

# PREDICTING THE RELATIVE PERFORMANCE OF ACTIVELY MANAGED EQUITY MUTUAL FUNDS USING DIVERSE PERFORMANCE EVALUATION TECHNIQUES

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## Abstract

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Mutual fund performance evaluation has seen an ever-growing interest for research amongst industry and academicians alike. In this paper an attempt has been made to compare and correlate global actively managed equity mutual funds' performance across time intervals, to evaluate and establish how predicting future performance can be made meaningful for investors using analysis of historical data based on monthly net asset values (NAVs) (March 2009–March 2021). Of the top 500 global equity mutual funds based on market-cap (on March 31, 2021), the paper evaluated 180 actively managed funds adding up to approximately USD 5 trillion of the fund assets as of March 31, 2021. The research gap which the paper aims to fill is to bring under one umbrella, prediction analysis using performance measures, downside risk measures, style factor analysis, and market timing models. For sampled equity funds various performance ratios and style attributes were computed and compared across periods for their relative performance. Relative performance was found to be stable (at 1% significance level) across periods and hence predictable. A portfolio of funds constructed optimally using historical performance was seen to be in the top quartile ex-post performance in the subsequent period. However, it was found that the market timing abilities of fund managers were unstable across periods and could not be used for predicting performance. Based on the study findings, it would be appropriate for investors to use the relative past performance of the funds and their style attribute analysis for the future allocation of investible surplus across these funds.

**Keywords:** Sharpe, Treynor, Jensen's Alpha, M-Squared, Appraisal Ratio, Treynor-Mazuy, Carhart Model

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## 1. INTRODUCTION

Mutual funds are considered as an avenue for a systematic approach to investing in financial markets for large and small investors giving advantages of liquidity, tax sops, and diversification amongst others (Kaur, 2021). They act as professional intermediaries to reduce the gap between time and skill constraints (Chander, 2002) and to provide calculated risk exposure designed for better returns for diverse investors who are constrained in time, resources, and knowledge for direct participation in equity markets. Globally the industry has grown and at present, the total net assets of worldwide regulated open-end funds stood at USD 54.9 trillion by 2020 (ICI, 2020) and are estimated to reach USD 145.4 trillion by 2025 (PwC, 2017). Historically, funds aim to outperform traditional investment avenues and equity benchmarks. Further, digital adaptation, the flexibility of products, regulated industry, low costs of investing, a platform for long-term financial planning, the economics of scale, small to large units of investment for all economic classes of the populations make it an attractive investment avenue. However, a multiplicity of products, differing returns make it a challenging task for an investor. Different ways of evaluation of fund performance have developed over a period. These include risk-adjusted returns tools, downside risk evaluation, market timing tools, and style and multi-factor models. According to Pilotte and Sterbenz (2006), ex-post performance ratios are most helpful for the evaluation of the historical performance of mutual funds. According to Illmer and Senik (2013), stakeholders like investors and investment managers need timely and accurate information on the performance of their investment portfolios as it would aid asset owners to make rational and effective decisions like continuing with the fund, adding more investments, diversifying into other funds, etc., it also assists the fund managers to identify the red flags of risks and helps them monitor funds more effectively.

The current paper analyses the top 180 actively managed equity global funds top funds based on their assets under management as of March 31, 2021 which add up to approximately USD 5 trillion; using all diverse tools to understand whether they can be used to predict mutual fund performance. The paper uses the past net asset value (NAV) data (March 2009–March 2021) for large actively managed equity mutual funds with investments in stocks across the globe. This data is split into 4 time periods of 36 months each to backtest whether fund performance can be predicted. In the paper, mutual fund performance has been evaluated using the Sharpe ratio, the Treynor ratio, the Jensen's alpha, the appraisal ratio, M-squared ( $M^2$ ) measure, the Sortino ratio, the Sterling ratio, and the Calmar ratio. Additionally, the evaluation analysis also includes analysis based on style factors (Carhart model) and analysis of the market timing ability of the fund managers (Treynor-Mazuy model).

Treynor (1965), Sharpe (1966) and Jensen (1968) introduced the risk-adjusted measures of performance evaluation of Mutual funds. Graham and Harvey (1994) made an equivalent representation of the Sharpe measure which was popularised by Modigliani and Modigliani (1997)

where in the fund returns are evaluated based on its benchmark or market risk as measured by standard deviation. On the risk and downside deviation side, Sortino and Price (1994) developed the Sortino ratio to measure a downside risk in comparison to total risk (standard deviation). Young (1991) introduced the Calmar ratio which indicated the maximum drawdown as a risk measure. On the style side, Carhart (1997) proposed a four-factor model, which strengthens the Fama-French model with an additional momentum factor.

The study has been undertaken with an objective to evaluate the consistency of relative performance of selected global equity mutual funds, based on multiple performance parameters including the Sharpe ratio, the Treynor ratio, the Jensen's alpha,  $M^2$  measure, and the appraisal ratio over the period. Additionally, the study aims to identify the presence of market timing abilities and style analysis of fund managers. A key aspect of evaluation funds is the downside risk. The study uses the Sortino, Calmar, and Sterling ratios to measure the down-risk of fund performance. These aforementioned tools are then used to evaluate the ex-post performance of portfolio constructed using allocation across these mutual funds that maximize performance measure based on the past data.

Most of the research done evaluates independently the performance ratio, market timing, and style analysis, and downside risk. The seminal papers by Treynor (1965) and Sharpe (1966) set the process of evaluation and further research has built upon these papers. However, each research paper focuses only on one or a few techniques of evaluating portfolio performance. For instance, Markovic-Hribernik and Kuzner (2013) compared various mutual funds based on Sharpe but did not use any other technique. Taleski and Bogdanovski (2015) analysed mutual funds based on the Sortino, Calmar, Sterling, Sharpe, Omega ratios, and upside potential but did not use market timing and style analysis. Bello (2008) undertook a comparative study of equity mutual funds' performance using style analysis as per the Carhart model but did not use any risk-return ratio analysis. This paper aims to fill the research gap wherein all these measures are computed on top global funds which would provide in-depth analysis and perspective to different stakeholders.

The paper also uniquely looks at the relative comparison method of performance evaluation, unlike the aforementioned research papers which emphasize absolute values of performance.

The significant question that arises is that if it is effective enough for investors and investment managers to just look at returns, risk, and fund manager characteristics in silos or will a combination of these factors give better insights to these stakeholders. Additionally, the question also arises as to whether the relative assessment is adequate for the stakeholders to make investment decisions.

The remainder of the paper is organized as follows. Section 2 discusses the literature review and develop hypotheses, Section 3 describes the research methodology covering the sample, methodology applied in the paper. Section 4 deliberates on the research results and Section 5 discusses the results respectively. The conclusions is presented in Section 6.

## 2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Treynor (1965), Sharpe (1966), and Jensen (1968) laid down the foundation for mutual fund performance evaluation. Over a period, variations and dimensions of new measurement have cropped up to analyse fund performance including market timing skills, a style analysis, an attribution model, downside risk amongst others for analysis.

