The Sharpe Ratio's Market Climate Bias – Theoretical and Empirical Evidence from US Equity Mutual Funds

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Working Paper

First Version: 2005-09-24

This Version: 2006-02-24

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Abstract

In this paper we analyze the influence of market climates on mutual fund Sharpe ratios. First, in a theoretical analysis based on a common factor model in performance analysis, we show that a significant bias results from market climate – in addition to the obvious influence of fund management performance. Market climate is determined by the random mean and standard deviation of market excess returns for a specific evaluation period. Especially the mean of the market excess returns has a considerable impact on the Sharpe ratios of funds. It causes one to overestimate the performance of funds that exhibit relatively high proportions of unsystematic risk in outstandingly negative market climates, and vice versa. Thus the Sharpe ratio does not provide a meaningful assessment of the performance of funds, especially in extraordinary times. Our theoretical results are supported by a subsequent empirical study of US equity mutual funds. We first find that, on average, poorly diversified funds exhibit a superior ranking based on the Sharpe ratio in bear markets, and vice versa. Subsequently, via regression analyses, we confirm the dependence of actual mutual fund Sharpe ratios on especially the mean excess returns of the market. We suggest using the "normalized" Sharpe ratio in future empirical research, in order to avoid the bias of Sharpe ratios and rankings due to market climate.

Keywords: portfolio performance evaluation, mutual funds, Sharpe ratio, bear market, market conditions

(JEL G11)

1 Introduction

William F. Sharpe presented the Sharpe ratio as a performance measure in 1966. Since its introduction, this ratio has been used to assess the performance of mutual funds in the finance literature and in practice for almost 40 years. Private investors compare and choose funds using the Sharpe ratio, which is available through financial publications and different information services on the Internet. The dominance of this performance measure is obvious. In the literature, the Sharpe ratio is referred to as the "most common measure of risk-adjusted return" (Modigliani and Modigliani, 1997, p. 46) or as "(o)ne of the most commonly cited statistics in financial analysis" (Lo, 2002, p. 36).

Despite its common use, the Sharpe ratio has come under question, especially in the recent past. Nevertheless, during periods of increasing stock prices – as commonly exemplified in textbooks explaining the Sharpe ratio – it is still regarded as a reliable measure. But it is often stated that during periods of declining share prices this measure leads to intuitively incomprehensible, if not actually erroneous conclusions (see, e.g., Tinic and West, 1979, Jobson and Korkie, 1981, Vinod and Morey, 2000, Ferruz and Sarto, 2004, and Israelsen, 2005). To address this problem, Israelsen (2003 and 2005) and Ferruz and Sarto (2004) have introduced modifications of the Sharpe ratio.

This repudiation of the original Sharpe ratio during bear markets is disputed by Sharpe himself (1975 and 1998). According to him, the Sharpe ratio is an appropriate performance measure, even for periods of decreasing share prices. The fund exhibiting the highest Sharpe ratio will also attain the highest average return when combined with a risk-free asset for any level of risk. This holds true in both bull and bear markets (see also Lobosco, 1999). McLeod and van Vuuren (2004) present another argument for the Sharpe ratio during declining markets. They argue that the fund with the maximum Sharpe ratio is the fund with the highest probability of outperforming a risk-free investment.

Obviously, there are contradictions in the literature with respect to the interpretation of Sharpe ratios in bear market periods and thus a need for further research in order to assess the fundamental informational value of this prominent measure in finance. Owing to the predominantly decreasing share prices at the beginning of the new millennium, use of a common three- or five-year data series has in many cases resulted in negative Sharpe ratios since 2003. Therefore, the criticism cited above is especially relevant for the beginning of the present century.

The main purpose of this article is to examine to what degree the Sharpe ratio of funds depends on random values of market returns. In the process, we answer the question of how far a fund management performance can be evaluated based on its Sharpe ratio. However, a discussion on how to forecast Sharpe ratios is not the subject of this paper.

The focus of this paper now turns rather to our theoretical analysis in Section 2, where we demonstrate that commonly specified ex-post Sharpe ratios do not allow for a meaningful performance assessment of funds during non-normal periods. Based on a single factor model, we use the main characteristics of funds and show the resulting Sharpe ratios to be subject to random market climates. In particular, we reveal the performance contribution of fund-specific risk which is either positive or negative, depending on the market climate. Section 3 presents empirical results on the practical importance of the market climate impact on Sharpe ratios based on a sample of 532 US equity mutual funds. Firstly, we highlight that, on average, funds exhibiting relatively high proportions of fund-specific risk show superior ranking according to the Sharpe ratio in bear markets, and vice versa. Subsequently, using regression analysis, we ascertain that the Sharpe ratios of funds significantly depend especially on the mean excess returns of the market. In Section 4, we recommend using the "normalized" Sharpe ratio for ex-post assessments of funds in order to overcome the impact of market climates on the Sharpe ratio. Furthermore, we employ this new ratio to measure the performance of our funds sample, identifying striking rank changes compared to corresponding fund rankings based on original Sharpe ratios. Section 5 concludes this paper.

2 The market climate bias – theoretical foundation

2.1 Sharpe ratio and main characteristics of funds

The ex-post Sharpe ratio SR_i of a fund i is usually calculated employing the mean ($\bar{er}_i = \bar{r}_i - \bar{r}_f$) and standard deviation (s_i) of the fund excess returns, which are computed as the difference between the total return of the fund r_i and a risk-free short-term interest rate r_f:[1]

$$(1) \qquad SR_i = \frac{\bar{r}_i - \bar{r}_f}{s_i}$$

Obviously, the return $\bar{r}_i$ depends on the performance of the fund management. But as can be seen later in more detail, the Sharpe ratio is also affected by the general market return. We investigate the direction and intensity of the impact of market climates on Sharpe ratios and resulting rankings of mutual funds.

Focusing on fund-specific characteristics enables us to break down the original Sharpe ratio into two components: The performance of fund management and the random influence of the market climate. In order to depict these novel interrelations, we presume the excess return of fund i for period t ($er_{it} = r_{it} - r_{ft}$) as being in accordance with a single factor model, subject to the market excess return ($er_{Mt} = r_{Mt} - r_{ft}$):

$$(2) \qquad er_{it} = JA_i + \beta_i \, er_{Mt} + \varepsilon_{it} \qquad \text{with } \varepsilon_{i,t} \sim N(0, \sigma^2_{\varepsilon_i})$$

The beta β_i denotes the level of the fund's assumed systematic risk.[2] Positive (negative) selection ability is determined by a positive (negative) Jensen Alpha JA_i. The associated fund-specific risk is given by the standard deviation σ_{ε_i} of the residual term ε_i. In this context, it is common practice to assume constant fund-specific characteristics JA_i, β_i, and $\sigma^2_{\varepsilon_i}$ during the evaluation period. This means that funds should be engaged in selection activities only.[3] In particular, the estimation of classical performance

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[1] See Sharpe (1975, p. 30), Sharpe (1994, pp. 50-52) and Sharpe (1998, p. 23). Alternatively, Sharpe (1966, p. 123) uses the return of a 10-year Treasury bond as a risk-free rate in the 10-year period examined. This implies that the investor has a corresponding planning horizon, since it would otherwise be impossible to attain this return without any risk. In later works, however, he regularly uses an average short-term rate as a risk-free rate, according to (1). In Sharpe (1994, pp. 50-52) he suggests using a benchmark return as an alternative to the risk-free rate. However, he did not specify the benchmark yield. This paper focuses on the original Sharpe ratio, which sets the benchmark as an investment in a risk-free asset.

