R6040A, R6045 and R6045A as well as the six control portfolios are used to demonstrate such an effect. Transaction costs are applied to the portfolios whenever a trade is deemed necessary during the holding period.

As shown in Table VIII, transaction costs have little effect on the control portfolios, because there are either no trades assumed or the amounts involved in the monthly rebalancing are minimal during the holding period. On the other hand, the portfolio values of R60, R6040, R6040A, R6045 and R6045A go down progressively as the commission rate goes up.

For example, R6040 has a terminal wealth of $113.59 before transaction costs. The portfolio value decreases to $104.90, $96.87 and $89.44 when commission of 1 percent, 2 percent and 3 percent are applied to each deemed transaction, respectively. This represents a reduction of 7.65 percent, 14.73 percent and 21.26 percent in wealth, respectively, when compared to the wealth before transaction costs. The wealth depletion would have been more significant should the number of transactions be more than ninety-six. Indeed, this is demonstrated by the higher wealth depletion rates of R6040A where there are one hundred and fifty six deemed trades during the holding period though ninety nine times involved only 50 percent of the portfolio value. The depletion rates are 8.94 percent, 17.05 percent and 24.44 percent for a commission of 1 percent, 2 percent and 3 percent charged to each deemed transaction, respectively. These rates are 15 percent – 17 percent higher than those of R6040 and are caused by the increased number of transactions during the holding period.

However, the active portfolios still outperform the control portfolios by a significant margin even after accounting for transaction costs. This suggests that the signals provided by Model 498 are economically significant. An investor can rely on the forecasts to establish a profitable asset allocation strategy between the two assets without having to worry about the transaction costs.

Nevertheless, the "churning" effect of transaction cost depends very much on how often trades will be transacted during the holding period. The more frequent the transactions, the greater the "churning" effect. For instance, the terminal wealth of R60 is reduced by 8.26 percent when a 1 percent commission is applied to the trades, which is 8 percent higher than that of R6040. The eight more trades transacted for R60 (i.e., one hundred and four trades for R60 as opposed to ninety six trades for R6040) during the holding period is the main reason for the 8 percent increase in the wealth depletion rate. As a result, investors should be prudent in changing the asset mix of a portfolio when the transaction costs involved are high while the confidence in the market assessment is low.

7 Conclusions

Model 498 is proved an efficient model by the remarkable investment results generated by the trading strategies, in particular R6040. Furthermore, it passes all the market-timing tests successfully. The results imply that a prediction model can be built to generate reliable forecasts on the direction of the upcoming movements between the S&P 500 Index and the MSCI EAFE Index. An investor can depend on the signals to actively manage the two-asset portfolio profitably, even after accounting for transaction costs. As a result, a dynamic asset allocation strategy can be established to enable an investor to make a superior risk-adjusted return over the holding period.

Obviously, the results of this research appeal to both academic researchers and practitioners. Since the seven predictor series and their lagged values are the fundamentals of Model 498 and the public knows them, this suggests that an investor can use public information variables to time the market and obtain a superior abnormal return on an investment, without incurring a higher risk.

The "churning" effect of transaction costs on an active portfolio is substantial. The wealth depletion rate depends very much on how frequently trades are made during the holding period. Since transaction costs cannot be avoided in the real world, an investor should be cautious in changing the asset mix of a portfolio when the transaction costs involved are high and the market expectations are low.

However, Model 498 does have limitations. It assumes that all lagged values of the explanatory variables are available at the time when a prediction is made. Also, the model only allows change of asset mix of a portfolio once a month, which may not be the case in the real world where a portfolio is monitored more frequently.

Although this study aims to develop a model to tactically manage a two-way asset allocation between the S&P500 Index and the MSCI EAFE Index, future research should exploit a three-way asset allocation to include a risk-free asset, say the U.S. Treasury bills. Because there are forty-nine months (i.e., 18.77 percent) in the two-hundred-and-sixty-one-month period during which both the returns of the S&P 500 Index and the MSCI EAFE Index are negative. During such time, an investor earns a negative return despite the fact that the two-asset model may have made a correct prediction on the upcoming states of the asset movements of these two indices.

A three-asset model will provide a signal to an investor to switch the asset of a portfolio to Treasury bills to guarantee a positive return for a particular month when the forecast for that month indicates that both the S&P 500 Index and the MSCI EAFE Index will generate a negative return. Consequently, a three-asset model could provide a better return than a two-asset model.

Since a binary logit model only deals with a dichotomous dependent variable, a multinomial (polytomous) logit model can be used when the dependent variable has three possible outcomes. As a result, future research on developing such a model is suggested.

Asset allocation among the assets can then be decided according to the signals provided by the three-asset model to improve the investment performance over the holding period.

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FIGURE I. Correlation between the S&P 500 Index and the MSCI EAFE Index

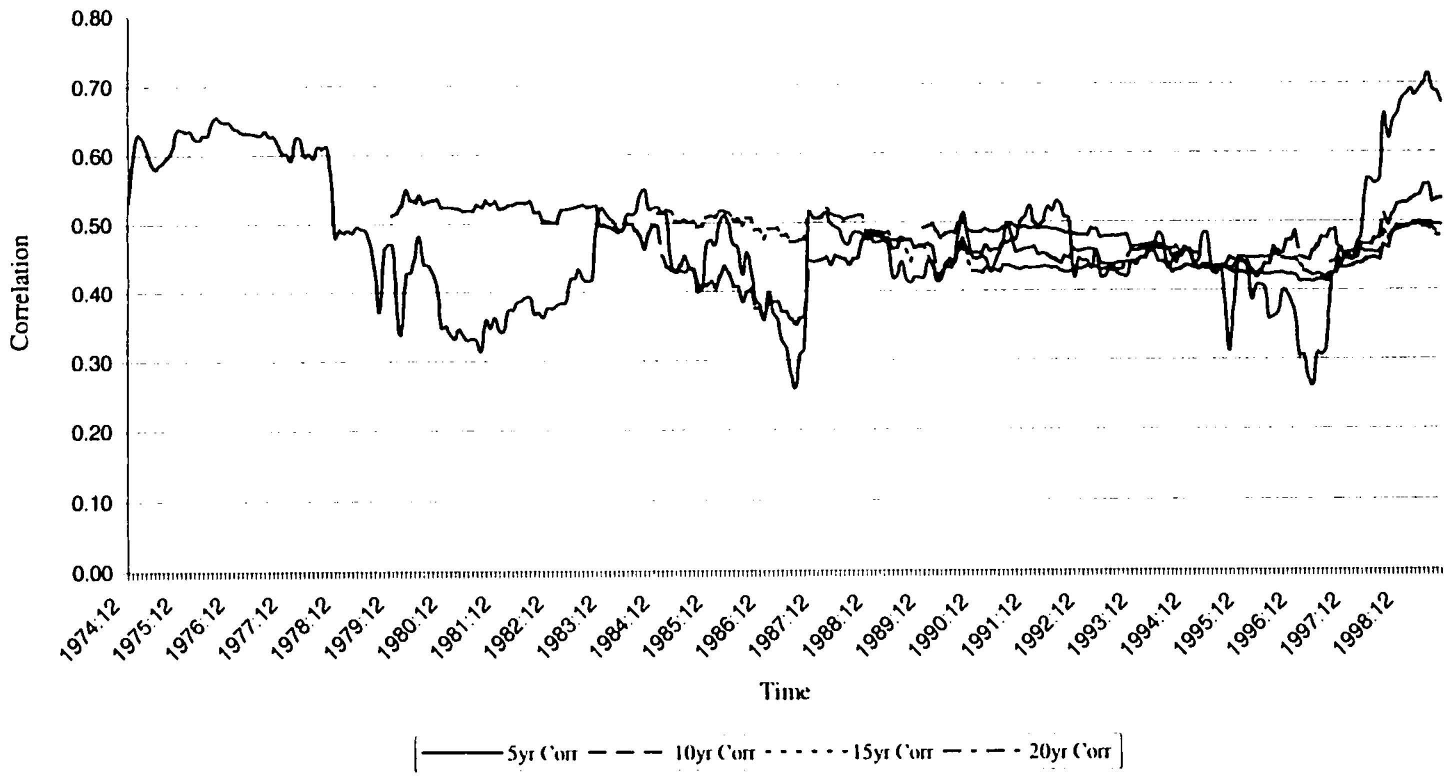

FIGURE II. Portfolio Wealth Over the Two-Hundred-and-Sixty-One-Month Holding Period