Sharpe (1966) undertook significant research in empirically testing and constructing the Sharpe ratio, i.e., the reward to risk ratio which enables to rank fund performance. Treynor and Mazuy (1966) developed a quadratic equation to measure the market timing abilities of fund managers. Jensen (1968) developed a technique to evaluate the fund performance skill of a fund manager based on returns in excess of the risk-free rate, generated by the portfolio over Capital Asset Pricing Model (CAPM) returns, he found limited evidence of outperformance. Further, multiple studies have been taken to evaluate the performance evaluation of mutual funds based on the Sharpe, Treynor ratios, and the Jensen's alpha. Studies by Debasish (2009), Agarwal and Mukhtar (2010) evaluated funds based on the Sharpe, Treynor ratios, and Jensen's alpha to identify top performing mutual funds. Findings by Ilo, Yinusa, and Elumah (2018) indicated that the ratios measures failed to provide superior risk-adjusted returns and ineffective portfolio diversification skills of fund managers in Nigeria. The underperformance of mutual funds was observed in Spain by García, Ortiz, Población, and Sarto (2013); Nafees, Ahmad, and Khan (2012) in Pakistan; Rahman, Qiang, and Barua (2012) in selected mutual funds in Bangladesh; Suppa-Aim, Jelic, and Theobald (2014) in Thailand. In a study of several countries of Central and Eastern Europe, BRICS, etc., findings suggested that the mutual funds did not outperform the relative benchmarks during the financial crisis, recession, and recovery period as well based on the Jensen's alpha, Sharpe, Treynor, and Carhart measures to assess the performance of the funds (Lemeshko & Rejnuš, 2015). Choudhary and Chawla (2016) analysed the risk and return of selected growth large-cap funds in India, for the period from 2005 to 2013 based on financial tests like average return, the Sharpe ratio, the Treynor ratio, standard deviation, beta and coefficient of determination ( $R^2$ ). Their findings indicated that the majority of funds outperformed the benchmark in the Sharpe and Treynor ratios, similarly, further, Khan, Jamil, and Uddin (2016) undertook a comparative study for the period from 2011 to 2015 of all the equity funds which were launched before 2012 in Oman and analysed their quarterly performance based on risk and return using diverse evaluation tools including the Sharpe ratio, the Treynor ratio, and the Jensen's alpha. Their results indicated the outperformance of Oman mutual funds compared to the benchmarks for the five years providing consistent good returns to investors.

Bhagyasree and Kishori (2016) studied 30 open-ended, growth-oriented equity schemes for the period from April 2011 to March 2015 based on Sharpe, Treynor, and Jensen's measures. Studies revealed a mixed outcome of fund returns. Arugaslan, Edwards, and Samant (2008) undertook

the study of 50 large-cap international equity funds in the USA through the  $M^2$  method, Sharpe and Treynor measures, and the Jensen's alpha for the period 1994–2003. The empirical study showed that once the degree of risk was embedded in the fund the attractiveness to investors for high average return funds get reduced. Kiymaz (2015) analysed the performance of 1037 Chinese mutual funds for the period from January 2000 to July 2013 using risk performance measures including the Sharpe ratio, the information ratio, the Treynor ratio,  $M^2$ , and the Jensen's alpha. Findings indicated positive alphas ( $\alpha$ ) for in the case of for aggressive allocation funds as well as funds with moderately aggressive allocation.

Markovic-Hribernik and Kuzner (2013) undertook a comparative study of the domestic and foreign mutual fund managers performance based on the Sharpe, Treynor, and Sortino ratios for the period 2006–2010 of 36 sampled domestic and foreign equity mutual funds, their findings indicated that foreign fund managers underperformed domestic operators whereas the majority of the sampled funds had negative Sortino ratios. Barjaktarovic, Jecmenica and Paunovic (2013) analysed the performance of 13 open investment funds in Serbia for the period 2007–2013 through the Sortino ratio, the Jensen's alpha, and the Sharpe ratio wherein they found that domestic investment funds underperformed their respective benchmarks and based on Sortino ratio only three open funds generated positive performance over the risk-free rate which was the minimum alternate rate (MAR).

According to Kumaran (2013), fear and risk of losing money are some of the most powerful emotions, and therefore, the analogy of the same is extended to portfolio planning and management. Various stakeholders including fund managers and investors aim to minimize and reduce their downside volatility with tools like lower partial movement and maximum drawdown. A common question circulating among academicians and investors is what are the probable good and best measures of risk (Rogers and Van Dyke, 2006). However, there is not one specific measure of risk that one can deep dive and minimize risk across funds. Tools like standard deviation, VaR, downside deviations to name a few have been developed over time.

Taleski and Bogdanovski (2015) undertook statistical and ratio-based analyses of 11 pension and investment mutual funds of Macedonia for the period from June 2011 to June 2014. The ratio-based evaluation was done using the Sortino, Calmar, Sterling, Sharpe, Omega, and upside potential to draw relevant conclusions regarding the risks and characteristic moments. Statistical analysis had shown that pension funds have delivered a significantly more positive volatility-adjusted risk premium than investment funds. Omega ratios provide positive values whereas the Calmar ratio was higher for pension funds indicating a lower downside risk. Van Heerden, Heymans, van Vuuren, and Brand (2014) examined hedge funds (38 significant hedge funds from the EU and 84 US hedge funds based on the Calmar, Sortino, Sharpe, Omega, Treynor ratios, and the Jensen's alpha. Their period of study was based on post the financial crisis, crisis period, and the period before the financial crisis, to evaluate the performance of the US and EU hedge funds during the aftermath of the financial

crisis. Their findings indicated that hedge funds generated better performance over the CAC 40, DAX, S&P 500, and Dow Jones from 2004 to 2011, further, the Sharpe, Sortino, Omega, Treynor, Calmar ratios, and Jensen's alpha, illustrated that the US hedge funds outperformed both EU hedge funds and the associated equity markets over this period. Singh and Padmakumari (2020) analysed the stock selection and market timing skills of fund managers using the  $M^2$  model, the Treynor-Mazuy model, the Sortino ratio, the information ratio, the Sharpe ratio, and the Treynor ratio for a full sample study of MNC mutual funds operating in India for 10 years from 2010 to 2019. Their findings suggest that multinational companies (MNC) funds perform better than the market and other theme-based mutual funds in India for most of the time frame.

Eling (2008) examined a dataset of 38,954 mutual funds in the period from 1996 to 2005 consisting of 7 asset classes. Using the Sharpe ratio, drawdown measures of Sterling, Calmar, and Burke ratio along with value at risk (VaR) and lower partial moment of order 1, 2, and 3, findings indicated that choosing a performance measure is not critical to funding evaluation and the Sharpe ratio is generally adequate. Giannotti and Mattarocci (2013) examined the downside risk of all the mutual fund constituents of the S&P Index of the USA real estate investment trusts (REITs) for the period from 2001 to 2012. They studied the Sortino, Calmar, Sterling, Burke, Kappa, Omega, and Sharpe ratios for the funds. They found that even if there is a correlation between all the rankings, results demonstrated that the choice of risk measure can affect the ranking positions of certain REITs as well as the time persistence results. Caporin and Lisi (2011) studied the mean of rank correlations of the performance measures understudy in order to examine the probability of the existence of rank correlation and aimed to suggest a method to identify which subset of the measures are not relevant and equivalent. Their findings highlighted that the performance measures are not stable over time based on monthly returns of the constituents S&P 1500 for the duration of January 1990 to October 2008 based on the 23 measures understudy including the  $M^2$ , the Calmar, Sterling, Sortino, Kappa, Sharpe, Treynor ratios, the appraisal ratio, VaR, and others.

