Mutual Fund Risk: Mean Reversion or Gaming?

Abstract

The issue of whether mutual fund managers behave as though they are competing in a tournament has been the focus of several recent studies. Tournament behavior may be influenced by managers' interim relative performance and whether they adjust their fund's risk by their trades to win the tournament, improve their ranking, or prevent deterioration in their present ranking. It is an empirical issue as to whether a change in intertemporal risk is *intentional* or simply arises from risk mean reversion. Our methodology differentiates funds that actively trade to change risk from those whose risk is changed by trades with alternative motivations. Funds that are statistically identified as trading to change return variance or tracking error variance do not exhibit risk mean reversion. Rather, funds more commonly trade to reduce tracking error variance, particularly those with already low tracking error variances. We find weak evidence that underperforming funds intentionally trade to reduce return variance, and that trades designed to change tracking error variance are not associated with prior performance.

JEL Classification: G11, G14

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I. Introduction

A mutual fund manager's compensation is a function of the assets under management and better performing funds attract more monies from investors. In response, managers that are underperforming may engage in risk-taking, or alternatively, focus on their tenure and reduce the risk of their portfolio to limit their losses. To investigate the relation between managerial risk-taking and prior performance, changes to a fund's risk that managers intended need to be distinguished from changes that occur through risk mean reversion. In the absence of this distinction, a spurious association between risk changes and prior return may be concluded. This follows because low risk funds which have lower expected returns revert towards higher risk and vice versa.

Several studies have debated whether mutual fund managers behave as though they are competing in a tournament, and whether their behavior is influenced by their interim relative performance. Specifically, the issue is whether managers trade to finish highly ranked, win the tournament, or prevent deterioration in their present ranking. Brown, Harlow and Starks (1996) and Chevalier and Ellison (1997) and others argue that mutual fund managers who have underperformed relative to their peers over a specific period may adjust the composition of the securities in their fund in an attempt to increase return over the remainder of the year. These studies argue that underperforming managers may trade securities that cause an increase in the risk of their fund. However, Schwarz (2008) suggests a manager lagging the benchmark may be concerned with job tenure and choose to "benchmark" to avoid slipping further behind. Chevalier and Ellison (1997) also suggest that funds outperforming the market may trade to reduce risk to ensure that they continue to outperform the market, or, alternatively, may increase their risk in order to make a “top performers” list.

The results of prior research examining tournament behavior are mixed. Brown, Harlow and Starks (1996) report empirical evidence that managers with poor relative performance in the first part of the year trade securities to increase the return of their portfolios during the last part of the year. During this process, the variance of fund returns also increases. Their measure of risk change is the ratio of the fund’s standard deviation of returns (return variance) over the last part of the year relative to the first part of the year.

Considering both total and systematic risk, Koski and Pontiff (1999) find a negative relation between a fund’s risk and prior performance that is robust to a fund’s use of derivatives. Busse (2001) and Goriaev, Nijman and Werker (2005) attribute the Brown, Harlow and Starks (1996) and Koski and Pontiff (1999) findings to biases in estimating return variance caused by the autocorrelation and cross-correlation of fund returns. Allowing for these biases, using either daily or monthly fund returns to compute fund return variances, they are unable to support the finding of tournament behavior.

Chevalier and Ellison (1997) avoid the econometric difficulties associated with autocorrelation and cross-correlation of fund returns by using the individual stocks held by the fund. They consider whether managers that are outperforming the market choose to adjust their fund to track a benchmark portfolio and whether underperforming managers increase their fund’s risk in an attempt to generate higher returns. To focus on managers’ risk-taking behavior, they use the change in the standard deviation of the difference in fund returns and market returns over time. Referred to as “tracking error variance”, this measure is calculated by weighting the covariances of the time series of excess returns of the individual stocks in the fund's portfolio.

Chen and Pennacchi (2007) develop a model that shows tracking error variance is the more appropriate measure of risk. Empirically, they find that when a fund is performing poorly, fund managers tend to increase tracking error variance, and not focus on total return variance. With the exception of Chevalier and Ellison (1997), who incorporate a piecewise linear term in their regression, prior analyses do not distinguish between underperforming funds that increase their return variance and better performing funds that consolidate their position and reduce their risk exposure.

Managers trade for a variety of reasons but an observed change in a portfolio's risk does not necessarily indicate an intention to alter the risk. Indeed, almost every purchase/sell decision causes a change in both a fund's return variance and its tracking error variance. Huang, Sialm, and Zhang (2008) support this view, noting that a fund manager may trade to exploit changing investment opportunities and, in the process, alter the risk of the fund. Other trades might involve rebalancing portfolios, changing industry weightings and the like.

While security trading causes fund risk to change, it is an empirical issue as to whether the change in risk is intentional or simply reflects risk mean reversion. That is, if a mutual fund has low (high) risk, trading will tend to increase (decrease) the risk unless the trades are deliberately designed to change the risk. Chevalier and Ellison (1997) find no evidence of mean reversion, but Schwarz (2008) shows both analytically and empirically how mean reversion can result from sorting on a particular risk measure. Both studies conclude that underperforming managers increase the risk of the fund in the last half of the year. With debate continuing on the appropriate measurement of risk and whether risk mean reverts, we explore these issues and the distinction between intended and inadvertent changes to a fund's risk.

We utilize a method that identifies the contribution that each stock in the portfolio makes towards a fund's overall risk and tracking error risk. This allows us to test for statistical significance, on a fund-by-fund basis, whether there is a relation between the trades made by fund managers and the contribution that each stock makes to the portfolio's risk. A statistically significant relation indicates that trades were deliberately made to change the risk. Our methodology allows us to distinguish between trades made to deliberately change the fund's risk and those made for other reasons. If trades are made for other reasons, then mean reversion may occur. If, on the other hand, trades are made to deliberately change risk, then a direct relation should exist and mean reversion should be less pronounced.

We contribute to the literature by first establishing with statistical significance whether increases or decreases to a fund's return variance and tracking error variance are intentional. Subsequently, we explore the relation between these adjustments and prior fund performance. With information providers, such as Lippers and Morningstar, ranking funds on a frequent basis, investors can frequently choose to switch funds. Accordingly, we investigate the relation between risk-taking and prior return on a moving quarterly basis. We use the quarterly stockholdings of 3,142 mutual funds between 1991 and 2006 as reported by Thomson Financial Services Inc., resulting in 49,661 fund-periods for analysis.