[2] We assume that the index is relatively μ-σ-efficient with respect to the fund's investment universe, see Grinblatt and Titman (1989).

[3] Timing activities of funds are not compatible with this assumption. This constraint is not crucial for our empirical analyses in Section 3, since the equity mutual funds analyzed do not show significant timing activities.

measures based on systematic risk, such as the Treynor ratio and the Jensen Alpha, rely on this assumption as well (see Treynor, 1965, and Jensen, 1968).[4]

Based on (2), market excess returns obviously influence the excess returns of funds. In order to focus on the influence the market climate exerts on Sharpe ratios, we furthermore assume the fund-specific characteristics as given and coinciding with the corresponding values (JA_i, β_i, and $s_{\varepsilon_i}^2$) for each evaluation period.[5] Based on this, the distribution parameters of the excess returns of fund i ($\bar{er}_i$ and s_i), which determine its Sharpe ratio, are specified as follows:

(3) $$\bar{er}_i = JA_i + \beta_i \, \bar{er}_M$$

(4) $$s_i = \sqrt{\beta_i^2 \, s_M^2 + s_{\varepsilon_i}^2}$$

In order to clearly work out any further considerations, we presume that, as usual, realized market excess returns are drawn from an identical and independent normal distribution over time (see, e.g., Grinblatt and Titman, 1989, Shukla and Trzcinka, 1992). Therefore, $\bar{er}_M$ and s_M^2 can be interpreted as stochastic values of the corresponding parameters during the evaluation period. Since empirical analyses are often based on relatively short-term periods, usually $\bar{er}_M$ and s_M^2 do not coincide with the distribution parameters' "true values" of the market index population. So far, we regard market climates (even bull market climates) as random events.[6]

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[4] An extension of this approach is possible, following conditional performance measurement, which takes into consideration publicly known information regarding changes in economic conditions that could be reflected in time-variable, fund-specific characteristics. See, e.g., Ferson and Schadt (1996) and Ferson and Warther (1996).

[5] By doing so, we initially disregard random variations of the mean and the variance of the fund-specific term for the evaluation period examined (as per assumption $\bar{\varepsilon}_i = 0$ and $\sigma_{\varepsilon_i}^2 = s_{\varepsilon_i}^2$). In line with the empirical analyses in Section 3.2, we will suspend this assumption. Furthermore, we will take into account potentially changing characteristics of funds over time.

[6] Naturally, these assumptions could be modified. The pivotal results of this paper would, however, remain unchanged.

2.2 Impact of market climates on the Sharpe ratio

Generally, for any given fund-specific characteristics in connection with the respective evaluation period, according to (3) and (4), the Sharpe ratio yields:

$$(5) \qquad SR_i = \frac{JA_i + \beta_i \, \overline{er}_M}{\sqrt{\beta_i^2 \, s_M^2 + s_{\varepsilon_i}^2}}$$

The Sharpe ratio is thus a function of random parameters $\overline{er}_M$ and s_M^2, and therefore a random variable itself. The Sharpe ratio of a fund varies from the Sharpe ratio of the market index only because of selection activities and its associated unsystematic risk.

Transforming (5) enables us to express the Sharpe ratio of a fund as sum of the market Sharpe ratio and the differential Sharpe ratio (DSR) of the fund according to (6). This DSR is composed of the differential Sharpe ratio 1 (DSR1) and the differential Sharpe ratio 2 (DSR2).[7] DSR1 and DSR2 thus determine the outperformance of a fund compared to the market:

$$(6) \qquad SR_i = SR_M + \underbrace{\underbrace{\underbrace{\frac{1}{\sqrt{\beta_i^2 \, s_M^2 + s_{\varepsilon_i}^2}}}_{A\,>\,0} JA_i}_{DSR1_i} + \underbrace{\underbrace{\left(\frac{\beta_i}{\sqrt{\beta_i^2 \, s_M^2 + s_{\varepsilon_i}^2}} - \frac{1}{s_M} \right)}_{B\,\leq\,0} \overline{er}_M}_{DSR2_i}}_{DSR_i}$$

Successful selection activities of a fund are reflected in a positive Jensen Alpha and lead to a positive $DSR1_i$ based on $A > 0$. The higher the Jensen Alpha of a fund, the higher is its $DSR1_i$. The second component $DSR2_i$ is the product of the market excess return $\overline{er}_M$ and the factor B, which is principally less than zero for $s_{\varepsilon_i}^2 > 0$, leading to a negative $DSR2_i$ in positive market climates ($\overline{er}_M > 0$), and a positive $DSR2_i$ for negative market climates.[8] This impact of the market climate is even greater (absolute B even higher), as the share of the fund unsystematic risk increases as a proportion of the

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[7] For a decomposition of the fund excess return, which clearly differs for declining markets, see Fama (1972).

[8] Only for $s_{\varepsilon_i}^2 = 0$, B is non-negative and equals zero. Independent of the market climate, this yields a $DSR2_i$ equaling zero. Therefore, the market climate influence on DSR2 can be attributed to the unsystematic risk of funds.

overall risk.[9] This dependence of the original Sharpe ratios of funds on market climates, especially on $\bar{er}_M$, will thus be referred to as market climate bias. It leads to an overestimation of the performance of mutual funds exhibiting relatively high proportions of unsystematic risk in extraordinarily negative market climates, but it also results in an underestimation of fund performance in outstandingly positive market climates. With this finding, our paper contributes to the mutual fund literature, which until now criticizes the use of Sharpe ratios only for declining markets.

Moreover, because of this market climate impact on DSR2, funds with successful selection activities ($JA > 0$) do not necessarily outperform the market index as based on the Sharpe ratio during positive market climates.[10] Such an outperformance implies that the positive contribution of the Jensen Alpha to the Sharpe ratio ($DSR1 > 0$) overcompensates for the higher unsystematic risk and its associated disadvantage ($DSR2 < 0$). During negative market climates, even funds with negative Jensen Alphas can outperform the market. The reason for this is the positive influence of fund-specific risk on the Sharpe ratio ($DSR2 > 0$) in bear markets. In short, the more positive the market climate, the more complicated it is for fund managers to achieve Sharpe ratios superior to the market, and vice versa.

While the effect of the market excess return for all funds is similar, such a statement cannot be made with respect to the effect of variance s_M^2. An increase in s_M^2 affects $DSR1$ either positively or negatively depending on the sign of the Jensen Alpha. The equivalent is true for the effect of s_M^2 on $DSR2$ in connection with the sign of the market excess return. Thus, we cannot determine with certainty how s_M^2 influences differential Sharpe ratios and Sharpe ratios of funds.

