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Changes to mutual fund risk: Intentional or mean reverting?

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ABSTRACT

An empirical issue is whether a mutual fund's change in intertemporal risk is *intentional* or arises from risk mean reversion. Our methodology uses actual fund trades to identify funds that actively change risk. Funds that are statistically identified as trading to change return variance or tracking error variance do not exhibit risk mean reversion. Mostly, funds trade to reduce risk and, in particular, tracking error variance. This is most evident for funds that previously attained a low tracking error variance. We find no evidence of a relation between past performance and intended changes to return variance or tracking error variance.

1. Introduction

A mutual fund manager's compensation is a function of the assets under management with investors providing more money to the better performing funds. In response, managers who are underperforming may attempt to increase returns by increasing the risk of their portfolio. Or, if tenure is a concern, they may instead reduce the risk to limit their losses. 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 of the individual stocks, but can change the risk of the fund by adding/deleting stocks or changing the proportion invested in each stock. The critical issue is how the changing proportions of the individual stocks affect the risk of the fund.

Several studies have examined whether mutual fund managers behave as though they are competing in a tournament, and whether their behavior is influenced by their interim relative performance. The results of this research are mixed. To investigate the relation between managerial risk taking and prior performance, changes to a fund's risk that managers intend[1] need to be distinguished from changes that occur through trades made for other reasons. Trades made for other reasons may cause mean reversion of risk. In the absence of a distinction between trades that result in risk mean reversion and trades intended to change risk, a spurious association between risk changes and prior returns may be concluded.[2] Brown et al. (1996) use total return variances in their examination of tournament behavior, while Chevalier and Ellison (1997) develop their model relative to tracking error variance.[3] There is continuing debate over which of these measures of risk is appropriate and whether these risks mean revert.

Previous studies do not make a distinction between intended and unintended changes to a fund's risk. A significant contribution

[1] Kempf et al. (2009) also refer to "intended" risk taking; however, they use this terminology only to distinguish changes to risk caused by a fund's *trades* from risk changes caused by changes in the *risk of the stocks* in the fund's portfolio. With this usage, *all* trades would be classed as intended to change a fund's risk. However, we use the terminology to make the distinction between trades that were designed or intended to change a fund's risk and trades made for other reasons that change a fund's risk.

[2] Schwarz (2009) cautions that previous studies that sorted on a fund's prior return may have simultaneously sorted on risk, and the finding that fund managers increase their risk following poor performance could be due to mean reversion of risk.

[3] Tracking error variance is defined as the variance of the difference between fund return and market return. The managers of index funds attempt to reduce tracking error variance to zero.

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of our paper is to address this shortcoming by identifying mutual funds that intentionally increase or decrease fund risk. We adapt the procedure in Cullen et al. (2010) by first determining the contribution that each stock in the portfolio makes to the overall risk. Then we rank the individual stocks on the risk contribution from low to high risk and partition the stocks into 20 equal value buckets. We regress the net value of the trades in each bucket made during the period on the risk contribution for each bucket. Since the stocks have been ranked on risk, unless trades to change risk dominate, no relation will be found between the trades and the risk measure. This method allows us to test for statistical significance, on a fund-by-fund basis, whether the risk for each fund-period has intentionally been changed. A significantly positive coefficient indicates a fund made trades to increase its risk, while a significantly negative coefficient indicates a fund made trades to reduce its risk.

We investigate the relation between fund risk taking and prior return on a moving quarterly basis. This is appropriate because investors wishing to switch funds may consult the frequent rankings by information providers such as Lipper Analytical Services and Morningstar. We use the quarterly stockholdings of 2836 mutual funds between 1991 and 2006 as reported by Thomson Financial Services Inc., resulting in 49,673 fund-periods in our analysis.

Our results show that some funds deliberately decrease, while others deliberately increase, both tracking error variance and return variance. Unlike previous studies that have implicitly assumed 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 to increase tracking error variance. This is particularly noticeable in funds with low initial tracking error variances. The propensity to reduce or increase both return variance and tracking error variance, however, varies over time. Funds trade stocks for various reasons that are not deliberately designed to alter the risk of their portfolios. Attributable to such trades, as a group, funds exhibit mean reversion of risk. However, those that we identify as trading to intentionally increase or decrease risk do not exhibit mean reversion. We also find no relation between prior returns and changes in return variance and tracking error risk changes.

The paper proceeds as follows. In Section 2 we discuss the literature and develop our empirical predictions. Section 3 discusses the data and methodology, while Section 4 provides the empirical results. We conduct robustness tests in Section 5 and conclude the study in Section 6.