Many studies have indicated the absence of market timing and lower overall performance by fund managers. Studies by Treynor and Mazuy (1966), Jagannathan and Korajczyk (1986), Henriksson and Merton (1981), Becker, Ferson, Myers, and Schill (1999) found insignificant or lack of market-timing amongst the funds. Alternatively, Lee and Rahman (1990), Cumby and Glen (1990), Grinblatt and Titman (1992), and Jiang, Yao, and Yu (2007) suggested the significant presence of market timing ability of fund managers.

Neto, Lobão, and Vieira (2017) examined market timing and selectivity of 51 Portuguese mutual funds from June 2002 to March 2012 based on Treynor-Mazuy (TM) and Henriksson-Merton (HM) models. Overall, both models show that on average the Portuguese mutual funds were not capable of identifying underpriced stocks or time the market successfully. Further, Bu (2019) examined whether mutual funds generated daily alpha and timed the market return daily, based on the TM and HM models for all funds that composed the Centre for

Research in Security Prices (CRSP) domestic equity funds in 2015 and 2017. The findings indicated that it was randomness that provided market timing. Thobejane, Simo-Kengne, and Muteba Mwamba (2017) examined 191 equity unitrust funds in South Africa (2006-2016) in order to check the market timing ability using the TM and HM models and to examine the persistence of performance of funds using both cross-sectional regression and the non-parametric rank correlation test. Their findings suggest weak evidence of stock selection, as well as market timing ability with the unit, trusts reporting insignificant coefficients of the models.

Susanti and Ichani (2019) undertook a study to determine whether the Carhart four-factor model can explain the level of the excess return of the expected stock. Based on constituents of the LQ45 Index in Indonesia (2012-2016), their findings indicated that the market return, SMB (small minus big), HML (high minus low), and WML (winner minus losers) had a significant effect (79%) on stock excess return. Bello (2008) undertook a comparative study of the Carhart model with the Fama-French model and CAPM regarding the quality of prediction and statistical goodness of fit based on a sample of 628 equity mutual funds (April 1986-March 2006). Findings indicated that 71% of fund returns were explained by three regression lines and that the difference between the three models was not significant. Bello (2008) suggested from work that the Carhart model was a better model than the CAPM and the Fama-French model. Boamah (2015) found that the Carhart model presented returns better than the Fama-French model in the case of the South African stock market based on the 848 funds (January 1996-April 2012), reflecting the underlying economic risk relating to the economy of South Africa.

Pedersen and Rudholm-Alfvén (2003) understood a study of the properties of classic and modern performance measures for mutual fund evaluation such as the Sharpe ratio, Treynor ratio, Jensen's alpha, Sortino ratio, and lower partial movements, and when are they likely to be more useful. The study was undertaken for 168 funds of global financial services institutions and UK micro-firms for the period from February 1998 to February 2003. Their findings indicated strong support for Sharpe-related measures, the need for effective risk management, tracking performance, and tight reporting requirements.

### 3. RESEARCH METHODOLOGY

#### 3.1. Sample

The study covers 180 funds listed in Table A.1, Appendix along with their respective benchmark indices and net assets. The selection is based on actively managed funds out of the top 500 equity mutual funds. Those actively managed funds which were not in existence in March 2009 are excluded. Also, global investment funds (particularly those in Europe and Asia-Pacific) for which there is no benchmark index or that the benchmark index is proprietary and hence index history is not readily available are excluded. Net assets of the individual funds range from USD 4 billion to USD 258 billion; totally adding up to USD 5 trillion which is about 33% of the actively managed funds across the globe.

The NAV data for these funds and their benchmarks were collected using Bloomberg (<https://www.bloomberg.com/europe>), Yahoo Finance (<https://finance.yahoo.com/>), and Investing.com (<https://www.investing.com/>) as the data sources. The names of the largest 20 funds are collated in Table A.2, Appendix.

### 3.2. Methodology

Monthly NAV data was collated for the sampled funds based on the selected time period of 144 months from March 31, 2019 to March 31, 2021. Monthly matching values of the benchmarks for these funds were also collated. Subsequently, the discrete monthly returns were computed for the funds as well as the benchmarks. The 3-year US treasury yields were taken as the surrogate for the risk-free rate of return. The matching months were of the same were collated and subtracted from the monthly returns of the mutual funds and their benchmarks for computing the returns over the risk-free returns. Thereafter the entire time period of 144 months was divided into 4 parts of 36 months each.

For undertaking the *performance analysis* for the active funds, i.e., equity mutual funds, the performance parameters used were an average monthly return, an average monthly standard deviation of return, the Sharpe ratio, Treynor ratio, Jensen's alpha, M<sup>2</sup> measure, and the appraisal ratio. The *downside risk* was evaluated using the Sortino, Calmar, and Sterling ratios. *Style analysis* and *market timing* were undertaken using the Carhart four-factor model and the Treynor-Mazuy model, respectively. These were discussed and computed using the following equations respectively:

a) *Holding period returns* (monthly return computations): Returns have been computed using the formula below:

$$\text{Holding period returns} = (P_1 - P_0)/P_0 \quad (1)$$

b) *Sharpe ratio* (total risk-adjusted return tool): This ratio computes the risk premium per unit of risk. A higher Sharpe ratio indicates higher performance relative to total risk:

$$\text{Sharpe ratio} = [R_p - R_f]/\sigma_p \quad (2)$$

c) *Treynor ratio* (market risk-adjusted return tool): In order to evaluate the fund performance, Treynor (1965) developed the risk-adjusted ratio wherein the excess return was divided by the fund beta, i.e., systematic risk. Known as the reward to volatility ratio this ratio helped to rank the funds. Where the Sharpe ratio assesses mutual fund performance in terms of the reward to variability while the Treynor ratio measured reward to volatility:

$$\text{Treynor ratio} = [R_p - R_f]/\beta_p \quad (3)$$

d) *Jensen's alpha* ( $\alpha_p$ ) (fund performance over expected return based on CAPM): It was developed in 1966, to study the fund managers' efficiency, here, the excess return of the portfolio is regressed against the excess return of the benchmark or market which is based on the CAPM. The intercept generated by the regression is known as Jensen's alpha and if the alpha is positive and statistically

significant it indicates efficient portfolio management and superior performance as compared to the market due to the stock selection ability and predictive ability of the fund manager (Reilly, 1989):