In the following, we examine whether random values of $\bar{er}_M$ or s_M^2 have a stronger influence on the Sharpe ratios of funds. We interpret $\bar{er}_M$ and s_M^2 as estimators $\hat{\mu}_M$ and $\hat{\sigma}_M^2$ of the distribution parameters of the market population (μ_M and σ_M^2). Based on this, we

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[9] This becomes evident by multiplying the first quotient of B with s_M, since the square of the resulting quotient can be interpreted as the systematic risk proportion of the overall risk (R^2). Strictly speaking, this holds only for "normal" funds with a positive beta, which is the assumption made in the following.

[10] For performance hypothesis testing with the Sharpe ratio, see Jobson and Korkie (1981) in conjunction with Memmel (2003).

determine the distribution of estimated Sharpe ratios of a fund with given characteristics in large samples and subsequently derive the proportion of asymptotic variance of the estimated Sharpe ratio $\widehat{SR}$ that is attributable to $\hat{\mu}_M$.[11]

With given characteristics JA_i, β_i, and $s^2_{\varepsilon_i}$ for an evaluation period, the Sharpe ratio of fund i, according to (5) depends on the estimated distribution parameters of the market. The estimators for μ_M and σ^2_M are asymptotically normally distributed, when assuming identical and independent, normally distributed market excess returns over time with finite mean and variance (see, for example, Greene, 2003, pp. 914-918, Memmel, 2003):

$$(7) \qquad \sqrt{T}\,(\hat{\mu}_M - \mu_M) \overset{a}{\sim} N(0, \sigma^2_M)$$

$$(8) \qquad \sqrt{T}\,(\hat{\sigma}^2_M - \sigma^2_M) \overset{a}{\sim} N(0, 2\,\sigma^4_M).$$

The estimation errors can thus, be approximated by $\mathrm{Var}(\hat{\mu}_M) \overset{a}{=} \sigma^2_M / T$ and $\mathrm{Var}(\hat{\sigma}^2_M) \overset{a}{=} 2\,\sigma^4_M / T$. Hence, for monthly market excess returns of realistic size, the variance of the estimator $\hat{\mu}_M$ is usually higher than the variance of $\hat{\sigma}^2_M$. Based on this, proportion A^{SR}_μ of the variance of the Sharpe ratio estimator that is attributable to estimator $\hat{\mu}_M$ asymptotically yields:[12]

$$(9) \qquad A^{SR}_\mu \overset{a}{=} \left(1 + \frac{(JA_i + \beta_i\,\mu_M)^2\,\beta_i^2\,\sigma^2_M}{2\,(\beta_i^2\,\sigma^2_M + s^2_{\varepsilon_i})^2}\right)^{-1}.$$

For realistic parameters μ_M and σ^2_M and for regular mutual funds, proportion A^{SR}_μ is close to one. Therefore, the estimator $\hat{\mu}_M$ compared with $\hat{\sigma}^2_M$ has a dominant impact on the estimated Sharpe ratios of funds in respective analyses.[13] Table 1 exhibits proportions

[11] Compare with the following regarding the distribution properties of the Sharpe ratio, however, without applying the single factor model, Lo (2002) in connection with Wolf (2003) and Lo (2003).

[12] For derivation see the Appendix. The complementary proportion A^{SR}_σ of the estimation error of $\hat{\sigma}^2_M$ amounts to $A^{SR}_\sigma \overset{a}{=} 1 - A^{SR}_\mu$.

[13] Furthermore, it can be shown that the estimator $\hat{\mu}_M$ compared with $\hat{\sigma}^2_M$ also has a dominant impact on the DSR of funds.

A_{μ}^{SR} for three exemplary funds[14] and different combinations of μ_M and σ_M of realistic size.

– Insert TABLE 1 about here –

Finally, random market climates, especially in the form of $\bar{er}_M$, can thus considerably influence the Sharpe ratio of funds. Therefore, the original Sharpe ratio of a fund does not only reflect the performance of the fund management, but it is also determined by the random market climate. Even the ranking of funds can vary owing to this market climate bias.

Until now, the question of the practical relevance of the market climate bias remains unanswered. How much do rankings of funds based on Sharpe ratios really vary as a result of differing market climates? How strong is the impact of changing market climates on Sharpe ratios and differential Sharpe ratios of mutual funds? The following examines actual US equity mutual funds, and how their Sharpe ratios and fund rankings based on this classical measure are impacted by market climates – which are considered random.

3 The market climate bias – empirical analysis

3.1 Data

We study monthly returns of all US "large funds" with a complete data history from January 1994, until June 2004, in the Morningstar data base[15] (for the Morningstar classification of funds see, e.g., Reichenstein, 2004).[16] For each of the 532 open-end equity mutual funds observed, there are 126 realized monthly returns. Typically, we are dealing with total returns including reinvestments of all distributions (e.g. dividends),

[14] The characteristics of the average fund A nearly correspond with the respective mean values of US equity mutual funds, which are observed in the empirical analysis in Section 3 (see Table 2).

[15] We thank Morningstar Inc. for providing us with the data.

[16] The data set points to a survivorship bias, which leads to a biased average performance of funds compared with the market. Since we are specifically analyzing changes of (differential) Sharpe ratios of individual funds and rankings of funds, our analyses are not sensitive to survivorship issues. See, for example, Brown and Goetzmann (1995), Elton, Gruber, and Blake (1996), and Carhart et al. (2002) for survivorship bias.

but disregarding load charges. Linear regression analyses of the monthly excess returns of funds, compared with the excess returns on the value-weighted index of all NYSE, AMEX, and NASDAQ stocks based on (2), yield the fund-specific characteristics Jensen Alpha, beta, and standard deviation of term ε summarized in Table 2.[17]

– Insert Table 2 about here –

In Section 2.1, we pointed out that funds should perform selection activities only as a precondition for determining the fund-specific characteristics according to (2). Therefore, we assess whether the funds engage in verifiable timing activities. Successful timing activities are identified by an increase (decrease) of the systematic risk of funds in above-average positive (negative) market climates.[18] Timing activities cannot be verified for most funds in our data set. Using the squared-regression approach proposed by Treynor and Mazuy (1966) at the 5 percent confidence level, we identify only 10 funds, or 1.88 percent, that show significant timing activities. Based on the dummy variable regression approach developed by Henriksson and Merton (1981), only 6 funds, or 1.13 percent, lead to the same outcome.[19] Hence, potential timing activities of funds should not be a serious problem for our data sample.

3.2 Impact of market climates on (differential) Sharpe ratios and fund rankings

In this Section, we analyze the impact of market climates on Sharpe ratios, differential Sharpe ratios, and fund rankings based on 91 consecutive evaluation periods. Beginning January 1994, these time frames are defined as 36-month periods which are rolled over monthly, ending December 1996, to June 2004. In our analyses, we separately calculate the specific characteristics of funds for each subperiod considered. In doing so, we take into consideration the possible changing characteristics of funds over time, as well as random values of the mean and the standard deviation of the fund-specific term ε. We conduct the following analyses for each of the 532 equity mutual funds. The results are presented as average values of the fund groups specified below.