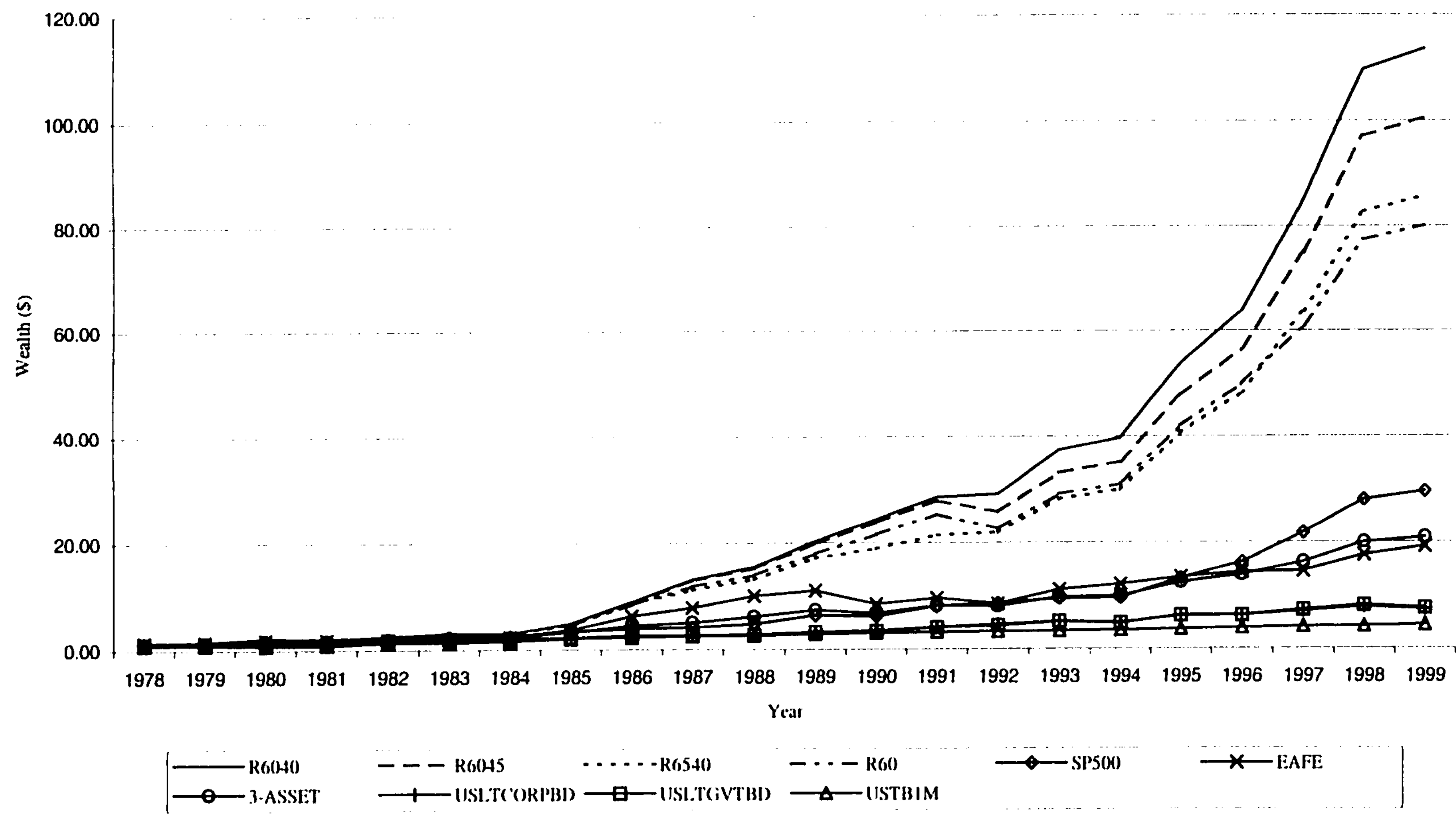

FIGURE III. Terminal Wealth: Strategies R5025 – R7545 Versus Strategies R5025A – R7545A

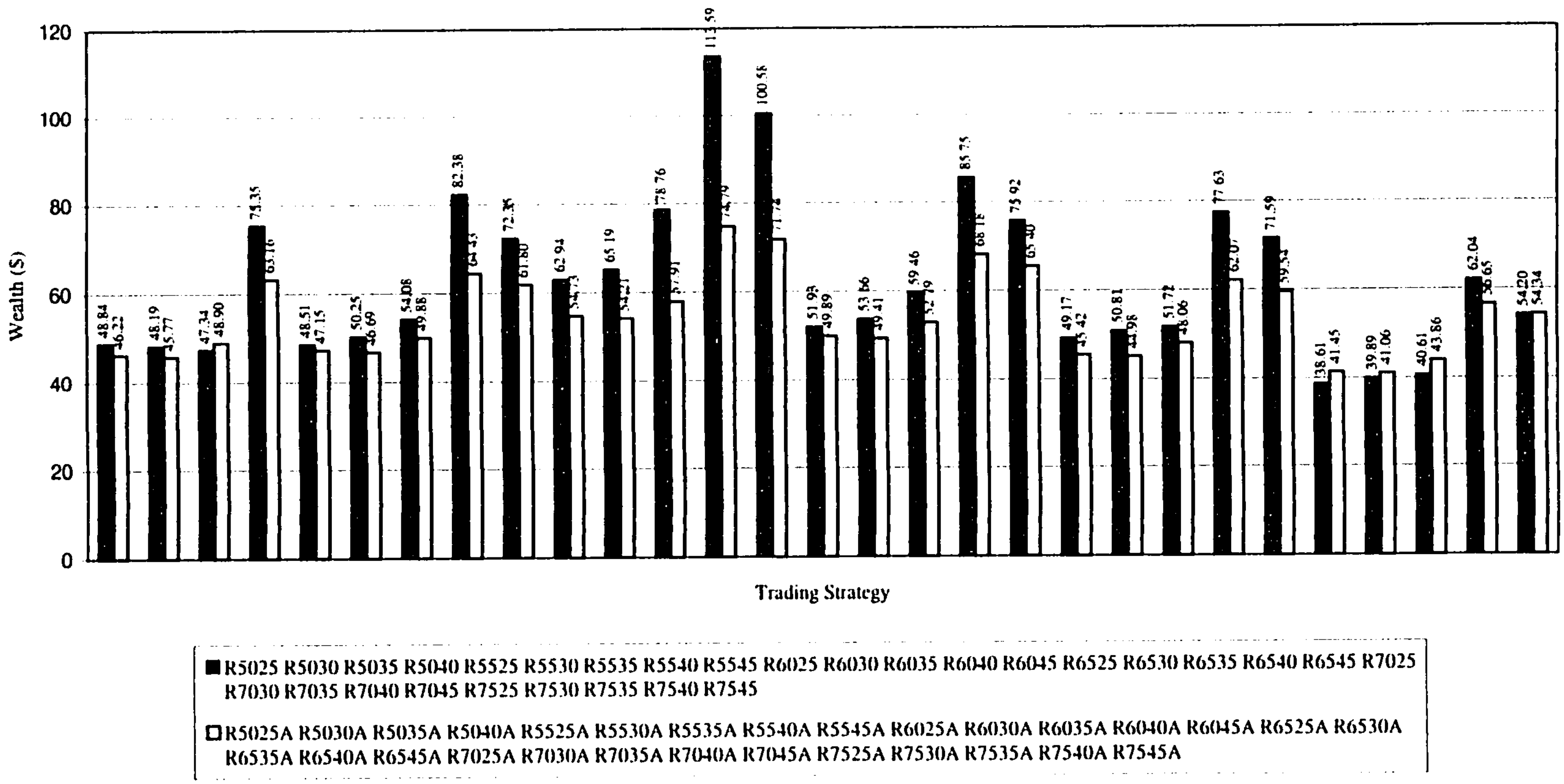

FIGURE IV. Sharpe Ratios: Strategies R5025 – R7545 Versus Strategies R5025A – R7545A