Our results show that some funds deliberately increase, while others decrease, both tracking error variance and return variance. Unlike previous studies that implicitly assume equal numbers of risk increasing and risk reducing funds based on the median risk change, we find substantially more funds trade to reduce rather than increase tracking error variance. Ignoring trade intentions, we find evidence of mean reversion in both risk measures, and that the mean reversion of the return standard deviation causes mean reversion of the tracking error standard deviation. We find limited support for a positive relation between prior returns and risk changes, a result that is inconsistent with tournament behavior. Focusing on the funds that intentionally trade to either increase risk or decrease risk, we find there is no evidence of mean reversion nor of prior returns driving risk changes.

The paper proceeds as follows. In Section II we develop our empirical predictions and in Section III we discuss the data and methodology. Section IV provides the empirical results and Section V concludes the study.

II. Empirical Predictions

The risk of a mutual fund is a function of the variances and covariances of the stocks in the portfolio. Fund managers cannot change the variances or covariances, but can change the risk of the fund by adding/deleting stocks or changing the proportion invested in each stock. Mutual funds may trade stocks to change the fund's risk or in response to fund flows, expectations of individual stock performances, or to alter industry weightings.

Previous literature has considered whether changes to fund risk are motivated by tournament behavior, where managers that experience poor returns deliberately increase their fund's risk in an effort to increase returns. However, changes to a fund's risk may also arise from trades that are motivated by reasons other than tournament behavior. Such trades produce, on average, mean reversion of fund return variances. This follows because high (low) risk funds hold stocks with high (low) variances and/or covariances, and trading of stocks which is not intended to alter a fund's risk will occur predominantly in stocks with lower (higher) variances and/or covariances than those in the extant portfolio.

Brown, Harlow and Starks (1996) use total return variances in their examination of tournament behavior, while Chevalier and Ellison (1997) develop their tournament model relative to tracking error variance, or the variance of the differences between fund return and market return. We show that both measures of risk are highly correlated. Furthermore, the mechanism responsible for mean reversion of return variance will, as a consequence of this relation, produce mean reversion of tracking error variance.

Chevalier and Ellison (1997) define tracking error variance (TEV_j) as:

$$TEV_j \equiv Var(r_j - r_m) \qquad (1)$$

where r_j and r_m are the monthly returns for fund j and the value weighted market index, respectively. This is equivalent to:

$$TEV_j = Var_j + Var_m - 2\rho_{jm} Var_j^{0.5} Var_m^{0.5} \qquad (2)$$

where ρ_{jm} is the correlation between the returns of fund j and the market. Equation (2) suggests that as an approximation, TEV_j is positively related to Var_j and negatively related to the square root of Var_j. Using the square roots of the variables to reduce heteroskedasticity, we can estimate the following approximation:

$$TESD_{jt-1} = a_0 + b_1 SD_{jt-1} + b_2 SD_{jt-1}^{0.5} + \varepsilon_{jt-1} \qquad (3)$$

where $TESD_j$ and SD_j are the square roots of TEV_j and Var_j, respectively. We predict that b_1 will be positive and close to unity while b_2 will be negative.

Given the approximate relation defined in equation (3), and taking the derivative with respect to SD_j we obtain:

$$\frac{dTESD_{jt-1}}{dSD_{jt-1}} = b_1 + \frac{b_2}{2} SD_{jt-1}^{-0.5} \qquad (4)$$

This provides us with a second approximate relation which we can estimate empirically:

$$\Delta TESD_{jt} = a_0 + b_1 \Delta SD_{jt} + b_2 \frac{\Delta SD_{jt}}{SD_{jt-1}^{0.5}} + \varepsilon_{jt} \qquad (5)$$

We predict that b_1 will also be positive and close to unity while b_2 will be negative.

Equation (5) defines the relation between changes to the standard deviation of fund returns and changes to the standard deviation of tracking errors which we establish empirically using 49,660 fund-periods. Because $\Delta TESD_{jt}$ is inversely related to the square root of SD_{jt-1}, b_2 will exert an influence over the sign of the relation between $\Delta TESD_{jt}$ and ΔSD_{jt} only for low values of SD_{jt-1}. Therefore, if b_1 has the expected sign, the relation between $\Delta TESD_{jt}$ and ΔSD_{jt} will be mainly positive. Accordingly, mean reversion of return standard deviation will produce mean reversion in tracking error standard deviation.

III. Data Description and Methodology

A. Data Description

We obtain the periodic stockholdings of all US equity mutual funds for the period January 1991 – June 2006 from Thomson Financial Services Ltd. Fund transactions are inferred from changes to the holdings, which are most commonly reported quarterly, while allowing for stock capitalization changes. The holdings data are combined with monthly stock price and return data from the Centre for Research in Security Prices (CRSP) database. Mutual Fund Links is used to match the Thomson's holdings with the monthly fund returns obtained from the CRSP database.

To ensure that the data adequately represent mutual fund holdings, the sample is restricted to funds with average equity holdings exceeding 80% and average cash holdings below 10%. Start-of-period CRSP stock prices are used with the Thomson holdings data to calculate the net tangible asset values of each mutual fund. These calculated values are compared with actual net tangible asset values and the fund is excluded if the discrepancy exceeds 10%. The final dataset consists of 3,142 funds with 49,661 fund-periods. The number of fund-periods for regressions that require the matching of fund returns and control variable data reduces to 24,724.

B. Methodology

Employing a method similar to Chevalier and Ellison (1997) to calculate fund tracking error and return variances, we explore the relation between tracking error variance and return variance for each fund-period. As a consequence we are able to discover how changes to a fund's portfolio simultaneously change both the tracking error variance and the return variance of the fund. We also investigate the relation between changes to fund risk and prior risk and prior return. Subsequently, we develop a method for identifying trades designed to change fund risk. Focusing on funds that we identify as having purposely altered their risk, we repeat the investigation of the relation between changes to fund risk and prior risk and prior return.

B.1. Dependence of Changes to Tracking Error Variance on Changes to Return Variance

We calculate the variance of returns on each fund’s equity portfolio at the start of each period, by weighting the covariances of the returns of the stocks in the portfolio measured over the previous 60 months[1] with the proportionate value that each stock comprises. Following Chevalier and Ellison (1997), we calculate the return variances at the end of each period by maintaining the same covariances, while using end-of-period proportionate values. We include stocks that are acquired during a period in our calculation of the covariances.

The start- and end-of-period tracking error variances are calculated in a similar manner, but instead use stock returns in excess of the value weighted market index over the preceding 60 months to derive the return covariances. We convert return variances and tracking error variances into standard deviations, SD and TESD, respectively, to follow Chevalier and Ellison (1997). These start- and end-of-period SDs and TESDs are used to calculate changes in the portfolios' standard deviation, ΔSD, and tracking error standard deviation, ΔTESD.

Equation (3) describes the relation between return standard deviation and tracking error standard deviation. This relation is tested by using the start of period SDs and TESDs calculated for 49,659 fund-periods. Similarly, the relation between changes to return standard deviation and tracking error standard deviation over a period is described by equation (5). Using the ΔSDs and ΔTESDs calculated for 49,659 fund-periods, the parameters in equation (5) are also estimated.