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[17] The index returns and the risk-free monthly T-bill returns are provided on Ken French's Website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[18] Corresponding timing activities lead furthermore to biased Jensen Alphas and beta coefficients. See, for example, Grinblatt and Titman (1989).

[19] The two-tailed t-tests are based on standard errors corrected for heteroskedasticity and autocorrelation according to Newey and West (1987).

The dominant influence of $\bar{er}_M$ on fund rankings according to the Sharpe ratio occurs, as described in Section 2.2, through DSR2. This influence is even stronger for funds exhibiting higher proportions of unsystematic risk. Therefore, we group the funds according to their proportions of unsystematic risk. Based on this share, we establish a ranking of funds for each of the 91 time frames. 69 funds belonging to the upper half of this share for each time frame are assigned to the group of "High Unsystematic Risk" (HUR) funds. The following 100 funds belonging to the corresponding lower half for all time frames make up the group of "Low Unsystematic Risk" (LUR) funds. The remaining 363 funds constitute the "Mid Unsystematic Risk" (MUR) fund group. Table 3 presents the average characteristics of these fund groups based on the entire evaluation period from January 1994, to June 2004.

– Insert TABLE 3 about here –

In order to determine the practical importance of the market climate bias on Sharpe ratios, we initially calculate the DSR2 of funds for each 36-month time frame according to (6). In this connection, we separately calculate and employ specific characteristics of the funds as well as means and standard deviations of the market excess returns for each period. The aggregate results are depicted in Figure 1. The left ordinate displays the DSR2 of funds, the right ordinate the market excess returns $\bar{er}_M$ for each of the 36-month time frames investigated. Obviously, the average contribution of DSR2 to the Sharpe ratio is the greatest in extreme market climates. As theoretically derived in Section 2.2 for the HUR funds, the highest (lowest) DSR2 values can be observed during the bullish (bearish) market periods, while the LUR funds exhibit relatively small DSR2.

– Insert FIGURE 1 about here –

The differences in the DSR2 of the fund groups should be reflected in their ranks. Figure 2 illustrates the average ranks of funds over time. While the MUR funds have a relatively constant average rank between 253 and 294, ranks for the other two fund groups vary greatly. Especially in positive market climates, the LUR funds exhibit an average rank of less than 200, while they are between 300 and 400 during negative market climates. As expected, HUR funds yield a somewhat reversed picture.

– Insert FIGURE 2 about here –

Following this visual examination of the market climate bias on fund rankings, we conduct longitudinal regression analyses of the fund Sharpe ratios. The Sharpe ratio (SR_{it}) and the differential Sharpe ratio of each fund ($DSR_{it} = SR_{it} - SR_{Mt}$) throughout the 91 time frames considered should be at least partly explained by the mean ($\bar{er}_{Mt}$) and the standard deviation (s_{Mt}) of the market excess returns.

Conducting augmented Dickey-Fuller tests leads to the conclusion that the variables are difference stationary.[20] Therefore, in the subsequent regression analysis we use first differences of all variables. In the following, Δ indicates the first difference, for example $\Delta SR_{it} = SR_{it} - SR_{it-1}$ denotes the change of a fund Sharpe ratio and represents the dependent variable. The changes of the mean ($\Delta\bar{er}_{Mt}$) and the standard deviation (Δs_{Mt}) of the market excess returns are employed as independent variables:[21]

$$\Delta SR_{it} = \gamma_{0i} + \gamma_{1i}\,\Delta\bar{er}_{Mt} + \gamma_{2i}\,\Delta s_{Mt} + \varepsilon_{it} \tag{10}$$

Table 6 summarizes the results of the regression analyses according to (10). The average γ_1 coefficient is positive, as expected, and amounts to 19.56 over all funds. Positive changes in the market climate clearly have a positive effect on the Sharpe ratios of a fund. The smallest average value of 16.66 is linked to the HUR funds. This confirms the theoretical notion in Section 2.2.

– Insert TABLE 4 about here –

We test the significance of regression coefficients γ_0 and γ_2 using a two-tailed t-test. Relying on the established assumption of positive γ_1 coefficients based on (5), these coefficients are tested for being less than or equal to zero.[22] It is striking that the γ_1

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[20] We apply augmented Dickey-Fuller tests, including an intercept at the 5 percent level to examine the unit root properties of our data. The Akaike information criterion is used to choose the respective lag parameter.

[21] The correlation between the independent variables $\Delta\bar{er}_{Mt}$ and Δs_{Mt} is –0.34, the variance inflation factor (VIF) is 1.13. As a rule of thumb, Kennedy (2003, p. 213) suggests that a VIF exceeding 10 indicates harmful collinearity. Therefore, multicollinearity should not be a statistical problem here.

[22] The t-statistics are based on standard errors corrected for heteroskedasticity and autocorrelation according to Newey and West (1987).

coefficients are significantly larger than zero at the 5 percent level for all funds. The adjusted R^2 averages 75.21 percent, whereas adding the second explanatory variable (Δs_{Mt}) increases this measure only marginally by 2.92 percent. This confirms the dominant effect of market climates on Sharpe ratios, especially of the mean of market excess returns.

Concerning fund rankings, the results of corresponding differential Sharpe ratio regression analyses according to (11) show interesting results, in particular with respect to the γ_1 coefficient. Because of their high share of unsystematic risks, when the γ_1 coefficient is –5.08, HUR funds exhibit a relatively strong negative influence from positive market excess returns on their differential Sharpe ratios. A one percent rise in the average market excess return causes an average decrease of 5.08 percent in the differential Sharpe ratio of HUR funds. Differing from regression analyses with respect to Sharpe ratios, the γ_1 coefficient is tested for being greater than or equal to zero, since we expect negative coefficients according to (6). 88.41 percent of the HUR funds γ_1-coefficients are identified as significantly less than zero. For MUR funds and LUR funds, the corresponding values are only –2.35 and 54.82 percent (–0.42 and 8.00 percent), respectively, which is explained by their smaller proportion of unsystematic risk. Thus, as expected, the HUR and the MUR fund groups often show a significant and negative bias.

(11) $$\Delta DSR_{it} = \gamma_{0i} + \gamma_{1i}\,\Delta \bar{er}_{Mt} + \gamma_{2i}\,\Delta s_{Mt} + \varepsilon_{it}$$

– Insert TABLE 5 about here –

Changes in the differential Sharpe ratio of funds, relevant to fund rankings, can be explained by the market parameters $\Delta \bar{er}_{Mt}$ and Δs_{Mt} at an average adjusted R^2 of 8.71 percent for all funds. However, the mean value of the adjusted R^2 is 16.05 % for the HUR funds and is only 1.60 % for the LUR funds. This difference is remarkable, since HUR funds exhibit a higher unsystematic risk also affecting changes in the differential Sharpe ratio.

The results of our empirical analysis show that changes in the market climate, especially in the mean of the market excess returns, significantly influence both the Sharpe ratios of the funds as well as their differential Sharpe ratios. This impact of market climates on the differential Sharpe ratio increases in significance with the proportion of the unsystematic risk of the fund. Therefore, fund rankings based on Sharpe ratios are only partially determined by the fund management performance.