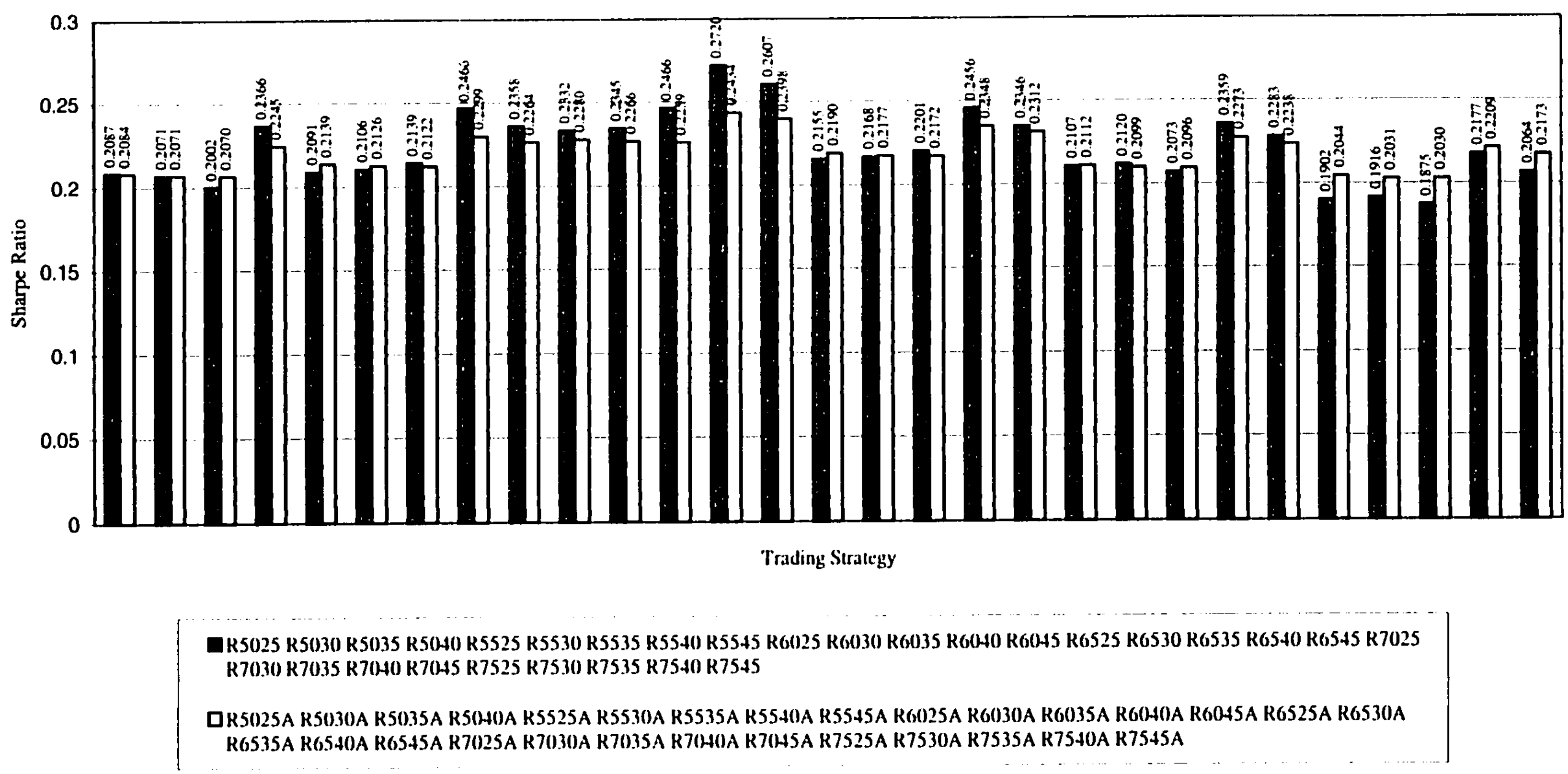

TABLE I. Terminal Wealth and Rates of Returns of Portfolios

	Control Portfolios					
	USLTCORPBD	USLTGVTBD	USTB1M	EAFE	SP500	3-ASSET
Terminal Wealth ($)	7.32	7.60	4.43	19.22	29.46	20.90
Mean Returns:						
Monthly (%)	0.77	0.78	0.57	1.14	1.30	1.17
Annualized (%)	9.19	9.36	6.87	13.67	15.66	14.06

	Portfolios Formed by Trading Strategies											
	R5	R10	R15	R20	R25	R30	R35	R40	R45	R50	R55	**R60**
Terminal Wealth ($)	27.90	27.48	32.25	35.74	35.37	34.70	40.01	67.57	62.53	58.38	60.10	**80.10**
Mean Returns:												
Monthly (%)	1.28	1.28	1.34	1.38	1.38	1.37	1.42	1.63	1.60	1.57	1.58	**1.69**
Annualized (%)	15.40	15.33	16.08	16.56	16.51	16.42	17.08	19.53	19.17	18.85	18.98	**20.32**
	R65	R70	R75	R80	R85	R90	R95	R5025	R5030	R5035	R5040	R5525
Terminal Wealth ($)	66.24	54.48	45.03	43.65	31.34	35.95	27.78	48.84	48.19	47.34	75.35	48.51
Mean Returns:												
Monthly (%)	1.62	1.54	1.47	1.46	1.33	1.38	1.28	1.50	1.50	1.49	1.67	1.50
Annualized (%)	19.43	18.52	17.63	17.49	15.94	16.58	15.38	18.01	17.95	17.87	20.04	17.98
	R5530	R5535	R5540	R5545	R6025	R6030	R6035	**R6040**	**R6045**	R6525	R6530	R6535
Terminal Wealth ($)	50.25	54.08	82.38	72.35	62.94	65.19	78.76	**113.59**	**100.58**	51.93	53.66	59.46
Mean Returns:												
Monthly (%)	1.51	1.54	1.70	1.65	1.60	1.61	1.69	**1.83**	**1.78**	1.52	1.54	1.58
Annualized (%)	18.14	18.49	20.45	19.85	19.20	19.36	20.24	**21.96**	**21.39**	18.30	18.45	18.93
	R6540	R6545	R7025	R7030	R7035	R7040	R7045	R7525	R7530	R7535	R7540	R7545
Terminal Wealth ($)	**85.75**	75.92	49.17	50.81	51.72	77.63	71.59	38.61	39.89	40.61	62.04	54.20
Mean Returns:												
Monthly (%)	**1.72**	1.67	1.50	1.52	1.52	1.68	1.65	1.41	1.42	1.43	1.59	1.54
Annualized (%)	**20.64**	20.07	18.04	18.20	18.28	20.18	19.80	16.92	17.07	17.15	19.13	18.50