B.2. Risk Mean Reversion and Return and Tracking Error Variances

If a fund's trades cause the return variance and tracking error variance to be mean reverting, then the change in return standard deviation (ΔSD_t) and tracking error standard deviation ($\Delta TESD_t$) should be negatively related to the start-of-period return

[1] We eliminate stocks without a minimum of 6 months of returns. If greater than 10% of the stocks by value are eliminated, then we remove the fund-period from consideration.

standard deviation and tracking error standard deviation, respectively. We investigate this relation by estimating equations (6) and (7) which are described in the following section.

B.3. Prior Performance and Changes to Return Variance and Tracking Error Variance

We investigate how the return variance, and tracking error variance are related to the return performance of a mutual fund over the preceding 9-, 6- and 3-month intervals. Tournament behavior is consistent with a negative relation between preceding period returns and changes to fund risk as measured by ΔSD and ΔTESD. Consistent with Chevalier and Ellison (1997) it is expected that funds that are underperforming (outperforming) their competitors will increase (decrease) the risk of their funds.

To achieve this, we estimate equations (6) and (7):

$$\Delta \mathrm{SD}_{jt} = (a_0 + b_1 \mathrm{R}_{jt-1} + b_2 \mathrm{SD}_{jt-1} + + b_3 \mathrm{MR}_t + b_4 \mathrm{VIX}_{t-1} + b_5 \mathrm{TO}_{jt} + b_6 \mathrm{Size}_{jt} + \varepsilon_{jt}) / 1{,}000 \quad (6)$$

$$\begin{aligned} \Delta \mathrm{TESD}_{jt} = (a_0 + b_1 \mathrm{R}_{jt-1} + b_2 \mathrm{TESD}_{jt-1} + b_3 \mathrm{SD}_{jt-1} + \\ + b_4 \mathrm{MR}_t + b_5 \mathrm{VIX}_{t-1} + b_6 \mathrm{TO}_{jt} + b_7 \mathrm{Size}_{jt} + \varepsilon_{jt}) / 1{,}000 \end{aligned} \quad (7)$$

Where:

$\Delta \mathrm{SD}_{jt}$ = change in return standard deviation of fund j over period t;
R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;
SD_{jt-1} = return standard deviation of fund j at the start of period t;
MR_t = 6 - month market return to time t;
VIX_t = 6 - month average market volatility (VIX) to time t;
TO_{jt} = portfolio turnover of fund j in period t;
Size_{jt} = standardized capitalization of fund j at time t;
$\Delta \mathrm{TESD}_{jt}$ = change in tracking error standard deviation of fund j over period t; and
TESD_{jt-1} = tracking error standard deviation of fund j at the start of period t.

Separate regressions are performed for returns over the previous 9-, 6- and 3-month periods. Mean reversion is tested in equations (6) and (7) by examining $\Delta \mathrm{SD}_{jt}$

and $\Delta TESD_{jt}$ relative to SD_{jt-1} and $TESD_{jt-1}$. Equation (6) includes the return standard deviation and equation (7) includes both the return standard deviation and the tracking error standard deviation at the start of each period. The market index return and market volatility are used as control variables, and both are expected to be positively related to the risk measures. When the market is increasing (decreasing), investors are more willing to assume more (less) risk. Similarly, the risk appetite of investors in mutual funds may reflect volatility in the broader market. Portfolio turnover is included because managers engaging in tournament behavior may be more likely to actively trade and because return may be a function of trading volume. Chevalier and Ellison (1997) point out that larger funds tend to engage in less risk adjustment than smaller funds, so size (corrected for growth over time) is also included as a control variable.

B.4. Identification of Trades Which Intentionally Change Return Variance and Tracking Error Variance

Virtually all trades conducted by a fund will alter the fund's return variance and tracking error variance. However, our aim is to identify trading designed to deliberately increase/decrease return variance and tracking error variance. We achieve this by measuring the contribution that each stock makes to the variances of a fund's portfolio and refer to these values as the stock's "return variance contribution" and "tracking error variance contribution". Next, we compare the return variance contributions of the stocks traded by a fund during a period with the return variance contributions of the stocks held at the start of the period. In a procedure similar to Sharpe and Cooper (1972), we rank the stocks held by a fund at the start of a period by their return variance contribution, and assign them into 20 equal value buckets. Stocks that are acquired by a fund during a period are also assigned to these buckets. Analogous to the Sharpe and Cooper (1972) weighting method, we compute the return variance contribution for each bucket as a value-weighted average of the return variance contribution of each stock in the bucket.

For each fund, we determine the value of the stocks traded during a period for each return variance contribution bucket. We assign a negative value to sell trades and a positive value to buy trades. By construction, there is no relation between the value of each bucket and the return variance contribution.[2] If trades are uniform across the 20 risk buckets, then no relation should be found between trades and their contribution to the fund's risk. However, if trades are designed to increase (decrease) risk, then stocks that contribute more (less) to a fund's risk will be more heavily purchased. Similarly, stocks that contribute less (more) to a fund's risk will be more heavily sold to increase (decrease) the fund's risk. Stock purchases and sales may occur simultaneously, and as a consequence, the risk of the fund will reflect the overall trades.

The contribution that each stock in a fund's portfolio makes to the fund's return variance and tracking error variance must be determined. Specifically, we calculate $\vec{\mathbf{T}}$, the vector of "return variance contributions" of each stock held by fund j during period t, where the ith element is defined as:

$$\vec{\mathbf{T}}_i = \sum_{k=1}^{n} x_k \operatorname{cov}(r_{it}, r_{kt}) \tag{8}$$

[2] When a fund's holdings are partitioned into equal value buckets, a particular stockholding usually straddles the boundary. When this occurs, we assign half the value of the stockholding and half the value of the trades to the return variance contribution bucket on either side of the boundary. We use 10 equal value return variance contribution buckets when we are unable to assign the stocks to 20 buckets (such as when a single stock comprises more than 5% of a fund's stockholding).

where: n = number of stocks held during the period;

x_k = proportion by value that stock k comprises at the start of period t;

r_{it} = monthly returns of stock i over the previous 60 months; and

r_{kt} = monthly returns of stock k over the previous 60 months.

The weighted average of the return variance contributions gives the fund's return variance, which in matrix notation is:

$$\vec{\mathbf{T}}\,\vec{\mathbf{X}}^T = \vec{\mathbf{X}}\ \mathbf{M}\ \vec{\mathbf{X}}^T = \sum_{i=1}^{n}\sum_{k=1}^{n} x_i x_k \operatorname{cov}(r_{it}, r_{kt}) = \operatorname{var}(\sum_{i=1}^{n} x_{it} r_{it}) = \operatorname{var}(r_t) \qquad (9)$$

where:

$\vec{\mathbf{X}}$ = vector of portfolio weights (x_{it}'s) for stock i held by fund j at the start of period t; and

$\mathbf{M}$ = covariance matrix of stock returns for fund j at the start of period t.