$$\alpha_p = R_p - \{R_f + \beta_p * (R_m - R_f)\} \quad (4)$$

e) *Appraisal ratio* (abnormal returns to unsystematic risk): This ratio divides the alpha of the portfolio ( $\alpha_p$ ) by the non-systematic risk ( $e_i$ ). It indicates the abnormal return per unit of unsystematic risk. It is a measure of a portfolio's performance computed by alpha (a measure of the fund's return, assuming the market return is zero) and dividing by its that in principle can be diversified away by holding a market index portfolio. Alpha is Jensen's alpha which is based on CAPM (Bodie, Kane, & Marcus, 2017):

$$\text{Appraisal ratio} = \alpha_p/\sigma_{ei} \quad (5)$$

f) *M<sup>2</sup> measure* (adjusted fund returns for market variance): It is an extended version of the Sharpe ratio. The numerical value of the Sharpe ratio is not easy to interpret. The M<sup>2</sup> measure is a risk-adjusted returns measure. In this measure, the returns of a portfolio are computed relative to the risk of the benchmark or market. The difference between this revised portfolio bearing market risk is then compared with the market return and the difference is considered as over or underperformance as compared to the market:

$$M^2 \text{ measure} = (\sigma_m/\sigma_p) * (R_p - R_f) + R_f \quad (6)$$

where, for (a) to (f): (i)  $R_p$  = return on the fund portfolio, (ii)  $R_f$  = risk-free rate of return, (iii)  $\sigma_p$  = standard deviation of the portfolio, (iv)  $\beta_p$  = Beta of the portfolio, (v)  $R_m/R_b$  = return on the fund to relevant benchmark, (vi)  $\sigma_{ei}$  = standard deviation of the non-systematic risk.

The *downside risk* was computed using the following techniques. Every investment (except a risk-free asset) has risk associated with it. One of the risks is the downside risk. The probability that a financial instrument will see a fall in its price leading to a probable loss is considered as a downside risk. The downside risks under the current study are discussed below:

a) *Sortino ratio* (based on negative deviations of returns): The Sharpe ratio measures risk based on standard deviation which is a total risk. However, Sortino suggested that an investor is more worried about the downside risk and prefers it to be minimised than upside risk in returns. This measure is a variation in the Sharpe ratio that factors in only downside risk while computing the standard deviations. It is a risk-adjusted return measure:

$$\text{Sortino ratio} = [R_p - R_f]/\sigma_p \quad (7)$$

b) *Sterling ratio* (maximum annual loss): This ratio divides the excess return with the maximum annual drawdown based on a cycle of 36 months. This measures the average drawdown of a fund rather than just the maximum drawdown. It is generally associated with hedge funds. The higher the ratio the better as this indicates that the hedge fund has a greater return relative to the expected

level of risk. It is calculated as a ratio between the fund's compounded annual return and maximum annual drawdown:

$$\text{Sterling ratio} = \frac{[R_p - R_f]}{\text{average maximum annual drawdown}} \quad (8)$$

c) *Calmar ratio* (based on the maximum total period loss): This is a modified version of the Sterling ratio. It is computed by dividing the average annual rate of return by maximum drawdown for the previous three years. The duration of 36 months is generally used to evaluate the performance of different hedge funds and to take decisions relating to the investment.

$$\text{Calmar ratio} = \frac{[R_p - R_f]}{\text{maximum drawdown}} \quad (9)$$

Apart from performance evaluation measures and downside risk, two key aspects in analysing a mutual fund are the style of fund management and the market timing ability of a fund manager.

The *style analysis and market timing* were undertaken using the Carhart model and TM model, respectively:

a) *Carhart model* (style factors for fund return prediction): This model is an extension of the Fama-French three-factor model, wherein a 4th-factor momentum has been added. Herein, the excess portfolio returns are regressed against the four factors as considered by Carhart in his model including:

1) Market risk premium factor which is  $\beta * (R_m - R_f)$

2) Size factor, i.e., a factor related to the market capitalization of portfolios consisting of the smallest set of firms and the largest set of firms in the portfolio (small minus big, SMB), the constituents for the SMB factor are based on excess returns of small and big firms in the portfolio.

3) The factor related to value (HML) is the difference of the return based on the value stocks and growth stocks.

4) Momentum factor which is also called the up-minus-down factor is the difference of returns of the positive advancing firms minus the negative advancing firms;

5) Alpha, i.e., performance not attributable to any of the four factors and

6)  $e_p$  which is the residuals or the idiosyncratic volatility.

$$\text{Carhart model} = [R_p - R_f] = \beta_1 * R_m + \beta_2 * HML + \beta_3 * SMB + \beta_4 * MOM + e_p \quad (10)$$

where, (i)  $R_p$  = return on the portfolio, (ii)  $R_f$  = risk-free rate of return, (iii)  $\beta_p$  = Beta factor, (iv) HML = high minus low (average return on high book-to-market portfolio minus average return on the low book to market portfolio), (v) SMB = small minus big (average return on small-cap portfolio minus average return on large-cap portfolio), (vi) MOM/WML = winners minus losers (return on portfolio of winners minus return on portfolio of losers) and  $e_p$  = error term not explained by the model.

b) *Market timing model* (analysing market timing ability of fund managers): The process of moving investment money in and out of markets

and across asset classes based on predictive financial models can be considered as market timing. It also refers to the act of actively managing portfolios through strategies. Market timing can be considered as (i) the process where the fund managers have to undertake tactical asset allocation and allocate funds across various asset classes, e.g., equities versus cash, in the anticipation of future market direction with success and (ii) it also tests the fund managers ability to adjust the sensitivity of the portfolio in relation to the market in response to the expected market return, i.e., increasing (decreasing) the portfolio beta in response to an anticipated bull (bear) market (Jiang, 2003). The paper applies the TM model to test for the market timing abilities of fund managers:

$$\text{Treynor - Mazuy model} = [R_{it} - R_{ft}] = \alpha_i + \beta_i * (R_{mt} - R_{ft}) + \gamma_i * (R_{mt} - R_{ft})^2 + e_{it} \quad (11)$$

where, (i)  $t$  = time, (ii)  $R_{it}$  = return on portfolio, (iii)  $\alpha_i$  = alpha factor, (iv)  $R_{mt}$  = market return, (v)  $\beta_i$  = Beta factor, (vi)  $\gamma_i$  = gamma for timing analysis,  $e_{it}$  = error term not explained by model.

Caporin and Lisi (2011) suggested the use of rank correlations to understand the performance of funds across funds. Therefore, after computing the performance above parameters, the funds were ranked based on the performance parameter for each of the two periods and the Spearman rank correlation coefficient was computed. The Spearman rank correlation has been used as it helps to measure the strength and direction of the association between the two periods under study.

$$\text{Spearman rank correlation coefficient} = 1 - [6 * \Sigma d^2 / n * (n^2 - 1)] \quad (12)$$

Post the computation of the Spearman rank correlation coefficient, it was tested for its statistical significance by computing the p-value. The t-statistic was computed as:

$$t = (r) * \text{Sqrt}\{(n - 2) / (1 - r^2)\} \quad (13)$$

where,  $r$  = correlation coefficient and  $n$  = sample data points for each series.