TABLE II. Year-to-Year Portfolio Values

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Control Portfolios																						
USLTCORPBD	1.00	0.96	0.93	0.92	1.31	1.39	1.63	2.12	2.54	2.53	2.80	3.26	3.48	4.17	4.56	5.16	4.86	6.19	6.27	7.09	7.85	7.32
USLTGVTBD	0.99	0.98	0.94	0.95	1.34	1.35	1.56	2.04	2.54	2.47	2.71	3.20	3.40	4.05	4.38	5.18	4.78	6.29	6.23	7.22	8.16	7.60
USTB1M	1.07	1.18	1.32	1.51	1.67	1.82	1.99	2.15	2.28	2.41	2.56	2.77	2.99	3.16	3.27	3.36	3.49	3.69	3.88	4.09	4.28	4.43
EAFE	1.34	1.43	1.77	1.76	1.74	2.17	2.34	3.67	6.23	7.78	10.01	11.09	8.52	9.58	8.45	11.23	12.13	13.53	14.39	14.69	17.68	19.22
SP500	1.07	1.26	1.67	1.59	1.93	2.36	2.51	3.32	3.93	4.14	4.83	6.36	6.16	8.04	8.65	9.52	9.64	13.25	16.31	21.75	27.96	29.46
3-ASSET	1.16	1.27	1.55	1.52	1.77	2.10	2.29	3.24	4.51	5.07	6.10	7.36	6.68	8.10	8.08	9.77	9.98	12.54	13.96	16.33	20.05	20.90
Portfolios Formed by Trading Strategies																						
R5	0.97	1.15	1.53	1.48	1.68	2.07	2.02	2.66	3.68	4.49	5.04	6.36	6.16	8.04	8.66	9.52	9.43	12.55	15.44	20.59	26.48	27.90
R10	1.02	1.16	1.54	1.49	1.70	2.08	2.03	2.69	3.79	4.57	5.14	6.41	6.21	8.11	8.73	9.60	9.43	12.55	15.45	20.60	26.49	27.48
R15	1.05	1.20	1.59	1.57	1.79	2.19	2.14	2.82	4.48	5.93	6.45	8.31	8.10	9.71	10.46	11.50	11.30	15.04	18.51	24.68	32.42	32.25
R20	1.05	1.20	1.63	1.60	1.94	2.41	2.40	3.17	4.72	6.24	6.78	9.00	8.77	11.19	11.47	12.62	12.89	17.15	21.11	28.15	36.98	35.74
R25	1.05	1.20	1.63	1.60	1.94	2.39	2.38	3.18	4.73	6.48	7.17	9.36	9.12	11.63	11.92	13.11	13.40	17.12	21.07	28.10	36.59	35.37
R30	1.05	1.20	1.63	1.60	1.91	2.35	2.35	3.14	4.66	6.38	7.07	9.22	8.99	11.57	11.86	13.05	13.33	17.03	20.84	27.57	35.90	34.70
R35	0.96	1.10	1.52	1.49	1.78	2.30	2.18	2.91	4.46	6.81	7.46	9.72	9.94	12.79	12.71	14.89	15.37	19.64	24.03	31.78	41.39	40.01
R40	1.07	1.23	1.69	1.66	2.02	2.63	2.53	3.51	5.38	8.22	8.85	11.54	13.93	17.93	19.34	23.75	25.23	32.24	40.01	53.00	69.90	67.57
R45	1.06	1.17	1.61	1.58	1.86	2.43	2.33	3.25	5.40	7.96	8.57	11.17	13.48	16.38	17.09	20.67	21.96	28.06	34.83	46.13	60.84	62.53
R50	1.06	1.17	1.61	1.52	1.78	2.33	2.24	3.13	5.19	7.65	9.02	12.12	14.63	17.78	17.51	19.51	20.75	26.51	32.90	43.58	56.37	58.38
R55	1.23	1.33	1.92	1.81	2.13	2.74	2.70	3.58	6.41	8.99	10.60	14.25	17.07	19.98	19.21	21.42	22.77	29.10	34.56	44.86	58.03	60.10
R60	**1.23**	**1.36**	**1.97**	**1.97**	**2.32**	**2.98**	**2.95**	**4.60**	**8.41**	**11.87**	**13.99**	**18.02**	**21.59**	**25.27**	**22.60**	**29.05**	**30.89**	**41.89**	**49.76**	**60.82**	**77.34**	**80.10**
R65	1.23	1.30	1.89	1.90	2.23	2.87	2.83	4.42	8.08	10.52	12.44	16.03	17.61	20.01	19.00	23.98	25.49	34.57	41.07	50.20	63.83	66.24
R70	1.23	1.36	1.97	1.98	2.32	2.99	2.95	4.52	7.31	9.53	11.27	14.51	15.95	18.13	17.21	23.00	24.06	31.88	37.17	41.29	52.50	54.48
R75	1.23	1.36	1.74	1.75	2.05	2.64	2.79	4.28	6.92	9.01	10.65	12.48	13.71	15.58	14.76	19.73	20.63	27.33	30.94	34.37	43.39	45.03
R80	1.23	1.36	1.74	1.75	2.07	2.67	2.82	4.32	6.99	9.10	10.76	12.40	13.62	14.83	13.38	17.79	18.93	24.18	28.01	32.59	42.07	43.65
R85	1.34	1.46	1.88	1.88	2.10	2.70	2.98	4.67	7.56	9.85	11.65	13.42	10.30	11.21	10.12	13.46	14.16	18.47	20.65	23.19	29.94	31.34
R90	1.34	1.41	1.87	1.87	2.09	2.69	2.97	4.65	7.91	10.30	13.57	14.84	11.40	12.82	11.30	15.02	15.81	20.62	23.06	25.90	33.06	35.95
R95	1.34	1.41	1.74	1.69	1.88	2.42	2.67	4.19	7.12	8.89	11.71	12.98	9.97	11.21	9.88	13.14	13.82	18.03	18.95	19.34	25.54	27.78
R5025	1.06	1.21	1.64	1.55	1.82	2.31	2.34	3.42	5.09	7.69	9.18	11.97	11.67	14.98	15.36	16.90	17.27	22.06	27.15	36.21	47.15	48.84
R5030	1.06	1.21	1.64	1.54	1.81	2.31	2.33	3.42	5.08	7.68	9.16	11.95	11.65	15.00	15.38	16.91	17.28	22.08	27.01	35.74	46.53	48.19

TABLE II (continued). Year-to-Year Portfolio Values

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Portfolios Formed by Trading Strategies (continued)																						
R5035	0.97	1.11	1.53	1.44	1.69	2.15	2.07	3.02	5.02	7.40	8.72	11.37	11.62	14.96	14.04	16.44	16.97	21.69	26.54	35.10	45.71	47.34
R5040	1.07	1.23	1.69	1.59	1.87	2.44	2.35	3.44	5.70	8.40	9.90	12.92	15.58	20.06	20.43	24.72	26.26	33.56	41.64	55.16	72.75	75.35
R5525	1.12	1.28	1.74	1.64	1.92	2.42	2.57	3.77	5.60	8.47	10.10	13.17	12.75	14.89	15.26	16.79	17.15	21.92	26.97	35.97	46.84	48.51
R5530	1.12	1.28	1.82	1.72	2.02	2.53	2.70	3.95	5.87	8.87	10.58	13.80	13.36	15.64	16.03	17.63	18.02	23.02	28.16	37.26	48.51	50.25
R5535	1.12	1.28	1.86	1.75	2.06	2.59	2.61	3.83	6.35	9.36	11.03	14.39	14.60	17.09	16.04	18.78	19.39	24.77	30.31	40.10	52.21	54.08
R5540	1.24	1.42	2.06	1.94	2.28	2.94	2.97	4.35	7.21	10.63	12.53	16.34	19.58	22.91	23.34	28.23	30.00	38.33	45.53	60.31	79.54	82.38
R5545	1.23	1.36	1.97	1.85	2.17	2.80	2.83	3.95	6.55	9.66	11.38	14.84	17.78	20.81	20.50	24.80	26.35	33.66	39.99	52.97	69.86	72.35
R6025	1.12	1.32	1.78	1.68	1.97	2.48	2.64	4.22	6.92	10.53	12.56	16.38	15.85	18.51	18.98	20.87	21.33	28.92	35.60	47.47	60.77	62.94
R6030	1.12	1.32	1.87	1.76	2.06	2.59	2.76	4.42	7.25	11.03	13.16	17.16	16.61	19.44	19.94	21.93	22.40	30.38	37.17	49.17	62.94	65.19
R6035	1.12	1.32	1.91	1.80	2.11	2.65	2.68	4.29	7.84	11.64	13.72	17.89	18.15	21.25	19.95	26.22	27.07	36.71	44.91	59.41	76.05	78.76
R6040	**1.24**	**1.46**	**2.11**	**1.99**	**2.34**	**3.01**	**3.04**	**4.87**	**8.90**	**13.22**	**15.58**	**20.32**	**24.34**	**28.49**	**29.02**	**37.31**	**39.65**	**53.77**	**63.86**	**84.60**	**109.68**	**113.59**
R6045	**1.23**	**1.39**	**2.01**	**1.90**	**2.23**	**2.87**	**2.90**	**4.76**	**8.70**	**12.92**	**15.23**	**19.86**	**23.79**	**27.85**	**25.70**	**33.04**	**35.10**	**47.60**	**56.54**	**74.90**	**97.11**	**100.58**
R6525	1.12	1.26	1.71	1.61	1.89	2.38	2.53	4.05	6.64	8.87	10.62	13.85	13.41	15.24	15.63	17.19	17.56	23.82	29.32	39.10	50.05	51.93
R6530	1.12	1.26	1.79	1.69	1.98	2.49	2.65	4.25	6.96	9.30	11.13	14.52	14.05	15.97	16.38	18.01	18.40	24.96	30.53	40.39	51.71	53.66
R6535	1.12	1.26	1.83	1.73	2.03	2.54	2.57	4.12	7.53	9.81	11.60	15.13	14.08	16.01	15.03	19.76	20.39	27.66	33.83	44.76	57.30	59.46
R6540	**1.24**	**1.40**	**2.03**	**1.91**	**2.24**	**2.89**	**2.92**	**4.68**	**8.56**	**11.14**	**13.18**	**17.19**	**18.88**	**21.47**	**21.86**	**28.11**	**29.87**	**40.51**	**48.12**	**63.74**	**82.63**	**85.75**
R6545	1.23	1.33	1.93	1.82	2.14	2.75	2.78	4.57	8.36	10.89	12.88	16.80	18.46	20.98	19.36	24.89	26.45	35.87	42.60	56.43	73.16	75.92
R7025	1.12	1.26	1.71	1.61	1.89	2.38	2.53	4.05	6.56	8.54	10.22	13.33	12.91	14.67	15.04	16.54	16.63	22.55	27.76	37.02	47.39	49.17
R7030	1.12	1.26	1.79	1.69	1.98	2.49	2.65	4.25	6.87	8.95	10.71	13.97	13.52	15.37	15.76	17.34	17.43	23.63	28.91	38.25	48.96	50.81
R7035	1.12	1.26	1.83	1.73	2.03	2.54	2.57	4.12	6.66	8.68	10.26	13.38	12.45	14.15	13.29	17.47	17.74	24.06	29.43	38.94	49.85	51.72
R7040	1.24	1.40	2.03	1.91	2.24	2.89	2.92	4.60	7.43	9.68	11.45	14.93	16.40	18.65	18.99	25.87	27.04	36.67	43.56	57.71	74.81	77.63
R7045	1.23	1.39	2.01	1.90	2.23	2.87	2.90	4.68	7.56	9.85	11.65	15.20	16.70	18.98	17.51	23.86	24.94	33.82	40.17	53.21	68.99	71.59
R7525	1.12	1.26	1.51	1.42	1.67	2.10	2.23	3.51	5.67	7.39	8.85	10.49	10.16	11.55	11.81	12.99	13.06	17.71	21.79	29.06	37.20	38.61
R7530	1.12	1.26	1.58	1.49	1.75	2.20	2.33	3.68	5.95	7.74	9.27	11.00	10.64	12.10	12.37	13.61	13.68	18.55	22.70	30.03	38.44	39.89
R7535	1.12	1.26	1.62	1.52	1.79	2.25	2.26	3.57	5.77	7.51	8.88	10.53	9.80	11.14	10.43	13.71	13.93	18.89	23.11	30.57	39.13	40.61
R7540	1.24	1.40	1.79	1.69	1.98	2.55	2.57	4.05	6.55	8.53	10.09	11.96	13.14	14.94	15.18	20.67	21.61	29.31	34.81	46.11	59.79	62.04
R7545	1.23	1.39	1.78	1.68	1.97	2.53	2.55	3.91	6.31	8.23	9.73	11.54	12.67	14.41	13.26	18.06	18.88	25.61	30.41	40.29	52.23	54.20