By calculating $\vec{\mathbf{T}}$, we can identify the vector elements corresponding to each stock and use these to rank and assign the stocks to one of the twenty return variance contribution buckets. The value of the stock contained in each contribution bucket is equal; however, the return variance contribution of a bucket will reflect the return variance contributions of the stocks it contains. For any particular bucket j the return variance contribution (RVC) is given by:

$$\text{RVC}_j \equiv \sum_{i=1}^{n}\left(Stock\ RVC_i \times \frac{Value\ stock_i\ held}{\sum_{i=1}^{n} Value\ stock_i\ held}\right); \qquad (10)$$

Stock RVC_i = element i in row vector $\vec{\mathbf{T}}$ defined in equation (8);

Value stock_i held = value of stock i (belonging to bucket j) held at the start of period t;

and n = number of stocks in RVC bucket j.

Trades that are made over the period change the weightings and cause the return variance contributions to change for each bucket, j, and as a consequence, the variance of the fund. To determine the nature of the trades, the value of the trades over the period in each bucket j is regressed on the RVCs of the buckets at the start of the period.

$$Trade\ Value_j = \alpha + \beta\,\mathrm{RVC}_j + \varepsilon_j \tag{11}$$

where $Trade\,Value_j \equiv \sum_{i=1}^{n} Value\ stock_i\ (belonging\ to\,bucket\ j)\,traded\ during\ period\ t.$

We contend that if the regression coefficient on $\mathrm{RVC_j}$ is significantly positive (negative), then the trades were made with the intention to increase (decrease) risk. If, however, the coefficient is not significant, the trades were not intended to change the risk of the fund.

Analogous calculations are made to determine the vector of each stock's contribution to the variance of the tracking error of fund j during period t, where the i^{th} element is given by:

$$\vec{\mathbf{T}}_i = \sum_{k=1}^{n} x_k \operatorname{cov}(r_{it} - r_{mt}, r_{kt} - r_{mt}) \tag{12}$$

where: r_{mt} = monthly market returns over the previous 60 months.

This equation is similar to equation (8), but excess returns are used in the calculations. It provides the tracking error variance contribution, TEVC, for each stock in the fund and allows ranking on this risk measure. By symmetry, TEVC replaces RVC in equations (10) and (11). Like equation (11), if the regression coefficient on $\mathrm{TEVC_j}$ is significantly positive (negative) at the 10% level, then the trades were made with the intention to increase (decrease) tracking error risk. If, however, the coefficient is not significant, the trades were not intended to change the TEV of the fund.

These regressions are performed on each of the 49,661 fund-periods between January 1991 and June 2006. We refer to the coefficients associated with RVC and TEVC as RVCBeta(s) and TEVCBeta(s), respectively. The number of RVCBetas (TEVCBetas) that are significantly different from zero could have occurred as a random event.[3] The cumulative binomial distribution is used to determine whether the observed number of significant RVCBetas (TEVCBetas) occurred by chance. The number of regressions is used as the number of trials, the level of significance at which we find the RVCBetas (TEVCBetas) to be positive or negative as the probability of a success, while the critical number of successes corresponds to a cumulative binomial probability of 1%.

B.5. Trades Intentionally Changing Return Variance and Tracking Error Variance – Prior Returns and Risk Mean Reversion

Funds with significant return variance betas and tracking error variance betas are classified as deliberately trading to change their risk. For both risk measures, the funds are classed as increasing or decreasing risk according to the sign of the corresponding beta. These binary outcomes are logistically regressed on the return performance of the mutual funds over the preceding 9-, 6- and 3-month intervals. If prior returns are motivating their risk changing behavior, then a relation between preceding months' returns and the sign of the RVCBeta and the TEVCBeta should be evident. Furthermore, if funds exhibit tournament behavior, the relation is expected to be negative, with funds that are underperforming (outperforming) their competitors increasing (decreasing) the risk of their funds.

[3] In separate tests, we confirm that our method generates the expected level of 5% negative and 5% positive betas when we randomly rank stocks.

Logistic regressions are used to estimate equations (13) and (14) where, respectively, RVCBeta and TEVCBeta take on values of +1 (-1) if the coefficient is significantly positive (negative). Equations (13) and (14) are estimated using only those funds that have statistically increased or decreased their portfolio's SD and TESD.

$$\text{RVCBeta}_{jt} = (a_0 + b_1\text{R}_{jt-1} + b_2\text{SD}_{jt-1} + b_3\text{MR}_t + b_4\text{VIX}_{t-1} + b_5\text{TO}_{jt} + b_6\text{Size}_{jt} + \varepsilon_{jt})/1{,}000 \quad (13)$$

$$\text{TEVCBeta}_{jt} = (a_0 + b_1\text{R}_{jt-1} + b_2\text{TESD}_{jt-1} + b_3\text{SD}_{jt-1} + b_4\text{MR}_t + b_5\text{VIX}_{t-1} + b_6\text{TO}_{jt} + b_7\text{Size}_{jt} + \varepsilon_{jt})/1{,}000 \quad (14)$$

Where:

RVCBeta_{jt} = significant return variance contribution beta for fund j over period t;
TEVCBeta_{jt} = significant tracking error variance contribution beta for fund j over period t;
R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;
SD_{jt-1} = return standard deviation of fund j at the start of period t;
MR_t = 6-month market return to time t;
VIX_t = 6-month average market volatility (VIX) to time t;
TO_{jt} = portfolio turnover of fund j in period t;
Size_{jt} = standardized capitalization of fund j in period t;
ΔTESD_{jt} = change in tracking error standard deviation of fund j over period t; and
TESD_{jt-1} = tracking error standard deviation of fund j at the start of period t.

Separate regressions are performed for returns over the previous 9-, 6- and 3-month periods. As before, if managers engage in tournament behavior, prior returns influence their decisions to change the risk of their funds and a negative relation is expected. The coefficient associated with SD_{jt-1} and $TESD_{jt-1}$ will be positive (negative) if managers achieve their intention of increasing (decreasing) the risk of high risk portfolios and decreasing (increasing) the risk of low risk portfolios. Unlike equations (6) and (7) where a negative coefficient on SD_{jt-1} and $TESD_{jt-1}$, respectively, could be produced by random trading leading to mean reversion, a negative coefficient in equations (13) and (14) will only result from deliberate action. Equation (13) includes the return standard deviation and equation (14) includes both the return standard deviation and tracking error standard deviation at the start of each period as independent variables. The control variables are the same as those previously used in equations (6) and (7).