#### 4. RESEARCH RESULTS

Relative performance of the selected funds across all performance parameters remained stable across the periods with the correlation coefficients across the periods were found to be significant at a 1% level of significance. The summary tables are as shown below. It can be seen in Tables 1, 2, 3, and 4 that the correlation coefficients of the relative performance of the sampled equity funds, i.e., the rank correlations across the various periods based on the performance measures of 1 return, 2 standard deviation, 3 Sharpe ratio, appraisal ratio, Treynor ratio, and Jensen's alpha are significant at 1%. This implies that the relative performance based on these measures is stable across the periods and hence reliably predictable. One exception is that the  $M^2$  ratio is not significant for the two periods as shown in Table 3 (marked with \*).

**Table 1.** Relative performance evaluated based on return and standard deviation

	Return			St.dev.		
	Correlation coefficient	t-statistic	p-value	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 2	0.43	6.43	0.00%	0.82	19.05	0.00
Rank for period 1 vs period 3	0.51	7.87	0.00%	0.66	11.82	0.00
Rank for period 1 vs period 4	0.48	7.38	0.00%	0.51	7.87	0.00
Rank for period 2 vs period 3	0.59	9.90	0.00%	0.86	22.67	0.00
Rank for period 2 vs period 4	0.71	13.60	0.00%	0.51	7.97	0.00
Rank for period 3 vs period 4	0.83	19.68	0.00%	0.57	9.28	0.00

**Table 2.** Relative performance evaluated based on the Sharpe ratio and the appraisal ratio

	Sharpe ratio			Appraisal ratio		
	Correlation coefficient	t-statistic	p-value	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 2	0.46	6.96	0.00	0.36	5.22	0.00%
Rank for period 1 vs period 3	0.24	3.28	0.00	0.23	3.18	0.09%
Rank for period 1 vs period 4	0.34	4.87	0.00	0.21	2.86	0.24%
Rank for period 2 vs period 3	0.50	7.64	0.00	0.62	10.70	0.00%
Rank for period 2 vs period 4	0.47	7.21	0.00	0.48	7.40	0.00%
Rank for period 3 vs period 4	0.80	17.62	0.00	0.76	15.77	0.00%

**Table 3.** Relative performance evaluated based on the M<sup>2</sup> ratio and Treynor ratio

	M <sup>2</sup> ratio			Treynor ratio		
	Correlation coefficient	t-statistic	p-value	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 2	0.16	2.16	0.02	0.29	4.10	0.00
Rank for period 1 vs period 3	0.09	1.18	0.12*	0.17	2.36	0.01
Rank for period 1 vs period 4	0.02	0.30	0.38*	0.17	2.26	0.01
Rank for period 2 vs period 3	0.39	5.68	0.00	0.33	4.66	0.00
Rank for period 2 vs period 4	0.47	7.15	0.00	0.45	6.74	0.00
Rank for period 3 vs period 4	0.74	14.52	0.00	0.68	12.46	0.00

**Table 4.** Relative performance evaluated based on the Jensen's alpha

	Jensen's alpha		
	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 2	0.30	4.24	0.00
Rank for period 1 vs period 3	0.34	4.80	0.00
Rank for period 1 vs period 4	0.30	4.23	0.00
Rank for period 2 vs period 3	0.55	8.71	0.00
Rank for period 2 vs period 4	0.37	5.27	0.00
Rank for period 3 vs period 4	0.76	15.67	0.00

By taking an average of the rank for the return across the periods, the correlation coefficient improved as shown in Table 5.

Rank correlation across the periods for the downside risk-return measure of the Sortino ratio (which is based on the downside standard

deviation) is also found to be stable, as shown in Table 6 below.

However, the downside risk measures based on drawdown (Sterling and Calmar ratios *vide* Tables 7 and 8) do not seem to offer stable outcomes over time in terms of relative performance across the funds.

**Table 5.** Relative performance evaluated based on the average returns across multiple periods

	Average returns		
	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 4	0.48	7.38	0.00
Rank for period 2 vs period 4	0.71	13.60	0.00
Rank for period 3 vs period 4	0.83	19.68	0.00
Average rank for periods 1, 2 and 3 vs period 4	0.84	20.47	0.00

**Table 6.** Relative performance based on the Sortino ratio

	Sortino ratio		
	Correlation coefficient	t-statistic	p-value
Rank for period 1 vs period 2	0.44	6.49	0.00
Rank for period 1 vs period 3	0.24	3.34	0.00
Rank for period 1 vs period 4	0.29	4.06	0.00
Rank for period 2 vs period 3	0.50	7.81	0.00
Rank for period 2 vs period 4	0.48	7.32	0.00
Rank for period 3 vs period 4	0.80	17.88	0.00

**Table 7.** Relative performance based on the Sterling ratio

	<i>Sterling ratio</i>		
	<i>Correlation coefficient</i>	<i>t-statistic</i>	<i>p-value</i>
Rank for period 1 vs period 2	-0.21	-2.89	1.00
Rank for period 1 vs period 3	-0.20	-2.76	1.00
Rank for period 1 vs period 4	-0.14	-1.95	0.97
Rank for period 2 vs period 3	0.62	10.57	0.00
Rank for period 2 vs period 4	0.60	9.98	0.00
Rank for period 3 vs period 4	0.82	19.53	0.00

**Table 8.** Relative performance based on the Calmar ratio

	<i>Calmar ratio</i>		
	<i>Correlation coefficient</i>	<i>t-statistic</i>	<i>p-value</i>
Rank for period 1 vs period 2	-0.21	-2.89	1.00
Rank for period 1 vs period 3	-0.20	-2.76	1.00
Rank for period 1 vs period 4	-0.14	-1.95	0.97
Rank for period 2 vs period 3	0.62	10.57	0.00
Rank for period 2 vs period 4	0.60	9.98	0.00
Rank for period 3 vs period 4	0.82	19.53	0.00

A portfolio was constructed out of the selected mutual funds to maximize the Sharpe ratio for the first three-time periods. Using the weights for the funds in this portfolio, the ex-post Sharpe ratio was computed for period 4. This was found to be at rank 43, i.e., within the top quartile performance (in terms of the Sharpe ratio) among the selected 180 funds.

**Table 9.** Portfolio of mutual funds maximizing the Sharpe ratio

<i>Mutual fund names</i>	<i>Mutual fund weights</i>
HBLAX	69.2%
PRHSX	17.7%
FSCSX	11.1%
PGBAX	2.0%
Sharpe for the period 4	<b>0.26</b>
Rank among the 180 funds plus this portfolio	<b>43</b>

For the style factor analysis, the factor returns for size, P/B, and momentum factors were sourced from Prof Kenneth French's data library available on the web. The excess fund returns were regressed on the style factors and for every 36 observations, the next (i.e., the 37th) period fund return was predicted using the regression factor coefficients. Thus, for the 108 months, predicted returns were calculated on a rolling basis. Averaging over 36 months, the average predicted monthly returns for the three periods of 36 months were computed and ranks for the funds were ascertained using these predicted returns. For the same set of the three periods, ranks based on the actual return performance were ascertained. For each period, the correlation coefficient of the ranks based on predicted performance vis-à-vis the ranks based on the actual performance was computed.