TABLE III.
Terminal Wealth: Strategies R5025 – R7545 Versus Strategies R5025A – R7545A

	R5025	R5025A	R5030	R5030A	R5035	R5035A
Terminal Wealth ($)	48.84	46.22	48.19	45.77	47.34	48.90
	R5040	R5040A	R5525	R5525A	R5530	R5530A
Terminal Wealth ($)	75.35	63.16	48.51	47.15	50.25	46.69
	R5535	R5535A	R5540	R5540A	R5545	R5545A
Terminal Wealth ($)	54.08	49.88	82.38	64.43	72.35	61.80
	R6025	R6025A	R6030	R6030A	R6035	R6035A
Terminal Wealth ($)	62.94	54.73	65.19	54.21	78.76	57.91
	R6040	R6040A	R6045	R6045A	R6525	R6525A
Terminal Wealth ($)	113.59	74.79	100.58	71.74	51.93	49.89
	R6530	R6530A	R6535	R6535A	R6540	R6540A
Terminal Wealth ($)	53.66	49.41	59.46	52.79	85.75	68.18
	R6545	R6545A	R7025	R7025A	R7030	R7030A
Terminal Wealth ($)	75.92	65.40	49.17	45.42	50.81	44.98
	R7035	R7035A	R7040	R7040A	R7045	R7045A
Terminal Wealth ($)	51.72	48.06	77.63	62.07	71.59	59.54
	R7525	R7525A	R7530	R7530A	R7535	R7535A
Terminal Wealth ($)	38.61	41.45	39.89	41.06	40.61	43.86
	R7540	R7540A	R7545	R7545A		
Terminal Wealth ($)	62.04	56.65	54.20	54.34		

TABLE IV. The Henriksson-Merton Test Results

The Henriksson-Merton Test Statistics (*p*-stat*) of Portfolios Formed by Trading Strategies

	R5	R10	R15	R20	R25	R30
p-stat	0.9929	0.9778	1.0088	1.0475	1.0554	1.0480
p-value	0.6763	0.7855	0.4896	0.2103	0.1810	0.2292
	R35	R40	R45	R50	R55	**R60**
p-stat	1.0867	1.2022	1.1644	1.1723	1.1268	**1.1732**
p-value	0.0838	0.0006	0.0054	0.0038	0.0266	**0.0030**
	R65	R70	R75	R80	R85	R90
p-stat	1.1429	1.1201	1.0820	1.0748	1.0753	1.0910
p-value	0.0112	0.0257	0.0938	0.1011	0.0756	0.0222
	R95	R5025	R5030	R5035	R5040	R5525
p-stat	1.0683	1.1173	1.1098	1.1255	1.2103	1.1100
p-value	0.0411	0.0276	0.0395	0.0250	0.0005	0.0417
	R5530	R5535	R5540	R5545	R6025	R6030
p-stat	1.1102	1.1258	1.2029	1.1648	1.1562	1.1564
p-value	0.0435	0.0265	0.0008	0.0055	0.0067	0.0071
	R6035	**R6040**	**R6045**	R6525	R6530	R6535
p-stat	1.1797	**1.2646**	**1.2265**	1.1411	1.1336	1.1417
p-value	0.0026	**0.0000**	**0.0002**	0.0142	0.0199	0.0151
	R6540	R6545	R7025	R7030	R7035	R7040
p-stat	**1.2265**	1.1884	1.1336	1.1261	1.1264	1.2113
p-value	**0.0002**	0.0015	0.0199	0.0272	0.0274	0.0004
	R7045	R7525	R7530	R7535	R7540	R7545
p-stat	1.1809	1.0955	1.0880	1.0884	1.1732	1.1427
p-value	0.0020	0.0774	0.0970	0.0956	0.0030	0.0119

*p-stat = $n_1/N_1 + n_2/N_2$, where n_1 = number of correct predictions that SP500EAFE > 0, N_1 = number of observations that SP500EAFE > 0, n_2 = number of correct predictions that SP500EAFE < 0, N_2 = number of observations that SP500EAFE < 0, n_3 = number of incorrect predictions that SP500EAFE > 0. The p-value is calculated as in Park and Switzer (1996)

$$p\text{-value} = \sum_{x=n_1}^{\min(N_1,n)} \binom{N_1}{x}\binom{N_2}{n-x} \Big/ \binom{N}{n}, \text{ where } N = N_1 + N_2 \text{ and } n = n_1 + n_3.$$