IV. Empirical Results

A. Descriptive Statistics

Table 1 presents descriptive statistics for the 3,142 funds involving 49,661 fund-periods between 1991 and 2006. The market capitalization distribution is highly skewed, reflecting a few very large funds. Fund market capitalization increased markedly over the period as the stock market increased and as new monies flowed into the funds. The period over which we examine the funds' trades is most commonly either 90 days (66%) or 180 days (27%). It is observed that the total return standard deviation is approximately twice as large as the tracking error standard deviation. Also, the average (median) correlation between the mutual funds' and the market returns is high at 0.865 (0.896).

[Insert Table 1]

B. Relation Between Return Variance and Tracking Error Variance

Equation (2) describes the theoretical relation between return variance and tracking error variance from which we derive the approximation that shows tracking error standard deviation relative to return standard deviation in equation (3). Similarly, we derive the approximation in equation (5) which relates change of tracking error standard deviation to change in return standard deviation. Table 2 documents the parameter estimates for these regressions. Both models have high explanatory power with adjusted r-squares of 0.779 and 0.763, respectively, and the coefficients are highly significant, with the predicted signs. Accordingly, mean reversion of the standard deviation will produce mean reversion in tracking error standard deviation.

[Insert Table 2]

C. Return Variance and Tracking Error Variance – Mean Reversion and Prior Returns

Table 3 reports the regression results for equation (6) where the change in fund return standard deviation is the dependent variable. The highly significant negative coefficient on the start-of-period return standard deviation in all models provides strong evidence that return variance is mean reverting. Model 1 is estimated using 48,436 fund-periods. In order to incorporate the tournament hypothesis, prior returns are needed, and Model 2 uses the subsample of 24,724 fund-periods for which we can match 9-month prior returns.

The significantly positive signs on prior returns do not support the tournament hypothesis that fund managers increase the risk of their portfolios following relatively poor performance. It should be noted that the addition of fund performance over the previous 9-, 6-, and 3-months in Models 3, 4 and 5, respectively, contributes little to the explanatory power of the model as indicated by the adjusted r-square.[4] As expected the control variables of market return and market volatility are significantly positively related to the change in return standard deviation. Similar to Chevalier and Ellison (1997), who suggest the smaller funds tend to adjust risk levels more than larger funds, the size of the funds is negatively related to risk. Turnover appears to be unrelated to risk.

[Insert Table 3]

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[4] The number of observations in models two through five varies slightly dependent on the number of matching return months available.

Table 4 reports the regression results for equation (7) where the change in the tracking error standard deviation is the dependent variable. Model 1 uses 48,436 fund-periods, but the sample is reduced to 24,723 fund-periods for Model 2. Highly significant negative coefficients are associated with both the start-of-period tracking error standard deviation and the return standard deviation, both of which indicate that the change in tracking error standard deviation is strongly mean reverting. As above, the addition of prior return performance in Models 3, 4 and 5 contributes little to the explanatory power of the model.[5] The size and significance of the coefficients on the control variables of market return, market volatility, and size are similar to the results shown in Table 3. Although Table 3 does not show that turnover is significantly related to ΔSD, there is some evidence in Table 4 that turnover is negatively related to ΔTESD.

[Insert Table 4]

In summary, irrespective of whether return variance or tracking error variance is used, the results support risk mean reversion and are not consistent with the tournament hypothesis.

D. Identification of Trades that Intentionally Change Return Variance and Tracking Error Variance

In general, it is expected that low risk portfolios produce lower returns. Accordingly, it is difficult to distinguish underperforming funds that deliberately increase the risk of their portfolios because of this underperformance, from funds

[5] The standardized coefficients (not shown) on start-of-period return standard deviation and tracking error standard deviation indicate that together they explain 37% of the change in the tracking error standard deviation compared with less than 7.5% from prior returns.

whose return variance and tracking error variance increase as a consequence of mean reversion. By examining changes to the individual fund's portfolio, however, we are able to determine with statistical confidence whether trades were conducted with the intention of increasing or decreasing these variances.

To determine if there is a relation between the proportion of stocks traded during a period and the stock's return variance contribution, 49,661 univariate linear regressions are performed. Each regression is for one fund-period, and fund-periods with return variance contribution betas (RVCBeta) significant at the 10% level (two-tailed) are identified. A repeat set of regressions using tracking error variance contribution are performed to determine the tracking error variance contribution betas (TEVCBeta). Table 5 reports the pooled count of significant regression coefficients (betas) over the sixteen-year period. A negative beta indicates trading that reduced the return variance or tracking error variance of a fund's portfolio. Funds exhibiting negative betas are preferentially purchasing stocks with low return variance contributions (tracking error variance contributions) or selling stocks with high return variance contributions (tracking error variance contributions) or both.

[Insert Table 5]

The binomial distribution is used to determine whether the frequency of the significant RVCBetas (TEVCBetas) differ from that expected by a random occurrence. Panel A of Table 5 shows that both negative and positive significant return variance betas exceed the corresponding 1% cumulative binomial critical values. At 14.4%, about twice as many funds trade to reduce the fund's return variance[6] as the 8.2% that trade to increase the funds' return variance. We find that gaming to increase total risk is less common than is implicitly assumed in other studies, such as Brown, Harlow and Starks (1996) who classify 50% of the funds as risk increasing and 50% as risk decreasing.

In Panel A, of the 49,661 TEVCBeta regression coefficients, 23.5% are significantly negative, which exceeds the 1% cumulative binomial critical value. Correspondingly, 4.5% of the coefficients are significantly positive and are significantly below the number that would be expected by chance. It is apparent that these funds consider the contribution a stock makes to the fund's tracking error variance. Furthermore, it is clear that almost one quarter of the funds trade stocks with a view to reducing the fund's tracking error variance, while those that trade to increase tracking error variance are relatively few. This contrasts with the underlying assumption of previous studies that assume funds "game" tracking error, which they increase or decrease with similar propensity.

The annual breakdown of RVCBeta and TEVCBeta is shown in Panel B of Table 5. The counts are time-variant, but negative RVCBetas occur more frequently than random expectation in all years, while the count of positive RVCBetas is above expectation in most years. The TEVCBetas exhibit more gradual changes, and all negative TEVCBetas occur more frequently and most positive TEVCBetas occur less frequently than randomly expected.

[6] The funds of interest are ones that conduct their trades to reduce return variance that we can statistically confirm at the 10% level. Clearly, other funds may also trade to reduce return variance, but this relation is either nonlinear or not statistically significant.