2. Literature and empirical predictions

Brown et al. (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 latter 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. These authors argue that underperforming managers may trade securities that cause an increase in the risk of their fund. Hereafter, we refer to predictions of this outcome as the "tournament hypothesis." Taylor (2003), however, argues that this tournament behavior may instead lead to the opposite outcome. He argues that it is rational for winning managers to anticipate that underperforming managers will increase their risk and do so themselves to maintain their ranking. If underperforming managers anticipate the reaction of the winners, they may instead decrease risk.

Considering both total and systematic risk, Koski and Pontiff (1999) find a negative relation between a fund's risk and prior performance. Furthermore, this relation is robust to a fund's use of derivatives. Busse (2001) and Goriaev et al. (2005) attribute the Brown et al. (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.

The econometric difficulties associated with autocorrelation and cross-correlation of fund returns are avoided by Chevalier and Ellison (1997) by calculating fund risk from the individual stocks they hold. 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 (2009) 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 rather than focusing on total return variance. Fund managers performing poorly will maintain their poor position if they simply track the market in the subsequent period. In an attempt to improve their position, they select securities without consideration of the market index. More recently, Elton et al. (2010) and Kempf et al. (2009) follow Chevalier and Ellison (1997) by using portfolio holdings to calculate fund risk. Elton et al. (2010) find that underperforming managers decrease the systematic and total risk of their portfolios, while Kempf et al. (2009) find that underperforming managers may either increase or decrease the fund's risk depending on whether concerns for compensation or tenure dominate.

Previous research has considered whether changes to fund risk are motivated by tournament behavior. However, changes to a fund's risk may also arise from trades that are motivated by reasons other than tournament behavior, such as portfolio rebalancing and changing industry weightings. Indeed, almost every purchase/sell decision causes a change in both a fund's return variance and its tracking error variance.[4] 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 that 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.[5]

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. Chevalier and Ellison (1997) find no evidence of mean reversion. However, Koski and Pontiff (1999) and Kempf et al. (2009) find the opposite.

The central focus of this research is to identify fund-period where the trades are designed to alter the fund's return variance

[4] Huang et al. (2009) 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.

[5] Simulations are performed for both return variance and tracking error variance. We simulate the effect of "random" trading on a fund portfolio's return (tracking error) variance by creating a randomly drawn "universe" of 100 stocks. The random selection process involves sampling from the CRSP database stocks with 60 consecutive monthly returns preceding an arbitrary date and choosing every 30th stock after ordering on PERMNO. From this universe of stocks we create 5000 equally weighted portfolios of 10 stocks and compute the portfolio's return (tracking error) variance. We replace one stock in each portfolio with another drawn from the universe and recalculate the portfolio's return (tracking error) variance. The change to each portfolio return (tracking error) variance is used as the independent variable that is regressed on the initial portfolio return (tracking error) variance to simulate the regression of ΔSD (ΔTESD) on SD_{t-1} ($TESD_{t-1}$). The coefficient on SD_{t-1} ($TESD_{t-1}$) is significantly negative, consistent with mean reversion of return (tracking error) variance.

or tracking error variance. By identifying funds whose trades have intentionally changed risk, we eliminate mean reversion as the cause of the risk changes.

3. Data description and methodology

3.1. 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 Center for Research in Security Prices (CRSP) database. Mutual Fund Links is used to match the Thomson 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% of total fund assets. 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 data set consists of 2836 funds with 49,673 fund-periods. The number of fund-periods reduces to 24,727 for the regressions that require the matching of fund returns and control variable data. In the regressions that follow, the sample size varies because of missing fund-return data. In addition, smaller sample sizes occur because not all funds intentionally change risk.

3.2. Methodology

The change in a fund's risk is an ambiguous signal because risk can be changed intentionally or can occur due to mean reversion. However, if we examine the stocks that were traded, additional insights can be obtained. We present a method below that statistically identifies trades that are intended to change the risk of the fund.

3.2.1. Identification of trades that intentionally change return variance and tracking error variance

Virtually all trades conducted by a fund will alter the fund's return variance. The traditional variance, as shown in Eq. (1), can be decomposed to reveal the contribution that each stock makes to the variance of a fund's portfolio.

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

where n = number of stocks held during the period; x_i = proportion by value that stock i comprises at the start of period t; 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; r_{kt} = monthly returns of stock k over the previous 60 months; $\vec{\mathbf{X}}$ = vector of portfolio weights (x_{it}'s) for stock i held by fund j at the start of period t; $\mathbf{M}$ = covariance matrix of stock returns for fund j at the start of period t; and $\vec{\mathbf{T}}$ = vector of return variance contributions.

By calculating $\vec{\mathbf{T}}$ (see (2)), we can identify the return variance contributions (RVCs) corresponding to each stock. This matrix manipulation essentially converts a complex function of variances and covariances into a function that is linear in the "contributions." The variance of returns of each mutual fund's equity portfolio at the start of each period is calculated by value weighting the covariances of the returns of the stocks in the fund measured over the previous 60 months.[6] Following Chevalier and Ellison (1997), the return variances at the end of each period are calculated by maintaining the same covariances, while using end-of-period proportionate values. Stocks that are acquired during a period are included in the calculation of the covariances.