TABLE V. The Cumby and Modest Regression Test Results

	R Sq.	R Bar Sq.	α	*t*-statistic	*p*-value	β	*t*-statistic	*p*-value	Net Forecast Result
R5	0.5831	0.5815	-0.0357	-13.0767	0.00	0.0736	19.0319	0.00	4.8898
R10	0.5836	0.5820	-0.0352	-13.0265	0.00	0.0736	19.0538	0.00	4.7348
R15	0.5831	0.5815	-0.0352	-12.7979	0.00	0.0735	19.0322	0.00	5.1688
R20	0.5817	0.5801	-0.0357	-12.7198	0.00	0.0734	18.9779	0.00	5.6395
R25	0.5815	0.5799	-0.0360	-12.7930	0.00	0.0735	18.9702	0.00	5.7074
R30	0.5817	0.5801	-0.0359	-12.7926	0.00	0.0735	18.9793	0.00	5.6161
R35	0.5801	0.5785	-0.0360	-12.5782	0.00	0.0734	18.9167	0.00	6.1411
R40	0.5708	0.5692	-0.0360	-11.7590	0.00	0.0733	18.5602	0.00	7.7615
R45	0.5734	0.5718	-0.0351	-11.7540	0.00	0.0731	18.6582	0.00	7.2792
R50	0.5740	0.5724	-0.0360	-11.9905	0.00	0.0733	18.6814	0.00	7.3279
R55	0.5761	0.5745	-0.0339	-11.6381	0.00	0.0729	18.7624	0.00	6.8489
R60	**0.5705**	**0.5688**	**-0.0330**	**-11.0488**	**0.00**	**0.0725**	**18.5479**	**0.00**	**7.5164**
R65	0.5744	0.5727	-0.0335	-11.4026	0.00	0.0727	18.6959	0.00	7.0842
R70	0.5770	0.5754	-0.0343	-11.8137	0.00	0.0730	18.7957	0.00	6.7144
R75	0.5800	0.5784	-0.0345	-12.1260	0.00	0.0732	18.9119	0.00	6.1825
R80	0.5805	0.5789	-0.0345	-12.1747	0.00	0.0732	18.9315	0.00	6.0796
R85	0.5817	0.5800	-0.0370	-13.0347	0.00	0.0736	18.9763	0.00	5.8224
R90	0.5805	0.5789	-0.0365	-12.7366	0.00	0.0735	18.9320	0.00	6.0968
R95	0.5827	0.5811	-0.0378	-13.3601	0.00	0.0737	19.0173	0.00	5.6324
R5025	0.5779	0.5763	-0.0356	-12.2311	0.00	0.0733	18.8301	0.00	6.6069
R5030	0.5783	0.5766	-0.0354	-12.2173	0.00	0.0733	18.8444	0.00	6.5176
R5035	0.5778	0.5762	-0.0361	-12.3281	0.00	0.0734	18.8280	0.00	6.6771
R5040	0.5685	0.5668	-0.0353	-11.4663	0.00	0.0730	18.4723	0.00	7.9053
R5525	0.5782	0.5766	-0.0354	-12.2073	0.00	0.0733	18.8435	0.00	6.5202
R5530	0.5780	0.5764	-0.0350	-12.0951	0.00	0.0732	18.8343	0.00	6.5498
R5535	0.5767	0.5751	-0.0349	-11.9551	0.00	0.0731	18.7846	0.00	6.7687
R5540	0.5676	0.5659	-0.0341	-11.1626	0.00	0.0727	18.4387	0.00	7.8585
R5545	0.5720	0.5703	-0.0338	-11.3209	0.00	0.0727	18.6031	0.00	7.3700
R6025	0.5739	0.5723	-0.0349	-11.7432	0.00	0.0730	18.6779	0.00	7.1878
R6030	0.5735	0.5719	-0.0346	-11.6288	0.00	0.0730	18.6631	0.00	7.2126
R6035	0.5700	0.5684	-0.0337	-11.1832	0.00	0.0726	18.5296	0.00	7.5788
R6040	**0.5573**	**0.5556**	**-0.0335**	**-10.5430**	**0.00**	**0.0722**	**18.0584**	**0.00**	**8.6935**
R6045	**0.5629**	**0.5612**	**-0.0331**	**-10.6819**	**0.00**	**0.0722**	**18.2625**	**0.00**	**8.2099**
R6525	0.5767	0.5750	-0.0360	-12.2106	0.00	0.0734	18.7828	0.00	6.8955
R6530	0.5765	0.5749	-0.0354	-12.0518	0.00	0.0732	18.7764	0.00	6.8377
R6535	0.5751	0.5735	-0.0347	-11.7603	0.00	0.0730	18.7237	0.00	6.9991
R6540	**0.5653**	**0.5636**	**-0.0346**	**-11.1547**	**0.00**	**0.0728**	**18.3533**	**0.00**	**8.1441**
R6545	0.5696	0.5679	-0.0341	-11.2784	0.00	0.0727	18.5134	0.00	7.6523
R7025	0.5775	0.5758	-0.0362	-12.3210	0.00	0.0734	18.8139	0.00	6.7743
R7030	0.5773	0.5756	-0.0356	-12.1618	0.00	0.0733	18.8065	0.00	6.7176
R7035	0.5770	0.5753	-0.0353	-12.0640	0.00	0.0732	18.7954	0.00	6.7417
R7040	0.5678	0.5662	-0.0349	-11.3505	0.00	0.0729	18.4474	0.00	7.9231
R7045	0.5708	0.5691	-0.0343	-11.3955	0.00	0.0728	18.5575	0.00	7.5377
R7525	0.5805	0.5788	-0.0368	-12.7844	0.00	0.0735	18.9300	0.00	6.1790
R7530	0.5802	0.5786	-0.0361	-12.6244	0.00	0.0734	18.9208	0.00	6.1281
R7535	0.5800	0.5784	-0.0359	-12.5273	0.00	0.0734	18.9126	0.00	6.1554
R7540	0.5730	0.5713	-0.0354	-11.7840	0.00	0.0731	18.6428	0.00	7.3681
R7545	0.5758	0.5742	-0.0354	-11.9874	0.00	0.0732	18.7503	0.00	6.9463

Regression test: $Y_t = \alpha + \beta X_t$, where Y_t = SP500TR − EAFETR for a prediction of SP500EAFE > 0, or Y_t = EAFETR − SP500TR for a prediction of SP500EAFE < 0, and X_t = 1 for a correct prediction, 0 otherwise. α and β represent the decrease and increase in mean monthly returns pertaining to the incorrect and correct predictions respectively. Net Forecast Result is a simple calculation of the holding period returns, without accounting for any compounding effects over the holding period, by subtracting the total decrease in return caused by incorrect forecasts (i.e., α times the number of incorrect forecasts) from the total increase in return caused by correct forecasts (i.e., β times the number of correct forecasts).

TABLE VI. Sharpe Ratios

	Control Portfolios					
	USLTCORPBD	USLTGVTBD	USTB1M	EAFE	SP500	3-ASSET
SharpeRatio	0.0679	0.0633	0.0000	0.1148	0.1698	0.1747
Monthly Mean Return (%)	0.7657	0.7801	0.5721	1.1391	1.3047	1.1715
Standard Deviation (%)	2.8516	3.2853	0.2391	4.9380	4.3145	3.4313

	Portfolios Formed by Trading Strategies											
	R5	R10	R15	R20	R25	R30	R35	R40	R45	R50	R55	**R60**
SharpeRatio	0.1642	0.1625	0.1793	0.1853	0.1837	0.1813	0.1870	0.2282	0.2242	0.2155	0.2205	**0.2410**
Monthly Mean Return (%)	1.2834	1.2776	1.3398	1.3797	1.3756	1.3682	1.4235	1.6273	1.5971	1.5705	1.5817	**1.6936**
Standard Deviation (%)	4.3334	4.3411	4.2821	4.3584	4.3744	4.3918	4.5527	4.6248	4.5729	4.6327	4.5787	**4.6542**
	R65	R70	R75	R80	R85	R90	R95	R5025	R5030	R5035	R5040	R5525
SharpeRatio	0.2221	0.2043	0.1883	0.1864	0.1519	0.1627	0.1440	0.2087	0.2071	0.2002	0.2366	0.2091
Monthly Mean Return (%)	1.6196	1.5435	1.4694	1.4574	1.3287	1.3820	1.2818	1.5010	1.4958	1.4889	1.6698	1.4984
Standard Deviation (%)	4.7168	4.7555	4.7644	4.7498	4.9803	4.9788	4.9303	4.4510	4.4610	4.5788	4.6387	4.4305
	R5530	R5535	R5540	R5545	R6025	R6030	R6035	**R6040**	**R6045**	R6525	R6530	R6535
SharpeRatio	0.2106	0.2139	0.2466	0.2358	0.2332	0.2345	0.2466	**0.2720**	**0.2607**	0.2155	0.2168	0.2201
Monthly Mean Return (%)	1.5121	1.5406	1.7045	1.6540	1.5997	1.6134	1.6870	**1.8298**	**1.7823**	1.5249	1.5376	1.5775
Standard Deviation (%)	4.4641	4.5273	4.5912	4.5882	4.4062	4.4396	4.5206	**4.6242**	**4.6421**	4.4213	4.4542	4.5681
	R6540	R6545	R7025	R7030	R7035	R7040	R7045	R7525	R7530	R7535	R7540	R7545
SharpeRatio	**0.2456**	0.2346	0.2107	0.2120	0.2073	0.2359	0.2283	0.1902	0.1916	0.1875	0.2177	0.2064
Monthly Mean Return (%)	**1.7201**	1.6727	1.5037	1.5164	1.5233	1.6814	1.6498	1.4096	1.4223	1.4293	1.5941	1.5415
Standard Deviation (%)	**4.6741**	4.6907	4.4220	4.4549	4.5885	4.7025	4.7206	4.4040	4.4374	4.5717	4.6949	4.6960