4 "Normalized" Sharpe ratio

Calculating Sharpe ratios, researchers and practitioners often use relatively short-term evaluation periods of three to five years. Owing to the above-identified influence of market climates, the Sharpe ratios that result often fail to provide a reliable measure of fund performance. This holds especially true for analyses based on unusually bearish or bullish market periods. The market climate quickly exceeds the impact of fund-specific characteristics. As a result, an adequate evaluation of the fund management quality based on the Sharpe ratio becomes impossible.

In order to evaluate the "pure" fund performance, the Sharpe ratio needs to be adjusted. In this context, we suggest a separate estimation of the fund characteristics and distribution parameters of the market excess return. Based on (5), a consolidation of these results to a normalized Sharpe ratio (nSR) is thus possible:

$$(12) \qquad nSR_i = \frac{\widehat{JA}_i + \hat{\beta}_i \hat{\mu}_{lM}}{\sqrt{\hat{\beta}_i^2 \hat{\sigma}_{lM}^2 + \hat{\sigma}_{\varepsilon_i}^2}}.$$

In order to estimate the fund-specific characteristics ($\widehat{JA}_i$, $\hat{\beta}_i$, and $\hat{\sigma}_{\varepsilon_i}^2$) properly, one could use monthly returns for a three- to five-year time frame, as long-ranging data does not exist, especially for new funds. Furthermore, performance and investment objectives of funds can change with increasing time horizons, for example, as a result of management change.[23] With respect to the distribution parameters of the market, considering relatively short time frames can lead to a market climate bias as described above. Thus, when assuming independent and identical distributed market excess returns, while estimating appropriate parameters of the market, investors should use long-term time frames (which are regularly available, unlike the fund returns) and employ the resulting long-term mean ($\hat{\mu}_{lM}$) and standard deviation ($\hat{\sigma}_{lM}^2$) in (12).[24]

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[23] In order to account for changing characteristics of funds over time one could alternatively implement more complex methods for estimating mutual fund alphas and betas, see Mamaysky, Spiegel and Zhang (2004).

[24] A continuation of this idea would allow the integration of time-variable-expected values, risk premiums, and volatilities of the market excess returns.

For the above-analyzed US equity mutual funds, we determine normalized Sharpe ratios for consecutive 36-month time frames ending December 1996, to June 2004. The estimation of the fund-specific characteristics results from regression analyses according to (2) for each fund and each 36-month time frame. The distribution parameters of the market index were estimated based on monthly data for the longest time period available to us from July 1926, to June 2004. The average market excess return for this long period is 0.65 percent (= $\hat{\mu}_{IM}$), the standard deviation 5.48 percent (= $\hat{\sigma}_{IM}$). Subsequently, we determine normalized Sharpe ratios and the related rankings according to (12) for all funds. Figure 3 depicts changes in the fund ranks owing to the normalization of the Sharpe ratios as opposed to ranking based on the original Sharpe ratio.

– Insert FIGURE 3 about here –

The changes in fund ranking are striking. Particularly, the average ranking of HUR funds derived from normalized Sharpe ratios are up to 60 rank positions better during outstanding positive market climates until October 2000, while clearly up to 127 rank positions worse during negative market climates starting in January 2001. As expected, the LUR funds exhibit nearly opposite changes in rank. For the MUR funds, however, the average ranking remains almost unchanged.

Normalizing the Sharpe ratio results in an adjustment of the original Sharpe ratio by the random market climate influence, allowing for a better assessment of the "pure" performance of funds. Furthermore, special emphasis should be placed on the (to some extent) distinct changes in ranking of the market index. Especially during negative market climates, the index exhibits a relative placement that is up to 141 rank positions better when the ranking is based on the normalized Sharpe ratio. The reason is to be found in the unsystematic risks of funds during negative market climates leading to an obvious overestimation of the performance of funds based on the original Sharpe ratio. Since this market climate effect is adjusted by normalizing the Sharpe ratio, this leads to a decline in fund ranking and hence to an improvement in the market index rank during negative market climates, and vice versa.

The introduced normalized Sharpe ratio can be interpreted as the risk-adjusted performance measure of a fund, which is realized based on fund-specific characteristics for an "average" market climate. The considerable advantage of the normalized Sharpe ratio is that it does not become distorted by random and exceptional market climates and thus allows for an adequate assessment of "pure" fund management performance.

5 Conclusion

We studied the debated issue of whether and to what extent one can evaluate the performance of funds using the original Sharpe ratio, particularly in non-normal market climates. In Section 2 we posed the question of what the original Sharpe ratio can tell us about the "pure" performance of fund management during a specific evaluation period. Defining fund-specific characteristics led to a detailed theoretical analysis of the market climate impact on the Sharpe ratio. In particular, we identified a reverse influence of fund-specific risk on Sharpe ratios in bearish and bullish market periods. Thus the Sharpe ratio of a fund is determined by the performance of the fund management and also by the respective (here considered random) market climate. Rankings of funds based on original Sharpe ratios can therefore vary over time as a result of the market climate bias, even when the specific characteristics of funds are stable.

The results of our empirical analyses in Section 3 confirm the practical relevance of the market climate bias presented theoretically in Section 2. Initially, we ascertained that, on average, poorly diversified mutual funds showing relatively large proportions of unsystematic risk have superior rank positions in declining markets, and vice versa. Subsequently, using longitudinal regression analyses, we confirmed the dependence of equity mutual fund (differential) Sharpe ratios on the mean and the standard deviation of the market excess returns.

The main findings of this paper are of theoretical as well as practical importance. Investors should not, as it is currently the case, rely on the original Sharpe ratio in order to assess the performance of funds. Instead, they should use the "normalized" Sharpe ratio introduced in Section 4, since this new measure separately measures the "pure" performance of fund management.

As we have found, the Sharpe ratios of mutual funds depend on their characteristics – and also on respective market climates, an observation that raises several interesting questions warranting additional research. Clearly, further performance analysis studies for mutual funds are justified. Moreover, the results of existing empirical analyses based on the original Sharpe ratio should be interpreted anew, taking the market climate bias into consideration. The normalized Sharpe ratio also provides new possibilities for forecasting future Sharpe ratios for funds. In this context, one could empirically evaluate which form of normalization would produce appropriate estimators for the future performance of funds. To do this, different underlying time frames will have to be evaluated, as well as models or methods estimating the specific characteristics of funds and the distribution parameters of the market. Lastly, the main conclusions presented here can be applied to other issues, such as merit-based reward for fund managers or risk-adjusted performance measurement of business units, for example, using RORAC or RAROC concepts in the banking industry.