E. Trades that Intentionally Change Return Variance and Tracking Error Variance – Mean Reversion and Prior Returns

The prior regressions statistically identified those funds that have deliberately traded to change the risk of the fund. The results of the binary logistic regression of RVCBeta on prior returns, start-of-period return standard deviation and control variables defined by equation (13) are provided in Table 6. Model 1 includes 10,985 fund-periods with significantly negative or positive RVCBetas. The sample is reduced to 5,565 fund-periods when matching prior returns are required for Model 2.

[Insert Table 6]

The coefficient on the SD_{jt-1} variable is insignificant in all models. If managers' of funds with high (low) return variance intended to reduce (increase) the funds' return variance this relation would have been negative, and conversely, would have been positive if managers of high (low) return variance funds had sought to increase (decrease) return variance. By restricting the analysis to fund-periods where managers deliberately change the return variance, we have removed the negative relation between changes to return variance (SD_{jt-1}) that was apparent in Table 3. This indicates that mean reversion of fund return variances are caused by trades that are not conducted with the intent to alter risk.

The coefficients for prior returns are only significant for 9- and 6-months, and being positive, do not support risk-gaming by underperforming fund managers. Similar to the Table 3 results, inclusion of the 9-, 6-, and 3-month prior returns only marginally improves the explanatory power of the model.

[Insert Table 7]

Table 7 provides results for analogous logistic regressions where the dependent variable is TEVCBeta using values that are significantly positive or negative. In Model 1, the 13,582 significant TEVCBetas are obtained from the sample of 48,430 fund-periods, while in Model 2 the 6,818 significant TEVCBetas are obtained from the 24,723 fund periods. Consistent with Table 6, the coefficient on start-of-period return standard deviation is not significant in any model. The coefficient on start-of-period tracking error standard deviation is significantly positive in all models and therefore has the incorrect sign for consistency with mean reversion of tracking error variance. Furthermore, it appears that our focus on fund-periods with statistically significant changes to tracking error variance has (similar to Table 6) removed the impact of 'random trading' to which we attribute the negative coefficients on SD_{jt-1} and $TESD_{jt-1}$ in Table 4.

Cognizant of the result in Table 5 that funds more commonly trade to reduce rather than increase tracking error variance, the positive coefficient on $TESD_{jt-1}$ in Table 7 suggests that funds with low tracking error variances are deliberately seeking to further reduce tracking error variance. This is consistent with the expectation that funds which exhibit trading aimed at reducing tracking error variance would, over time, tend to have lower tracking error variances. Notably, no evidence of tournament behavior is found as the relation between intentional changes to tracking error variance and prior return is insignificant in all models.

For Table 6 the RVCBeta is significantly positively related to the market return and market volatility control variables. We also find that turnover is negatively related to RVCBeta. This negative relation may be because most funds are trying to reduce return variance, and those that more actively trade are more successful in achieving the reduction. Since the number of funds trying to increase return variance is close to random, the overall results are driven by those seeking to reduce return variance. Fund size is positively related to RVCBeta. We conjecture that the smaller funds are trading to more closely track the index and, hence, to reduce return variance. Because large established funds are more likely to reflect the index, it is less likely that they trade to reduce return variance. The TEVCBeta results shown in Table 7 parallel those for the RVCBeta.

F. Dependence of Changes to Tracking Error Variance on Changes to Return Variance

Of the 11,223 fund-periods with significant RVCBetas and 13,905 fund-periods with significant TEVCBetas reported in Table 5, 6,259 fund-periods exhibit both significant RVCBetas and TEVCBetas. That is, with statistical confidence, these funds' trades simultaneously alter return variance and tracking error variance. This finding indicates that some fund managers in adjusting risk, simultaneously alter both return variance and tracking error variance, though not necessarily in the same direction.

V. Conclusions

Trading by a fund alters the composition of the assets in its portfolio and changes its return variance and tracking error variance. If managers trade with no intention of changing the risk of the fund, the risk of high risk funds will tend to revert downward and the risk of low risk funds will tend to revert upward. Chevalier and Ellison (1997) examine this issue but find no evidence of mean reversion. In contrast, our results support risk mean reversion for funds whose trade motivation is unclear.

However, managers deliberately trying to reduce the risk of the fund can actively purchase low risk stocks or avoid buying high risk stocks. An opposite strategy could be used to increase risk. The methodology developed in this study allows the identification of management trading to deliberately change the risk of the fund, and distinguish these risk changes from those attributed to mean reversion. Focusing only on funds that exhibit statistically significant preferences for increasing or decreasing risk, we find that 23.5% of the funds deliberately trade to reduce tracking error variance from one period to the next while only 4.5% trade to increase tracking error variance. Although less pronounced, asymmetric preferences for reducing total return variance risk are found.

By examining tournament behavior in funds that deliberately trade to change their risk, we find weak evidence that funds that increase return variance do so after experiencing returns that exceed those of funds that decrease return variance. We find no association between prior return and tracking error variance. This contrasts with previous studies which do not distinguish deliberate from inadvertent risk changes, and find that poor prior returns motivate fund managers to increase the fund’s risk in an attempt to increase returns. Overall, our methodology allows a more precise examination of tournament behavior than earlier studies by avoiding the confounding effect of risk mean reversion

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Table 1

Descriptive Statistics for Mutual Funds, 1991-2006

Tracking error variance is defined as $\mathrm{var}(r_{jt} - r_{mt})$ and return variance as $\mathrm{var}(r_{jt})$ where r_{jt} and r_{mt} are the returns of stock j and the market over the previous 60 months.

	Mean	Median	Standard Deviation
Number of fund-periods	49,661		
Number of funds	3,142		
Market capitalization ($ million)			
1991 – 1996	563.6	143.1	1,688.5
1997 – 2001	1,216.8	229.2	4,355.7
2002 – 2006	1,542.1	320.4	5,379.8
Number of stocks in portfolio	122	86	224
Period (days)	127	92	43
Return variance	0.0047	0.0028	0.0074
Return standard deviation	0.0612	0.0530	0.0313
Δ Return variance	-0.0001	0.0000	0.0023
Δ Return standard deviation	-0.0003	-0.0001	0.0077
Tracking error variance	0.0017	0.0008	0.0045
Tracking error standard deviation	0.0336	0.0282	0.0247
Δ Tracking error variance	-0.0001	0.0000	0.0016
Δ Tracking error standard deviation	-0.0002	0.0001	0.0072
Market variance	0.0020	0.0021	0.0008
Correlation (fund and market)	0.865	0.896	0.165

Table 2

Relation between Tracking Error Standard Deviation and Standard Deviation

Tracking Error Standard Deviation: $TESD_{jt-1} = a_0 + b_1 SD_{jt-1} + b_2 SD_{jt-1}^{0.5} + \varepsilon_{jt-1}$

Change in Tracking Error Standard Deviation: $\Delta TESD_{jt} = a_0 + b_1 \Delta SD_{jt} + b_2 \frac{\Delta SD_{jt}}{SD_{jt-1}^{0.5}} + \varepsilon_{jt}$

where $TESD_{jt-1}$ is the tracking error standard deviation of fund j at time t-1, SD_{jt-1} is the return standard deviation of fund j at time t-1. $\Delta TESD_{jt}$ and ΔSD_{jt} are changes in these variables over period t.