Sharpe Ratio = (Monthly Mean Return of the Portfolio - Monthly Mean Return of U.S. One-Month T-Bills) / Standard Deviation of the Portfolio

TABLE VII. Sharpe Ratios: Strategies R5025 - R7545 Versus Strategies R5025A - R7545A

	R5025	R5025A	R5030	R5030A	R5035	R5035A	R5040	R5040A	R5525	R5525A	R5530	R5530A
Sharpe Ratio	0.2087	0.2084	0.2071	0.2071	0.2002	0.2070	0.2366	0.2245	0.2091	0.2139	0.2106	0.2126
Monthly Mean Return (%)	1.5010	1.4795	1.4958	1.4758	1.4889	1.5015	1.6698	1.6010	1.4984	1.4873	1.5121	1.4836
Standard Deviation (%)	4.4510	4.3551	4.4610	4.3643	4.5788	4.4897	4.6387	4.5824	4.4305	4.2783	4.4641	4.2878
	R5535	R5535A	R5540	R5540A	R5545	R5545A	R6025	R6025A	R6030	R6030A	R6035	R6035A
Sharpe Ratio	0.2139	0.2122	0.2466	0.2299	0.2358	0.2264	0.2332	0.2280	0.2345	0.2266	0.2466	0.2259
Monthly Mean Return (%)	1.5406	1.5092	1.7045	1.6088	1.6540	1.5926	1.5997	1.5453	1.6134	1.5416	1.6870	1.5673
Standard Deviation (%)	4.5273	4.4153	4.5912	4.5094	4.5882	4.5083	4.4062	4.2682	4.4396	4.2777	4.5206	4.4051
	R6040	R6040A	R6045	R6045A	R6525	R6525A	R6530	R6530A	R6535	R6535A	R6540	R6540A
Sharpe Ratio	0.2720	0.2434	0.2607	0.2398	0.2155	0.2190	0.2168	0.2177	0.2201	0.2172	0.2456	0.2348
Monthly Mean Return (%)	1.8298	1.6669	1.7823	1.6507	1.5249	1.5093	1.5376	1.5055	1.5775	1.5312	1.7201	1.6308
Standard Deviation (%)	4.6242	4.4981	4.6421	4.4972	4.4213	4.2792	4.4542	4.2886	4.5681	4.4160	4.6741	4.5096
	R6545	R6545A	R7025	R7025A	R7030	R7030A	R7035	R7035A	R7040	R7040A	R7045	R7045A
Sharpe Ratio	0.2346	0.2312	0.2107	0.2112	0.2120	0.2099	0.2073	0.2096	0.2359	0.2273	0.2283	0.2238
Monthly Mean Return (%)	1.6727	1.6146	1.5037	1.4728	1.5164	1.4690	1.5233	1.4947	1.6814	1.5943	1.6498	1.5781
Standard Deviation (%)	4.6907	4.5085	4.4220	4.2646	4.4549	4.2740	4.5885	4.4021	4.7025	4.4968	4.7206	4.4956
	R7525	R7525A	R7530	R7530A	R7535	R7535A	R7540	R7540A	R7545	R7545A		
Sharpe Ratio	0.1902	0.2044	0.1916	0.2031	0.1875	0.2030	0.2177	0.2209	0.2064	0.2173		
Monthly Mean Return (%)	1.4096	1.4373	1.4223	1.4335	1.4293	1.4592	1.5941	1.5587	1.5415	1.5425		
Standard Deviation (%)	4.4040	4.2319	4.4374	4.2414	4.5717	4.3707	4.6949	4.4669	4.6960	4.4656		

Sharpe Ratio = (Monthly Mean Return of the Portfolio - Monthly Mean Return of U.S. One-Month T-Bills) / Standard Deviation of the Portfolio

TABLE VIII. Effect of Transaction Costs on Portfolio Wealth

	Control Portfolios						Portfolios Formed by Filter Rules				
	USLTCORPBD	USLTGVTBD	USTB1M[a]	EAFE	SP500	3-ASSET	R60[b]	R6040[c]	R6040A[d]	R6045[e]	R6045A[f]
Panel A. Transaction Cost, 0 percent											
Terminal Wealth ($)	7.32	7.60	4.43	19.22	29.46	20.90	80.10	113.59	74.79	100.58	71.74
Mean Returns:											
Monthly (%)	0.7657	0.7801	0.5721	1.1391	1.3047	1.1715	1.6936	1.8298	1.6669	1.7823	1.6507
Annualized (%)	9.1887	9.3611	6.8651	13.6686	15.6558	14.0576	20.3232	21.9577	20.0025	21.3880	19.8079
Panel B. Transaction Cost, 1 percent											
Terminal Wealth ($)	7.32	7.60	4.43	19.22	29.45	20.85	73.48	104.90	68.10	92.73	65.44
Wealth Depletion Rate (%)	0.04	0.04	-	0.04	0.04	0.26	8.26	7.65	8.94	7.81	8.78
Mean Returns:											
Monthly (%)	0.7656	0.7799	0.5721	1.1389	1.3045	1.1704	1.6600	1.7988	1.6304	1.7506	1.6149
Annualized (%)	9.1868	9.3591	6.8651	13.6667	15.6539	14.0453	19.9199	21.5850	19.5647	21.0077	19.3787
Panel C. Transaction Cost, 2 percent											
Terminal Wealth ($)	7.32	7.59	4.43	19.21	29.44	20.79	67.40	96.87	62.04	85.48	59.69
Wealth Depletion Rate (%)	0.08	0.08	-	0.08	0.08	0.53	15.86	14.73	17.05	15.01	16.80
Mean Returns:											
Monthly (%)	0.7654	0.7798	0.5721	1.1387	1.3043	1.1694	1.6264	1.7677	1.5941	1.7189	1.5791
Annualized (%)	9.1849	9.3572	6.8651	13.6647	15.6520	14.0331	19.5163	21.2121	19.1289	20.6272	18.9486
Panel D. Transaction Cost, 3 percent											
Terminal Wealth ($)	7.31	7.59	4.43	19.20	29.43	20.74	61.82	89.44	56.51	78.80	54.43
Wealth Depletion Rate (%)	0.13	0.13	-	0.13	0.13	0.79	22.82	21.26	24.44	21.66	24.12
Mean Returns:											
Monthly (%)	0.7652	0.7796	0.5721	1.1386	1.3042	1.1684	1.5927	1.7366	1.5578	1.6872	1.5432
Annualized (%)	9.1829	9.3553	6.8651	13.6628	15.6500	14.0208	19.1126	20.8391	18.6930	20.2465	18.5183

[a]No transaction costs are assumed on the purchase of U.S. one-month Treasury Bills.
[b]Number of transactions during the two-hundred-and-sixty-one-month holding period: 104
[c]Number of transactions during the two-hundred-and-sixty-one-month holding period: 96
[d]Number of transactions during the two-hundred-and-sixty-one-month holding period: 156
[e]Number of transactions during the two-hundred-and-sixty-one-month holding period: 98
[f]Number of transactions during the two-hundred-and-sixty-one-month holding period: 146

APPENDIX I. Data and Sources

(1) Ibbotson Associates	
EAFETR*	Morgan Stanley Capital International Europe, Australia, and the Far East (MSCI EAFE) Index Total Return.
EAFE3MTR#*	EAFE Cash Equivalents Total Return.
EAFELTGVTTR#*	EAFE Long-Term World Government Bonds Total Return.
SP500TR*	Standard and Poor's 500 (S&P 500) Index Total Return.
USTB1MTR	U.S. Thirty-Day Treasury Bills Total Return.
USLTCORPTR	U.S. Long-Term Corporate Bond Total Return.
USLTGVTTR	U.S. Long-Term Government Bond Total Return.
USDEFAULTPREM*	U.S. Bond Default Premium (The geometric difference between total returns on Long-Term Corporate Bonds and Long-Term Government Bonds).
USHORIZONPREM*	U.S. Bond Horizon Premium (The geometric difference between total returns on Long-Term Government Bonds and U.S. Thirty-Day Treasury Bills).
(2) DataStream	
EAFEBUSCONF_Z#*	EAFE Business Confidence Indicator (The individual indicator is standardized by subtracting its mean and dividing by its estimated standard deviation.)
EAFECONSCONF_Z#*	EAFE Consumer Confidence Indicator (The individual indicator is standardized by subtracting its mean and dividing by its estimated standard deviation.)
EAFEDY#*	EAFE Dividend Yield.
USBUSCONF*	U.S. National Association of Purchasing Management Index (Mfg Survey), seasonally adjusted.
USCONSCONF*	U.S. Consumer Confidence: The Conference Board's Index for U.S., seasonally adjusted.