Appendix

The Sharpe ratio of a fund i, with a given set of fund-specific characteristics JA_i, β_i and $s^2_{\varepsilon_i}$, is determined through $SR_i = f(\mu_M, \sigma^2_M) = (JA_i + \beta_i\, \mu_M) / \sqrt{\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i}}$. The estimation errors in $\hat{\mu}_M$ and $\hat{\sigma}^2_M$ thus influence the estimator of the Sharpe ratio: $\widehat{SR}_i = f(\hat{\mu}_M, \hat{\sigma}^2_M)$. Assuming independent and identically normally distributed market excess returns, Sharpe ratio $\widehat{SR}_i$ also has an asymptotically normal distribution, which can be interpreted as a weighted average of asymptotic variances of $\hat{\mu}_M$ and $\hat{\sigma}^2_M$:[25]

$$(13)\qquad \sqrt{T}\,(\widehat{SR}_i - SR_i) \overset{a}{\sim} N(0, V^{SR}_i) \text{ with } V^{SR}_i = \left(\frac{\partial f}{\partial \mu_M}\right)^2 \sigma^2_M + \left(\frac{\partial f}{\partial \sigma^2_M}\right)^2 2\, \sigma^4_M,$$

where $\overset{a}{\sim}$ denotes the asymptotic character of this relationship for large samples. The two partial derivatives of function f are:

$$(14)\qquad \frac{\partial f}{\partial \mu_M} = \frac{\beta_i}{\sqrt{\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i}}}$$

$$(15)\qquad \frac{\partial f}{\partial \sigma^2_M} = -\frac{(JA_i + \beta_i\, \mu_M)\, \beta^2_i}{2\, (\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i})^{3/2}}.$$

Inserting these derivatives in (13), the variance of Sharpe ratio estimator V^{SR}_i asymptotically results in:

$$(16)\qquad V^{SR}_i \overset{a}{=} \frac{\beta^2_i \sigma^2_M}{\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i}} \left(1 + \frac{(JA_i + \beta_i\, \mu_M)^2\, \beta^2_i \sigma^2_M}{2\, (\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i})^2}\right)$$

The impact of the estimation errors in $\hat{\mu}_M$ and $\hat{\sigma}^2_M$ on the estimated Sharpe ratio $\widehat{SR}_i$ becomes evident when computing the proportion of the asymptotic variance of $\widehat{SR}_i$ that is attributable to $\hat{\mu}_M$. This proportion A^{SR}_μ asymptotically yields:

$$(17)\qquad A^{SR}_\mu \overset{a}{=} \frac{(\partial f / \partial \mu_M)^2\, \sigma^2_M}{V^{SR}_i} = \left(1 + \frac{(JA_i + \beta_i\, \mu_M)^2\, \beta^2_i \sigma^2_M}{2\, (\beta^2_i\, \sigma^2_M + s^2_{\varepsilon_i})^2}\right)^{-1}.$$

[25] See, e.g., Greene (2003, pp. 916-917), Lo (2002, p. 38), Memmel (2003).

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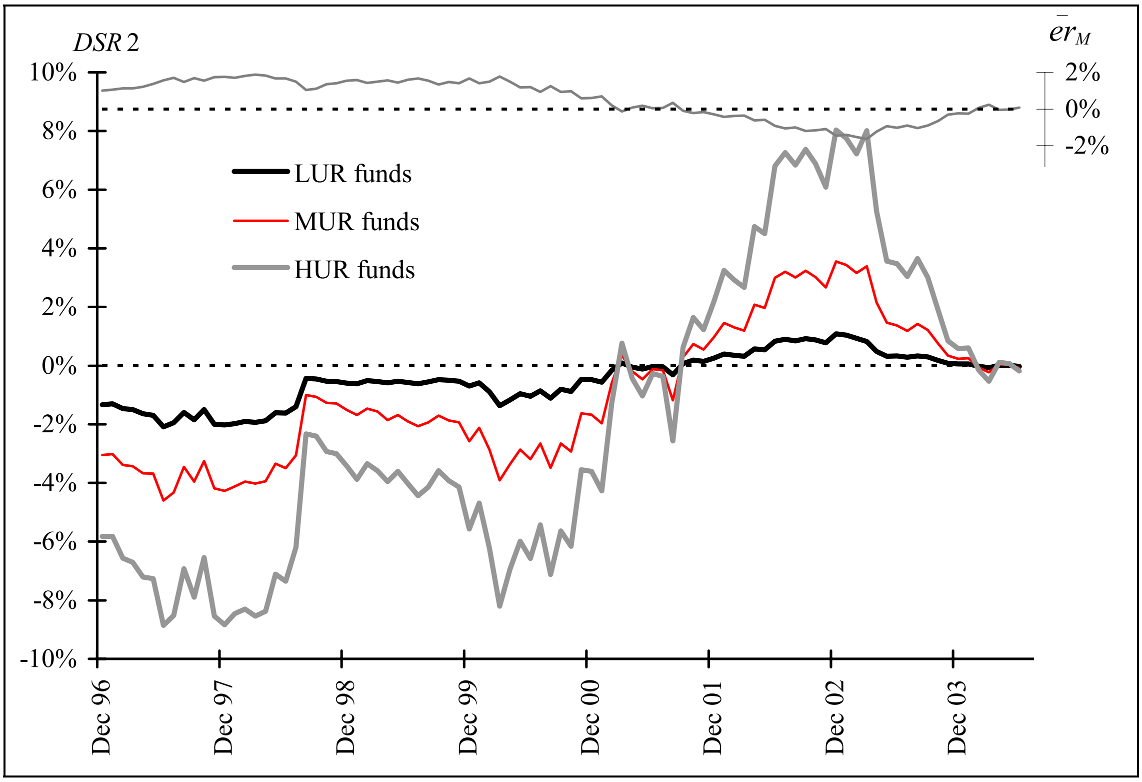
Figure 1