N=49,656	Coefficient	Standardized Coefficient	t-statistic	Adjusted R Square
Panel A: Tracking Error Standard Deviation				
Constant	0.032***		44.02	0.779
SD_{jt-1}	1.188***	1.503	133.34	
Square root SD_{jt-1}	-0.294***	-0.640	-56.75	
Panel B: Change in Tracking Error Standard Deviation				
Constant	0.000***		12.64	0.763
ΔSD_{jt}	1.341***	1.446	177.06	
ΔSD_{jt}/square root SD_{jt}	-0.187***	-0.610	-74.69	

***indicates significance at the 1 percent level.

Table 3

Change to Return Variance – Prior Returns and Risk Mean Reversion

Regression of:

$$\Delta \text{SD}_{jt} = (a_0 + b_1 \text{R}_{jt-1} + b_2 \text{SD}_{jt-1} + b_3 \text{MR}_t + b_4 \text{VIX}_{t-1} + b_5 \text{TO}_{jt} + b_6 \text{Size}_{jt} + \varepsilon_{jt}) / 1{,}000$$

Where:

ΔSD_{jt} = change in return standard deviation of fund j over period t;

R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;

SD_{jt-1} = return standard deviation of fund j at the start of period t;

MR_t = 6-month market return to time t;

VIX_t = 6-month average market volatility (VIX) to time t;

TO_{jt} = portfolio turnover of fund j in period t; and

Size_{jt} = standardized capitalization of fund j in period t.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	3.010***	3.449***	3.479***	3.454***	3.537***
	(7.56)	(6.51)	(6.57)	(6.515)	(6.72)
$R9_{jt-1}$			1.317***		
			(3.80)		
$R6_{jt-1}$				3.052***	
				(10.27)	
$R3_{jt-1}$					2.236***
					(11.00)
SD_{jt-1}	-75.64***	-83.305***	-83.374***	-84.187***	-85.114***
	(-66.32)	(-51.00)	(-51.05)	(-51.38)	(-51.28)
MR_t	9.812***	9.652***	9.952***	10.335***	10.190***
	(29.77)	(22.32)	(22.65)	(23.48)	(23.20)
VIX_t	0.113***	0.121***	0.124***	0.130***	0.129***
	(18.35)	(15.18)	(15.48)	(16.25)	(16.27)
TO_{jt}	-0.148	0.175	0.190	0.185	0.202
	(-1.36)	(1.18)	(1.28)	(1.25)	(1.36)
$Size_{jt}$	-1.409***	-1.626***	-1.712***	-1.769***	-1.804***
	(-3.91)	(-3.38)	(-3.56)	(-3.68)	(-3.78)
N	48,436	24,724	24,724	24,576	24,529
Adjusted R^2	0.127	0.145	0.146	0.150	0.150

***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.
t-statistic is given in parentheses.

Table 4

Change to Tracking Error Variance – Prior Returns and Risk Mean Reversion

Regression of:

$$\Delta\text{TESD}_{jt} = (a_0 + b_1\text{R}_{jt-1} + b_2\text{TESD}_{jt-1} + b_3\text{SD}_{jt-1} + b_4\text{MR}_t + b_5\text{VIX}_{t-1} + b_6\text{TO}_{jt} + b_7\text{Size}_{jt} + \varepsilon_{jt})/1{,}000$$

Where:

ΔTESD_{jt} = change in tracking error standard deviation of fund j over period t;

R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;

TESD_{jt-1} = tracking error standard deviation of fund j at the start of period t;

SD_{jt-1} = return standard deviation of fund j at the start of period t;

MR_t = 6 - month market return to time t;

VIX_t = 6 - month average market volatility (VIX) to time t;

TO_{jt} = portfolio turnover of fund j in period t; and

Size_{jt} = standardized capitalization of fund j in period t.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	4.525***	5.021***	5.080***	5.078***	5.186***
	(12.10)	(10.27)	(10.39)	(10.40)	(10.69)
$R9_{jt-1}$			1.508***		
			(4.68)		
$R6_{jt-1}$				2.952***	
				(10.73)	
$R3_{jt-1}$					2.270***
					(12.08)
$TESD_{jt-1}$	-79.025***	-90.367***	-92.840***	-96.366***	-96.126***
	(-3.22)	(-26.54)	(-26.96)	(-28.07)	(-28.22)
SD_{jt-1}	-13.287***	-16.470***	-15.014***	-13.848***	-15.80***
	(-6.40)	(-6.35)	(-5.75)	(-5.31)	(-6.11)
MR_t	3.278***	2.187***	2.515***	2.751***	2.46***
	(10.60)	(5.49)	(6.22)	(6.80)	(6.09)
VIX_t	0.082***	0.086***	0.089***	0.095***	0.094***
	(14.27)	(11.69)	(12.12)	(12.86)	(12.80)
TO_{jt}	-0.415***	-0.212	-0.195	-0.192	-0.180
	(-4.07)	(-1.55)	(-1.42)	(-1.41)	(-1.33)
$Size_{jt}$	-2.910***	-2.949***	-3.088***	-3.160***	-3.155***
	(-8.53)	(-6.61)	(-6.91)	(-7.09)	(-7.13)
N	48,430	24,723	24,723	24,575	24,528
Adjusted R^2	0.109	0.127	0.128	0.134	0.134

***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively.
t-statistic is given in parentheses.

Table 5

Significant Variance Contribution Betas

We report the number of statistically significant (10%) return variance contribution betas generated from 49,661 linear regressions of: $\text{TradeValue}_j = \alpha + \beta\,\text{RVC}_j + \varepsilon_j$, where:

$$\text{TradeValue}_j \equiv \sum_{i=1}^{n} \text{Value stock}_i \text{ traded};$$

$$\text{RVC}_j \equiv \sum_{i=1}^{n} \left(\text{Stock RVC}_i \times \frac{\text{Value stock}_i \text{ held}}{\sum_{i=1}^{n} \text{Value stock}_i \text{ held}} \right);$$

Value stock_i traded = value of stock i (belonging to bucket j) traded during period t;

Value stock_i held = value of stock i (belonging to bucket j) held at the start of period t;

$$\text{Stock RVC}_i = \sum_{k=1}^{n} x_k \operatorname{cov}(r_{it}, r_{kt}); \text{ and}$$

n = number of stocks in RVC bucket j.