For each of the three periods, the correlations were significantly positive suggesting stability in fund managers' styles indicating that the style-based factors can help predict fund manager performance.

**Table 10.** Relative performance based on the style-based factors

	<i>Correlation</i>	<i>t-stat</i>	<i>p-value</i>
Period 2: predicted return rank — Actual return rank	0.56	9.07	0.00%
Period 3: predicted return rank — Actual return rank	0.21	2.90	0.21%
Period 4: predicted return rank — Actual return rank	0.52	8.17	0.00%

Finally, excess fund returns were regressed on the excess market return and the square of the excess market return, *vide* Treynor-Mazuy model. The coefficient (gamma) of the square term denotes the market timing ability of a fund manager. This analysis was carried out for two periods of 72 months each, as it requires a longer time span to effectively capture the quadratic term in the regression equation. Ranks based on gamma coefficients were ascertained. Rank correlation across the two periods was not found to be significant denoting that the market timing ability may not be stable over time and hence not a good predictor of the fund performance. The market timing ability of fund managers is based on their institution about the expected market movements and hence subjective. The calls made by fund managers based on such subjective methods may not be always on the right of the market. Hence, these results are not surprising.

**Table 11.** Relative performance based on market timing

	<i>Correlation</i>	<i>t-stat</i>	<i>p-value</i>
rank_g1-rank_g2	-0.097612066	-1.31	9.56%

## 5. DISCUSSION OF THE RESEARCH RESULTS

The research results as presented above indicate that past performance measures of mutual funds may indeed help in predicting future performance if taken as a relative measure across the basket of



equity funds. The absolute performance whether as return, standard deviation as in terms of any of the risk-return ratios is known to fluctuate over time. However, when compared across various funds; these performance measures (viz, return, standard deviation, the Sharpe ratio, the Treynor ratio, the appraisal ratio, the  $M^2$  ratio, the Jensen's alpha and the Sortino ratio, and the style-based factors) remain stable on a relative basis. While earlier research papers have pointed out such a finding for anyone or a few measures; this research paper comprehensively looks at all such performance measures. The drawdown-based measures viz, the Sterling ratio and the Calmar ratio are found to not remain stable over time in relative terms and hence offer limited predictability. Also, the market timing ability of these fund managers is not found to be consistently stable over time in relative terms.

To validate the predictability of the relative fund performance; a portfolio of funds was constructed using Markowitz optimization of the Sharpe ratio based on historical fund performance. This portfolio was seen to be in the top quartile ex-post performance in the subsequent period as shown in Table A.3, Appendix.

## 6. CONCLUSION

In summary, the study indicates that while absolute return performance for an individual fund may not be predictable in the future; the relative performance of a large group of actively managed equity funds is likely to be predictable and hence may be used for asset allocation.

Various risk-return ratios and measures should be used to construct ranks of the mutual funds. It can be stated that such ranks would remain stable with a 1% significance. This applies to all the measures discussed in the research papers except for drawdown-based measures such as the Sterling ratio and the Calmar ratio.

Also, ranks of fund managers based on their market timing ability are seen to not remain stable over time. This may be attributed to the subjective

elements involved in fund managers' market timing methods. Subjectivity in judgement about market timing may not be amenable to consistently superior outcomes. Hence superior market timing ability displayed by a fund manager in the past period (relative to other fund managers) may not sustain in the future.

The findings of the paper are useful for the investors targeting selection of actively managed funds so as to gain superior performance relative to the funds not selected as well relative to the benchmarks of the selected funds.

There are some limitations and scope of the future study. The research is based on secondary data which has been collated from websites and fact sheets and therefore the shortcomings of the use of secondary data are probable. The data analysis has led to certain research findings which are analysed based on the market and economic scenarios as prevailing in the selected period for research and hence the findings and outcomes are to be read in accordance with the situations and facts of these periods under study. As the market situations change globally the future performance is subject to such variations as well.

Various factors such as the size of the funds, genre of the funds, prior background and experience of the fund managers, entry/exit of fund managers and concomitant discontinuity in fund management, quality of the fund management processes followed by the fund houses, the extent of portfolio churn by the fund managers, impact on performance due to fact that many of these funds are open-ended, changes in the regulatory scenario periodically and such other factors have not been addressed in this paper. This provides scope for further expanding the dimensions of evaluation of the past and prediction of the future mutual fund performance. The research is based on a sample of 180 funds and the sample can be widened to expand the scope of further research. The study is based on selected tools, like the Sharpe ratio, the Treynor ratio, the Sterling ratio, Treynor-Mazuy model, etc. Additional tools relating to time series analysis can be considered for future research.