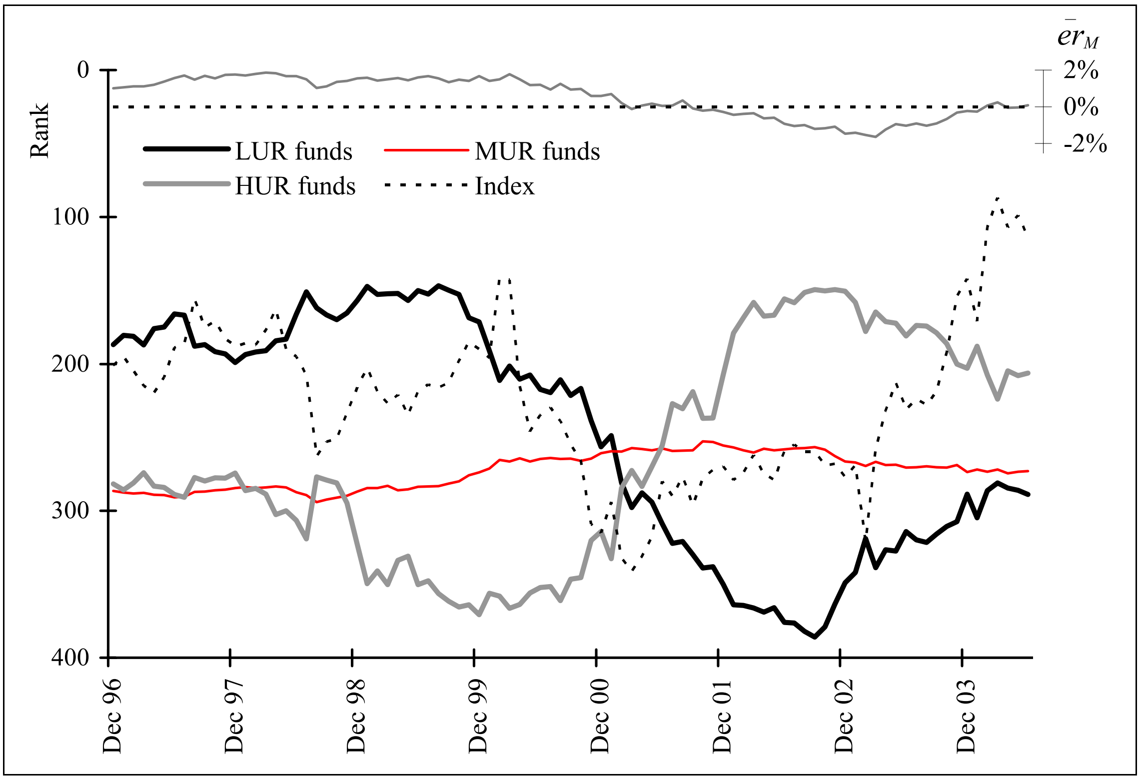
Differential Sharpe ratios 2



This figure plots the average differential Sharpe ratios 2 (DSR2) of three fund groups for 91 consecutive 36-month periods ending December 1996, to June 2004. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting “High Unsystematic Risk”, LUR stands for “Low Unsystematic Risk” and MUR for “Mid Unsystematic Risk”. The left ordinate shows the average DSR2 of fund groups, the right ordinate the mean market excess returns ($\overline{er}_M$) for each of the 36-month time frames.

Figure 2

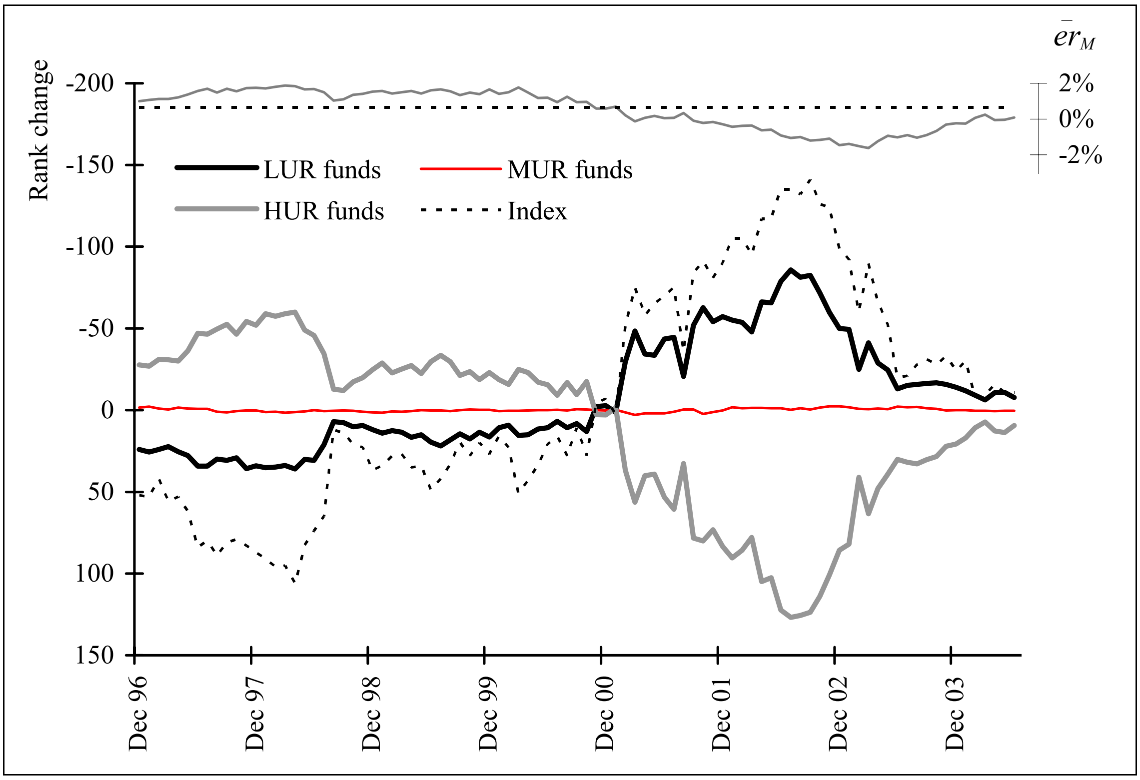
Ranks based on the Sharpe ratio



This figure plots the average ranks of three fund groups and the rank of the index based on Sharpe ratios for 91 consecutive 36-month periods ending December 1996, to June 2004. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting "High Unsystematic Risk", LUR stands for "Low Unsystematic Risk" and MUR for "Mid Unsystematic Risk". The left ordinate shows the average ranks of fund groups and the index rank, the right ordinate the mean market excess return ($\bar{er}_M$) for each of the 36-month time frames.

Figure 3

Changes in rank positions between rankings based on normalized and non-normalized Sharpe ratios



This figure plots the changes in average ranks of three fund groups and the rank change of the index between rankings based on normalized and non-normalized (original) Sharpe ratios for 91 consecutive 36-month periods ending December 1996, to June 2004. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting "High Unsystematic Risk", LUR stands for "Low Unsystematic Risk" and MUR for "Mid Unsystematic Risk". The left ordinate shows the average rank changes of the fund groups and the rank change of the index, the right ordinate the mean market excess return ($\bar{er}_M$) for each of the 36-month time frames.

Table 1

Proportions A_{μ}^{SR} of asymptotic variance of Sharpe ratio estimators that are attributable to $\hat{\mu}_M$

	σ_M	μ_M 0.2 %	0.7 %	1.2 %
Average fund A ($JA_A = 0$, $\beta_A = 0.9$, $s_{\varepsilon_A} = 2$ %)	3 %	99.91 %	98.88 %	96.77 %
	6 %	99.96 %	99.48 %	98.48 %
Aggressive fund B ($JA_B = 1$ %, $\beta_B = 1.2$, $s_{\varepsilon_B} = 5$ %)	3 %	99.31 %	98.50 %	97.39 %
	6 %	99.33 %	98.54 %	97.45 %
Risk-averse fund C ($JA_C = 0$, $\beta_C = 0.7$, $s_{\varepsilon_C} = 1$ %)	3 %	99.85 %	98.22 %	94.95 %
	6 %	99.95 %	99.39 %	98.24 %

This table presents the proportions A_{μ}^{SR} of asymptotic variance of Sharpe ratio estimators that are attributable to estimator $\hat{\mu}_M$ for three exemplary funds and different combinations of μ_M and σ_M of realistic size. The fund-specific characteristics JA_i, β_i and s_{ε_i} are given and monthly market excess returns are assumed to be independent and identical distributed.