Results for tracking error variance contribution beta are generated using an analogous methodology which differs in that the market return is subtracted from the stock returns prior to calculating the return covariances. These are performed on 49,661 fund-periods between January 1991 and June 2006.

Year	N	Return Variance Contribution Beta Negative (%)	Return Variance Contribution Beta Positive (%)	Tracking Error Variance Contribution Beta Negative (%)	Tracking Error Variance Contribution Beta Positive (%)
Panel A: Full Sample					
1991-2006	49,661	14.4***	8.2***	23.5***	4.5***
Panel B: Annual Breakdown					
1991	1159	8.6***	11.6***	18.6***	4.9
1992	1806	13.6***	9.2***	20.2***	5.1
1993	1982	14.7***	5.1	22.7***	4.0*** L
1994	2222	14.8***	5.1	25.2***	3.6** L
1995	2579	19.0***	4.8	28.3***	2.5*** L
1996	2610	19.1***	3.9*** L	29.7***	2.8*** L
1997	3519	15.6***	6.4***	25.0***	4.0*** L
1998	3739	14.1***	8.4***	23.3***	5.2
1999	3525	11.8***	9.7***	23.1***	5.7**
2000	4327	17.8***	12.0***	25.6***	7.1***
2001	3848	14.8***	10.7***	26.6***	5.0
2002	4191	15.3***	9.5***	25.0***	4.5* L
2003	4059	13.5***	10.2***	20.0***	4.9
2004	4509	11.0***	9.2***	19.5***	4.2*** L
2005	4372	11.8***	4.9	20.0***	2.7*** L
2006	1214	12.1***	6.1**	22.2***	3.1*** L

***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively using the cumulative binomial distribution.

L denotes occurrences less than what is expected by random

Table 6

Significant Return Variance Contribution Betas and Prior Returns

Logistic regression of:

$$\text{RVCBeta}_{jt} = a_0 + b_1\text{R}_{jt-1} + b_2\text{SD}_{jt-1} + b_3\text{MR}_t + b_4\text{VIX}_{t-1} + b_5\text{TO}_{jt} + b_6\text{Size}_{jt} + \varepsilon_{jt}$$

Where:

RVCBeta_{jt} = significant return variance beta for fund j in period t; positive beta = 1, negative beta = -

R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;

SD_{jt-1} = return standard deviation of fund j at the start of period t;

MR_t = 6 - month market return to time t;

VIX_t = 6 - month average market volatility (VIX) to time t;

TO_{jt} = portfolio turnover of fund j in period t; and

Size_{jt} = standardized capitalization of fund j in period t.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	-2.193***	-2.387***	-2.389***	-2.422***	-2.347***
	(79.17)	(46.56)	(46.59)	(47.66)	(44.53)
$R9_{jt-1}$			0.470**		
			(4.52)		
$R6_{jt-1}$				0.461**	
				(6.07)	
$R3_{jt-1}$					0.091
					(0.50)
SD_{jt-1}	-0.501	-0.342	-0.306	-0.336	-0.588
	(0.62)	(0.12)	(0.10)	(0.12)	(0.34)
MR_t	0.616***	1.025***	1.114***	1.105***	1.070***
	(10.20)	(14.26)	(16.45)	(16.00)	(14.64)
VIX_t	0.044***	0.042***	0.043***	0.042***	0.043***
	(129.66)	(61.39)	(63.74)	(62.34)	(63.29)
TO_{jt}	-1.158***	-0.986***	-0.975***	-0.970***	-0.990***
	(299.75)	(106.41)	(103.70)	(102.49)	(105.90)
$Size_{jt}$	1.317***	1.458***	1.436***	1.471***	1.418***
	(35.25)	(21.34)	(20.66)	(21.57)	(19.94)
N	10,985	5,565	5,565	5,542	5,516
Cox & Snell R^2	0.046	0.036	0.037	0.036	0.036
Nagelkerke R^2	0.063	0.049	0.050	0.050	0.049

***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively. Wald statistic is given in parentheses.

Table 7

Significant Tracking Error Variance Contribution Betas and Prior Returns

Logistic regression of:

$$\text{TEVCBeta}_{jt} = a_0 + b_1 \text{R}_{jt-1} + b_2 \text{TESD}_{jt-1} + b_3 \text{SD}_{jt-1} + b_4 \text{MR}_t + b_5 \text{VIX}_{t-1} + b_6 \text{TO}_{jt} + b_7 \text{Size}_{jt} + \varepsilon_{jt}$$

Where:

TEVCBeta_{jt} = significant tracking error variance beta for fund j in period t;

R_{jt-1} = annualized excess return on fund j over 9, 6, or 3 months to the start of period t;

TESD_{jt-1} = tracking error standard deviation of fund j at the start of period t;

SD_{jt-1} = return standard deviation of fund j at the start of period t;

MR_t = 6 - month market return to time t;

VIX_t = 6 - month average market volatility (VIX) to time t;

TO_{jt} = portfolio turnover of fund j in period t; and

Size_{jt} = standardized capitalization of fund j in period t.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	-2.599***	-2.733***	-2.732***	-2.718***	-2.732***
	(80.66)	(44.43)	(44.39)	(43.50)	(43.76)
$R9_{jt-1}$			0.062		
			(0.06)		
$R6_{jt-1}$				0.087	
				(0.15)	
$R3_{jt-1}$					-0.089
					(0.33)
$TESD_{jt-1}$	7.220***	6.717**	6.624**	6.378**	7.102***
	(15.40)	(6.50)	(6.19)	(5.71)	(7.05)
SD_{jt-1}	1.921	2.578	2.643	2.512	1.863
	(1.76)	(1.71)	(1.77)	(1.58)	(0.87)
MR_t	1.072***	1.403***	1.418***	1.367***	1.346***
	(22.25)	(19.05)	(18.77)	(17.12)	(16.08)
VIX_t	0.025***	0.018***	0.019***	0.019***	0.019***
	(30.80)	(8.56)	(8.61)	(8.78)	(8.78)
TO_{jt}	-2.065***	-1.971***	-1.970***	-1.987***	-1.990***
	(501.65)	(227.00)	(226.44)	(227.28)	(226.68)
$Size_{jt}$	0.975***	1.154***	1.150***	1.152***	1.182***
	(13.79)	(9.64)	(9.54)	(9.50)	(9.99)
N	13,582	6,818	6,818	6,779	6,756
Cox & Snell R^2	0.054	0.047	0.047	0.047	0.046
Nagelkerke R^2	0.092	0.079	0.079	0.079	0.079

***, ** and * indicate significance at the 1, 5 and 10 percent levels respectively. Wald statistic is given in parentheses.