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## APPENDIX

Table A.1. List of sample mutual funds

Sr. No.	MF	Index	Sr. No.	MF	Index	Sr. No.	MF	Index	Sr. No.	MF	Index
1	AEPGX	MXEA	51	FAGOX	RLG	101	MFEBX	RLV	151	SMGIX	RIY
2	AGTHX	SPX	52	FASMX	SPX	102	MFEGB	RLG	152	SVAAX	DJDVY
3	AIVSX	SPX	53	FBRGX	RLG	103	MGIAX	MXEA	153	SWTSX	SPXT
4	AMCFX	SPX	54	FCGAX	SPX	104	MGRAX	MXWD000G	154	TBGVX	MXEA
5	AMCPX	SPX	55	FCNTX	SPX	105	MGRFX	RDG	155	TCIEX	MXEA
6	AMECX	SPX	56	FDGFX	SPX	106	MIEIX	MXEA	156	TEDIX	MXWD
7	AMRFEX	SPX	57	FDGRX	RAG	107	MLAAX	RLG	157	TEMTX	SPX
8	AMRMX	SPX	58	FDIVX	MXEA	108	MRIBX	MXEA	158	TEPLX	MXWD
9	ANCFX	SPX	59	FDNRX	RIY	109	MSFRX	SPX	159	TIBAX	SPX
10	ANEFX	SPX	60	FDSSX	SPX	110	MSIGX	SPX	160	TILIX	RLG
11	ANWPX	MXWD	61	FDYZX	RIY	111	NBGNX	RTY	161	TRBCX	SPX
12	APGAX	RIY	62	FEMSX	MXEF	112	NEWFX	MXWD000G	162	TRIGX	MXEA
13	ARTIX	MXEA	63	FGSRX	MXEA	113	NOSIX	SPX	163	TRLGX	RLG
14	ARTKX	MXEA	64	FIGRX	MXEA	114	NYVTX	SPX	164	TROX	MXEA
15	AULRX	RLG	65	FKDNX	RLG	115	OAKMX	SPX	165	TRVLX	SPX
16	AWSHX	SPX	66	FKGRX	SPX	116	ODMAX	MXEF	166	TWCGX	RLG
17	CAFAX	SPX	67	FLPKX	RTY	117	OIGAX	MXWDU	167	TWCUX	RLG
18	CAFEX	SPX	68	FLPSX	RTY	118	OPGIX	MXWD	168	TWEIX	SPX
19	CAFEX	SPX	69	FMAGX	SPX	119	OPPAX	MXWD	169	VADAX	SPW
20	CAFFX	SPX	70	FNIAI	SPX	120	OSMAX	MXWDUSM	170	VAFAX	RLG
21	CAIBX	MXWD	71	FOCKX	CCMP	121	OTCFX	RTY	171	VEXPX	R2500G
22	CDIRX	RIY	72	FOCPX	CCMP	122	OWLSX	MXEA	172	VHCOX	RDG
23	CMLAX	SPX	73	FOSFX	MXEA	123	PCBIX	SPXT	173	VHIAI	RAG
24	CMLCX	SPX	74	FRDAX	SPX	124	PEYAX	RLV	174	VLCAX	CRSPLC1
25	CMLEX	SPX	75	FRDPX	SPX	125	PGBAX	MXWO000V	175	VQNPX	SPX
26	CMLFX	SPX	76	FRDRX	SPX	126	PIHX	MXEA	151	SMGIX	RIY
27	CNGAX	MXWD	77	FSCSX	MXWO	127	PLGJX	RLG	152	SVAAX	DJDVY
28	CNGCX	MXWD	78	GATEX	SPX	128	PMBMX	RMC	153	SWTSX	SPXT
29	CNGEX	MXWD	79	GOIOX	MXWO	129	PMEGX	MID	154	TBGVX	MXEA
30	CNGFX	MXWD	80	GOETX	SPX	130	POAGX	SPX	155	TCIEX	MXEA
31	CWGIX	MXWO	81	HACAX	RLG	131	POGRX	SPX	156	TEDIX	MXWD
32	CWMAX	SPX	82	HBLAX	RLV	132	POSKX	SPX	157	TEMTX	SPX
33	CWMCX	SPX	83	HFCMX	MID	133	PBRLX	SPX	158	TEPLX	MXWD
34	CWMEX	SPX	84	HLIEX	RLV	134	PRDGX	SPX	159	TIBAX	SPX
35	CWMFX	SPX	85	IGIFX	MIMUAWUN	135	PRDSX	M2USSC	160	TILIX	RLG
36	DDFIX	RLV	86	IHGIX	SPX	136	PRFDX	SPX	161	TRBCX	SPX
37	DDFRX	RLV	87	JAMRX	RLG	137	PRGFX	SPX	162	TRIGX	MXEA
38	DFCEX	MXEF	88	JARTX	SPX	138	PRHSX	SPX	163	TRLGX	RLG
39	DFEOX	RAY	89	JEMSX	MXEF	139	PRILX	SPX	164	TROX	MXEA
40	DFLVX	RLV	90	JENSX	SPX	140	PRITX	MXWDU	165	TRVLX	SPX
41	DFQTX	RAY	91	JGMAX	R2500G	141	PRMSX	MXEF	166	TWCGX	RLG
42	DFSVX	RUJ	92	JGRTX	RDG	142	PRMTX	SPX	167	TWCUX	RLG
43	DFTCX	RAY	93	JUEAX	SPX	143	PRNHX	RUO	168	TWEIX	SPX
44	DFUSX	SPX	94	JVLAX	SPX	144	PRSCX	SPX	169	VADAX	SPW
45	DODBX	SPX	95	JVMIX	RLV	145	RPMGX	MID	170	VAFAX	RLG
46	DODFX	MXEA	96	LBSAX	RIY	146	SBLGX	RLG	171	VEXPX	R2500G
47	DODGX	SPX	97	LSGRX	SPX	147	SBLYX	RIY	172	VHCOX	RDG
48	DODWX	M1WO	98	LZEMX	MXEF	148	SEEGX	RLG	173	VHIAI	RAG
49	EGFFX	SPX	99	MADVX	RLV	149	SGENX	MXWO	174	VLCAX	CRSPLC1
50	EGFIX	SPX	100	MAHX	MXEA	150	SMCWX	MSLUAWO	175	VQNPX	SPX
									176	VTCIX	RIY
									177	VTRIX	MXEA
									178	VWNDX	RLV
									179	VWNFEX	RLV
									180	VWUSX	RLG

Source: <https://www.investing.com/>; <https://finance.yahoo.com/>; Bloomberg Terminal

Table A.2. Names of the 20 largest funds along with their assets under management

Sr. No.	Name	Net assets adjusted (USD bn)
1	American Funds The Growth Fund of America® Class A	258.8
2	American Funds Washington Mutual Investors Fund Class A	146.8
3	American Funds New Perspective Fund® Class A	132.8
4	Fidelity® Contrafund® Fund	131
5	American Funds Fundamental Investors® Class A	121.6
6	American Funds The Income Fund of America® Class A	121.4
7	American Funds Investment Company of America	115.7
8	American Funds Capital World Growth and Income Fund® Class A	114.2
9	American Funds Capital Income Builder® Class A	107.7
10	T. Rowe Price Blue Chip Growth Fund	94.4
11	American Funds AMCAP Fund® Class F-2	82.2
12	Dodge & Cox Stock Fund	81.1
13	American Funds American Mutual Fund® Class F-2	75.9
14	American Funds SMALLCAP World Fund® Class A	69.4
15	T. Rowe Price Growth Stock Fund	69.3
16	Fidelity® Growth Company	62.5
17	MFS Value Fund Class B	59.2
18	American Funds New World Fund® Class A	56.8
19	Vanguard Windsor™ II Fund Investor Share	54
20	Fidelity® Blue Chip Growth Fund	51

Note: Assets values are as on the end of March 2021.

Source: <https://www.investing.com/>; <https://finance.yahoo.com/>; Bloomberg Terminal

Table A.3. Fund portfolio based on the previous period performance to maximize the Sharpe ratio (Part 1)

Fund ticker	Sharpe ratio period 4	Rank	Percentile
FAGOX	0.4325	1	0.56%
PRMTX	0.3652	2	1.11%
FBGRX	0.3553	3	1.67%
VWUSX	0.3503	4	2.22%
PRNHX	0.3473	5	2.78%
FSCSX	0.3446	6	3.33%
FDYZX	0.3425	7	3.89%
EGFIX	0.3423	8	4.44%
SEEGX	0.3406	9	5.00%
FKDNX	0.3390	10	5.56%
FDGRX	0.3380	11	6.11%
FDNRX	0.3356	12	6.67%
VHIAX	0.3332	13	7.22%
JARTX	0.3317	14	7.78%
FOCPX	0.3235	15	8.33%
TRLGX	0.3198	16	8.89%
PRSCX	0.3176	17	9.44%
TWCUX	0.3172	18	10.00%
PRILX	0.3165	19	10.56%
MFEGX	0.3131	20	11.11%
PRBLX	0.3122	21	11.67%
PLGJX	0.3121	22	12.22%
TILIX	0.3117	23	12.78%
AULRX	0.3104	24	13.33%
MLAAX	0.3064	25	13.89%
LSGRX	0.3035	26	14.44%
TWCGX	0.3033	27	15.00%
GOETX	0.3021	28	15.56%
VAFAX	0.2929	29	16.11%
HACAX	0.2913	30	16.67%
PRGFX	0.2848	31	17.22%
JAMRX	0.2781	32	17.78%
JENSX	0.2768	33	18.33%
SBLIX	0.2765	34	18.89%
TRBCX	0.2746	35	19.44%
FCGAX	0.2727	36	20.00%
SBLGX	0.2723	37	20.56%
FCNTX	0.2694	38	21.11%
FKGRX	0.2689	39	21.67%
FGSRX	0.2650	40	22.22%
PRDGX	0.2643	41	22.78%
PRHSX	0.2637	42	23.33%
<b>Fund portfolio (max. Sharpe)</b>	<b>0.2618</b>	<b>43</b>	<b>23.89%</b>
JUEAX	0.2616	44	23.89%
EGFFX	0.2610	45	24.44%
VLCAX	0.2529	46	25.00%
OTCFX	0.2509	47	25.56%
SMGIX	0.2505	48	26.11%
VTCIX	0.2490	49	26.67%
DFUSX	0.2475	50	27.22%