Table 2

Summary statistics for US equity mutual fund characters

	Jensen Alpha	Beta	Standard deviation of term ε	R^2
Maximum	0.64 %	1.63	5.75 %	99.43 %
2/3 quantile	0.05 %	0.96	2.19 %	88.57 %
Median	–0.02 %	0.90	1.89 %	84.47 %
1/3 quantile	–0.10 %	0.83	1.56 %	77.46 %
Minimum	–1.16 %	0.32	0.34 %	19.37 %
Mean	–0.03 %	0.92	1.96 %	80.51 %
Standard deviation	0.20 %	0.20	0.75 %	13.15 %

This table presents the maximum, the 2/3 quantile, the median, the 1/3 quantile, the minimum, the mean and the standard deviation of the fund-specific characters Jensen Alpha, beta, standard deviation of term ε, and R^2 for 532 US equity mutual funds. Values are estimated via regression analyses according to a single factor model for monthly excess returns ($er_{i\,t} = JA_i + \beta_i\, er_{M\,t} + \varepsilon_{i\,t}$) based on the evaluation period from January 1994, to June 2004. The excess returns are calculated as differences between the monthly total returns of funds or the index and the risk-free monthly T-bill return. The index employed is the value-weighted index of all NYSE, AMEX, and NASDAQ stocks.

Table 3

Average fund-specific characters for selective fund groups

Fund types	Jensen Alpha	Beta	Standard deviation of term ε	R^2
LUR	–0.03 %	0.96	1.12 %	93.78 %
MUR	–0.05 %	0.93	2.03 %	80.55 %
HUR	0.05 %	0.79	2.81 %	61.05 %
Overall	–0.03 %	0.92	1.96 %	80.51 %

This table presents average fund-specific characters Jensen Alpha, beta, standard deviation of term ε, and R^2 for three fund groups and over all funds. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting "High Unsystematic Risk", LUR stands for "Low Unsystematic Risk" and MUR for "Mid Unsystematic Risk". Values are estimated via regression analyses according to a single factor model for monthly excess returns ($er_{it} = JA_i + \beta_i \, er_{Mt} + \varepsilon_{it}$) based on the evaluation period from January 1994, to June 2004. The excess returns are calculated as differences between monthly total returns of funds and the index and the risk-free monthly T-bill return. The market index employed is the value-weighted index of all NYSE, AMEX, and NASDAQ stocks.

Table 4

Influence of market climates on Sharpe ratios

	Average regression coefficients			Proportion of significant regression coefficients (α = 5 %)			Adjusted R^2	
Fund types	$\gamma_{0\,i}$	$\gamma_{1\,i}$	$\gamma_{2\,i}$	$\gamma_{0\,i} \neq 0$	$\gamma_{1\,i} > 0$	$\gamma_{2\,i} \neq 0$	Average value	Increase with respect to a single factor regression
LUR	–0.21 %	**21.58**	–5.27	1.00 %	**100.00 %**	76.00 %	**85.98 %**	2.88 %
MUR	–0.18 %	**19.55**	–4.93	1.10 %	**100.00 %**	51.24 %	**75.69 %**	2.98 %
HUR	–0.18 %	**16.66**	–4.32	0.00 %	**100.00 %**	62.32 %	**57.06 %**	2.67 %
Overall	–0.19 %	**19.56**	–4.92	0.94 %	**100.00 %**	57.33 %	**75.21 %**	2.92 %

This table reports the results of the following regression:

$$\Delta SR_{i\,t} = \gamma_{0\,i} + \gamma_{1\,i}\,\Delta \bar{er}_{M\,t} + \gamma_{2\,i}\,\Delta s_{M\,t} + \varepsilon_{i\,t}$$

We use the changes in the Sharpe ratio of a fund ($\Delta SR_{i\,t} = SR_{i\,t} - SR_{i\,t-1}$) as dependent variable. The changes in the mean ($\Delta \bar{er}_{M\,t}$) and the standard deviation ($\Delta s_{M\,t}$) of market excess returns are employed as independent variables. Market excess returns are calculated as differences between the monthly total returns of the market index and the risk-free monthly T-bill return. The index employed is the value-weighted index of all NYSE, AMEX, and NASDAQ stocks. Presented are the average regression coefficients and the proportions of significant regression coefficients for three fund groups and over all funds. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting “High Unsystematic Risk”, LUR stands for “Low Unsystematic Risk” and MUR for “Mid Unsystematic Risk”. The coefficients γ_0 and γ_2 are tested for being equal to zero. The γ_1 coefficients are tested for being less than or equal to zero. The t-statistics are based on standard errors corrected for heteroskedasticity and autocorrelation according to Newey and West (1987). Furthermore, the average adjusted R^2 and its increase with respect to the average adjusted R^2 of a corresponding single factor regression ($\Delta SR_{i\,t} = \gamma_{0\,i} + \gamma_{1\,i}\,\Delta \bar{er}_{M\,t} + \varepsilon_{i\,t}$) are reported.

Table 5

Influence of market climates on differential Sharpe ratios

Fund types	Average regression coefficients			Portion of significant regression coefficients (α = 5 %)			Adjusted R^2	
	γ_{0i}	γ_{1i}	γ_{2i}	$\gamma_{0i} \neq 0$	$\gamma_{1i} < 0$	$\gamma_{2i} \neq 0$	Average value	Increase with respect to a single factor regression
LUR	–0.07 %	**–0.42**	0.72	1.00 %	**8.00 %**	35.00 %	**1.60 %**	1.08 %
MUR	–0.04 %	**–2.35**	1.06	0.00 %	**54.82 %**	37.74 %	**9.27 %**	2.74 %
HUR	–0.06 %	**–5.08**	1.66	0.00 %	**88.41 %**	27.54 %	**16.05 %**	2.21 %
Overall	–0.05 %	**–2.34**	1.07	0.19 %	**50.38 %**	35.90 %	**8.71 %**	2.36 %

This table reports the results of the following regression:

$$\Delta DSR_{it} = \gamma_{0i} + \gamma_{1i}\,\Delta\overline{er}_{Mt} + \gamma_{2i}\,\Delta s_{Mt} + \varepsilon_{it}$$

We use the changes in the differential Sharpe ratio of a fund ($\Delta DSR_{it} = DSR_{it} - DSR_{it-1}$) as dependent variable. The changes in the mean ($\Delta\overline{er}_{Mt}$) and the standard deviation (Δs_{Mt}) of market excess returns are employed as independent variables. Market excess returns are calculated as differences between the monthly total returns of the market index and the risk-free monthly T-bill return. The index employed is the value-weighted index of all NYSE, AMEX, and NASDAQ stocks. Presented are the average regression coefficients and the proportions of significant regression coefficients for three fund groups and over all funds. Funds are grouped according to their proportion of unsystematic risk. HUR denotes funds exhibiting "High Unsystematic Risk", LUR stands for "Low Unsystematic Risk" and MUR for "Mid Unsystematic Risk". The coefficients γ_0 and γ_2 are tested for being equal to zero. The γ_1 coefficients are tested for being greater than or equal to zero. The t-statistics are based on standard errors corrected for heteroskedasticity and autocorrelation according to Newey and West (1987). Furthermore, the average adjusted R^2 and its increase with respect to the average adjusted R^2 of a corresponding single factor regression ($\Delta DSR_{it} = \gamma_{0i} + \gamma_{1i}\,\Delta\overline{er}_{Mt} + \varepsilon_{it}$) are reported.