APPENDIX I (continued). Data and Sources

(3) International Monetary Fund (International Financial Statistics)

EAFEDCPI[#]*	EAFE Consumer Price Index (CPI) Monthly Return (The monthly rate of change of the CPI, i.e., CPI/CPI(-1) - 1.)
EAFEDIPI[#]*	EAFE Industrial Production Index (IPI) Monthly Return (The monthly rate of change of the IPI, i.e., IPI/IPI(-1) - 1.)
EAFEDPPI[#]*	EAFE Producer Price Index (PPI) Monthly Return (The monthly rate of change of the PPI, i.e., PPI/PPI(-1) - 1.)
EAFEDEXCHR[#]*	EAFE Exchange Rate (EXCHR) Monthly Return (The monthly rate of change of the period-averaged exchange rate, expressed in national currency unit per U.S. dollar, i.e., EXCHR/EXCHR(-1) - 1.)
EAFEEXPMIMP[#]*	EAFEEXPORTS (the EAFE export values) minus EAFEIMPORTS (the EAFE import values), expressed in billions of U.S. dollar.

(4) The Federal Reserve Board

USTB3MS*	U.S. Three-Month Treasury Bill Rate, secondary market.
USCPIAUCNS*	U.S. Consumer Price Index for All Urban Consumers, not seasonally adjusted.
USINDPRO*	U.S. Industrial Production Index, seasonally adjusted.
USPPIFGS*	U.S. Producer Price Index, Finished Goods.

(5) Standard and Poor's

SP500DY*	S&P 500 Dividend Yield at the end of the month.
USEQRSKPREM*	"Fundamental Based" Equity Risk Premium: E/P ratio for the S&P 500 (i.e., the inverse of P/E for the S&P 500) minus the one-month T-bill rate.
USTB1MR*	U.S. One-Month Treasury Bill Rate.

[#]The EAFE data are the GDP-weighted average of ten of the EAFE countries, namely United Kingdom, Germany, France, Netherlands, Switzerland, Italy, Spain, Sweden, Australia and Japan. The total GDP of the ten EAFE countries represents 85.18 percent of the total GDP of the twenty countries in the MSCI EAFE Index.
*Candidate time series for the prediction model.

APPENDIX II. Pairwise Granger Causality Test Results

Variables that caused changes in SP500EAFE at a significance level of 15 percent				
Variable	Optimal Lag Length	R Bar Sq.	F-statistic	*p*-value
EAFETR	1	0.0282	3.5150	0.0659
SP500TR	1	0.0282	3.5150	0.0659
DEAFEDY	1	0.0569	4.8605	0.0317
DSP500DY	2	0.0251	2.1624	0.1246
DUSCONSCONF	1	0.0322	3.7686	0.0572
DUSTB1MR	3	0.1823	5.6396	0.0019
USDEFAULTPREM	1	0.0342	3.8914	0.0534
USHORIZONPREM	2	0.0648	3.4420	0.0389
USEQRSKPREM	3	0.1268	4.1165	0.0105

All time series have been tested for unit root using Augmented Dickey-Fuller Test at a significance level of 5 percent. Non-stationary series are transformed into stationary series using first-differencing technique. The Akaike Information Criterion (AIC) is used to determine the optimal lag length of a variable to be used in the Granger Causality Test. A maximum of three lags is used in the AIC process.

APPENDIX III. List of Trading Strategies

Strategy	Cutoff Probability	Strategy	Probability Neutral Zone (Upper Bound - Lower Bound)
R5	5%	R5025	50% - 25%
R10	10%	R5030	50% - 30%
R15	15%	R5035	50% - 35%
R20	20%	R5040	50% - 40%
R25	25%	R5525	55% - 25%
R30	30%	R5530	55% - 30%
R35	35%	R5535	55% - 35%
R40	40%	R5540	55% - 40%
R45	45%	R5545	55% - 45%
R50	50%	R6025	60% - 25%
R55	55%	R6030	60% - 30%
R60	60%	R6035	60% - 35%
R65	65%	R6040	60% - 40%
R70	70%	R6045	60% - 45%
R75	75%	R6525	65% - 25%
R80	80%	R6530	65% - 30%
R85	85%	R6535	65% - 35%
R90	90%	R6540	65% - 40%
R95	95%	R6545	65% - 45%
		R7025	70% - 25%
		R7030	70% - 30%
		R7035	70% - 35%
		R7040	70% - 40%
		R7045	70% - 45%
		R7525	75% - 25%
		R7530	75% - 30%
		R7535	75% - 35%
		R7540	75% - 40%
		R7545	75% - 45%

APPENDIX IV. Correlation Matrix

	SP500EAFE	SP500TR(-1)	DEAFEDY(-1)	DSP500DY(-1)	DSP500DY(-2)	DUSTB1MR(-1)	DUSTB1MR(-2)
SP500TR(-1)	-0.1528						
DEAFEDY(-1)	0.0640	-0.6133					
DSP500DY(-1)	0.0700	-0.5795	0.5498				
DSP500DY(-2)	0.0089	-0.0083	0.1459	0.2677			
DUSTB1MR(-1)	-0.0754	-0.0286	0.0121	-0.0400	-0.2435		
DUSTB1MR(-2)	0.0246	-0.1871	0.1542	0.1904	-0.0401	0.0392	
DUSTB1MR(-3)	-0.1300	-0.0371	0.0764	0.2373	0.1896	-0.1054	0.0397
USDEFAULTPREM(-1)	0.0972	0.0053	-0.0911	-0.0414	-0.0471	0.0172	-0.0758
USHORIZONPREM(-1)	-0.0988	0.3497	-0.1393	-0.1707	0.1717	-0.3724	-0.0691
USHORIZONPREM(-2)	-0.0446	0.0943	-0.1382	-0.3541	-0.1698	-0.1771	-0.3741
USEQRSKPREM(-1)	-0.0100	0.0906	-0.1213	-0.0485	0.0950	-0.2469	-0.2335
USEQRSKPREM(-2)	-0.0466	0.1726	-0.2097	-0.2191	-0.0470	0.1317	-0.2485
USEQRSKPREM(-3)	-0.0460	0.1093	-0.1794	-0.1978	-0.2182	0.1879	0.1312

	DUSTB1MR(-3)	USDEFAULTPREM(-1)	USHORIZONPREM(-1)	USHORIZONPREM(-2)	USEQRSKPREM(-1)	USEQRSKPREM(-2)
SP500TR(-1)						
DEAFEDY(-1)						
DSP500DY(-1)						
DSP500DY(-2)						
DUSTB1MR(-1)						
DUSTB1MR(-2)						
DUSTB1MR(-3)						
USDEFAULTPREM(-1)	0.0489					
USHORIZONPREM(-1)	0.0002	-0.4514				
USHORIZONPREM(-2)	-0.0691	0.1427	0.0927			
USEQRSKPREM(-1)	-0.1537	0.0856	0.1429	0.1603		
USEQRSKPREM(-2)	-0.2308	0.1093	0.0300	0.1441	0.9116	
USEQRSKPREM(-3)	-0.2458	0.0955	-0.0231	0.0302	0.8046	0.9111