Table A.3. Fund portfolio based on the previous period performance to maximize the Sharpe ratio (Part 2)

<i>Fund ticker</i>	<i>Sharpe ratio period 4</i>	<i>Rank</i>	<i>Percentile</i>
NOSIX	0.2463	51	27.78%
FMAGX	0.2461	52	28.33%
SWTSX	0.2412	53	28.89%
SMCWX	0.2394	54	29.44%
VQNPX	0.2364	55	30.00%
VHCOX	0.2329	56	30.56%
PCBIX	0.2318	57	31.11%
APGAX	0.2312	58	31.67%
FDSSX	0.2308	59	32.22%
VEXPX	0.2307	60	32.78%
MSIGX	0.2299	61	33.33%
NBGNX	0.2274	62	33.89%
FRDPX	0.2262	63	34.44%
MGRFX	0.2262	64	35.00%
PMBMX	0.2259	65	35.56%
RPMGX	0.2259	66	36.11%
PMEGX	0.2247	67	36.67%
JGRTX	0.2228	68	37.22%
FNIAx	0.2201	69	37.78%
LBSAX	0.2199	70	38.33%
FASMX	0.2178	71	38.89%
VWNFX	0.2172	72	39.44%
MSFRX	0.2171	73	40.00%
FOCKX	0.2137	74	40.56%
DFOOX	0.2087	75	41.11%
PRDSX	0.2085	76	41.67%
HBLAX	0.2067	77	42.22%
IHGIX	0.2043	78	42.78%
MGIAX	0.2039	79	43.33%
DFQTX	0.1981	80	43.89%
HFMCX	0.1970	81	44.44%
DFTCX	0.1970	82	45.00%
FRDAX	0.1960	83	45.56%
TRVLX	0.1958	84	46.11%
VADAX	0.1921	85	46.67%
POSKX	0.1902	86	47.22%
GOIOX	0.1888	87	47.78%
FRDRX	0.1884	88	48.33%
DODBX	0.1865	89	48.89%
OPPAX	0.1854	90	49.44%
JEMSX	0.1847	91	50.00%
PEYAX	0.1839	92	50.56%
ANWPX	0.1839	93	51.11%
MGRAX	0.1837	94	51.67%
HLIEX	0.1825	95	52.22%
NYVTX	0.1810	96	52.78%
MADVX	0.1805	97	53.33%
OWLSX	0.1800	98	53.89%
NEWFX	0.1771	99	54.44%
JGMAX	0.1748	100	55.00%
DODGX	0.1737	101	55.56%
CWGIX	0.1708	102	56.11%
CDIRX	0.1703	103	56.67%
GATEX	0.1689	104	57.22%
POGRX	0.1673	105	57.78%
TWEIX	0.1666	106	58.33%
FIGRX	0.1642	107	58.89%
FDIVX	0.1639	108	59.44%
OAKMX	0.1620	109	60.00%
AGTHX	0.1563	110	60.56%
VWNDX	0.1547	111	61.11%
POAGX	0.1540	112	61.67%
AMRFX	0.1531	113	62.22%
OSMAX	0.1529	114	62.78%
CMLFX	0.1527	115	63.33%
MIEIX	0.1526	116	63.89%
MFEEX	0.1505	117	64.44%
FOSEX	0.1498	118	65.00%
AMRMX	0.1496	119	65.56%
PRFDX	0.1488	120	66.11%
FDGFX	0.1488	121	66.67%
CMLAX	0.1482	122	67.22%
CMLEX	0.1443	123	67.78%
PRITX	0.1426	124	68.33%
SGENX	0.1423	125	68.89%
FEMSX	0.1398	126	69.44%

Table A.3. Fund portfolio based on the previous period performance to maximize the Sharpe ratio (Part 3)

<i>Fund ticker</i>	<i>Sharpe ratio period 4</i>	<i>Rank</i>	<i>Percentile</i>
CWMFX	0.1389	127	70.00%
AWSHX	0.1366	128	70.56%
JVMIX	0.1365	129	71.11%
CWMAX	0.1356	130	71.67%
CMLCX	0.1351	131	72.22%
AMCFX	0.1324	132	72.78%
CAIBX	0.1320	133	73.33%
JVLAX	0.1318	134	73.89%
CWMEX	0.1316	135	74.44%
CNGFX	0.1310	136	75.00%
CAFFX	0.1307	137	75.56%
OPGIX	0.1305	138	76.11%
ANEFX	0.1296	139	76.67%
AMCPX	0.1285	140	77.22%
CNGAX	0.1278	141	77.78%
MRIBX	0.1270	142	78.33%
DODWX	0.1268	143	78.89%
CAFAX	0.1265	144	79.44%
OIGAX	0.1259	145	80.00%
CWMCX	0.1239	146	80.56%
CNGEX	0.1230	147	81.11%
AIVSX	0.1222	148	81.67%
DFSVX	0.1218	149	82.22%
TIBAX	0.1218	150	82.78%
ODMAX	0.1205	151	83.33%
CAFEX	0.1205	152	83.89%
AMECX	0.1202	153	84.44%
PIIIX	0.1189	154	85.00%
AEPGX	0.1166	155	85.56%
ANCFX	0.1146	156	86.11%
PRMSX	0.1083	157	86.67%
CNGCX	0.1074	158	87.22%
IGIFX	0.1042	159	87.78%
CAFCX	0.1031	160	88.33%
TROSX	0.1021	161	88.89%
DDFIX	0.0987	162	89.44%
TCIEX	0.0968	163	90.00%
MAIIX	0.0954	164	90.56%
TEDIX	0.0931	165	91.11%
VTRIX	0.0929	166	91.67%
SVAAX	0.0923	167	92.22%
TEMTX	0.0913	168	92.78%
DDFRX	0.0904	169	93.33%
DFLVX	0.0899	170	93.89%
ARTKX	0.0886	171	94.44%
TBGVX	0.0846	172	95.00%
DFCEX	0.0787	173	95.56%
PGBAX	0.0763	174	96.11%
DODFX	0.0641	175	96.67%
TEPLX	0.0575	176	97.22%
TRIGX	0.0520	177	97.78%
FLPKX	0.0477	178	98.33%
FLPSX	0.0467	179	98.89%
ARTIX	0.0340	180	99.44%
LZEMX	0.0088	181	100.00%