Since our aim is to identify trading designed to deliberately increase/decrease return variance, we focus on Eq. (2). The RVCs are the elements of the vector $\vec{\mathbf{T}}$ for each stock i held by fund j during period t. It follows from Eq. (1) that the ith element of vector $\vec{\mathbf{T}}$ is:

$$\vec{\mathbf{T}}_i = \sum_{k=1}^{n} x_k \mathrm{cov}(r_{it}, r_{kt}) \tag{2}$$

We use the RVCs of the stocks held by a fund at the start of a period as the ranking variable prior to the assignment of these stocks to 20 equal value buckets. The RVC of each bucket will reflect the RVCs of the stocks it contains.[7] For any particular bucket j, the return variance contribution is given by:

$$\mathrm{RVC}_j \equiv \sum_{i=1}^{\mathrm{n}} \left(\mathrm{StockRVC}_i \times \frac{\mathrm{Value\ stock}_i\ \mathrm{held}}{\sum_{i=1}^{\mathrm{n}} \mathrm{Valuestock}_i\ \mathrm{held}} \right) \tag{3}$$

where Stock RVC_i = element i in row vector $\vec{\mathbf{T}}$ defined in Eq. (2); 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 on the RVC of stock i and, as a consequence, cause the RVC of bucket j to change. 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.

$$\mathrm{Trade\ Value}_j = \alpha + \beta \mathrm{RVC}_j + \varepsilon_j \tag{4}$$

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

We contend that if the regression coefficient on 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. Following Cullen et al. (2010), we perform repeat regressions, one for each fund-period, of the value of the stocks in a bucket that were traded[8] during a period on the average of the ranking risk variable for each bucket. In calculating the value of the stocks traded, buy trades are assigned a positive and sell trades a negative value. By construction, there is no initial relation between the value of each bucket and the ranking variable, such that the regression will reveal an association that is attributable to the trading during the period.

The other measure of portfolio risk is tracking error variance. Chevalier and Ellison (1997) define tracking error variance as;

$$\mathrm{TEV}_j \equiv \mathrm{Var}(\mathrm{r}_j - \mathrm{r}_m) \tag{5}$$

where r_j and r_m are the monthly returns for fund j and the value-weighted market index, respectively. Analogous calculations are made to determine the vector of each stock's contribution to the

[6] Stocks without a minimum of 6 months of returns are eliminated. If more than 10% of the stocks by value are eliminated, then the fund-period is removed from consideration. Five years of monthly or weekly data are generally used by practitioners or investment advisory services such as Value Line, Morningstar, and Merrill Lynch.

[7] The number of stocks in each bucket varies depending on the total number of stocks in the funds and the market value of the stocks in each bucket. For example, for a hypothetical portfolio of 200 stocks, each of the 20 buckets will have about 10 stocks if their market values are reasonably similar.

[8] Similar to Cullen et al. (2010), we jointly rank stocks that are held at the start of a period with those acquired during the period such that they are also assigned to buckets.

variance of the tracking error of fund j during period t, where the ith element is given by:

$$\vec{\mathbf{T}}_i = \sum_{k=1}^{n} x_k \mathrm{cov}(r_{it} - r_{mt}, r_{kt} - r_{mt}) \tag{6}$$

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

This equation is similar to Eq. (2), 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 Eqs. (3) and (4). Similar to Eq. (4), if the regression coefficient on 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 49,673 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. The cumulative binomial distribution is used to determine whether the observed number of significant RVCBetas (TEVCBetas) occur 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%.

3.2.2. Trades intentionally changing return variance and tracking error variance—prior returns and risk mean reversion

Return variances and tracking error variances are converted 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.

Funds with significant return variance contribution betas and tracking error variance contribution betas are classified as deliberately trading to change their risk. For both risk measures, the funds are classified 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, the tournament hypothesis predicts the relation to be negative, with funds that are underperforming (outperforming) their competitors increasing (decreasing) the risk of their funds.

Logistic regressions are used to estimate Eqs. (7) and (8), where, respectively, RVCBeta and TEVCBeta take on values of +1 (−1) if the coefficient is significantly positive (negative). Eqs. (7) and (8) are estimated using only those funds that have statistically increased or decreased their portfolio's SD and TESD.

$$\mathrm{RVCBeta}_{jt} = a_0 + b_1\mathrm{R}_{jt-1} + b_2\mathrm{SD}_{jt-1} + b_3\mathrm{MR}_t + b_4\mathrm{TO}_{jt} + b_5\mathrm{Size}_{jt} + \varepsilon_{jt} \tag{7}$$

$$\mathrm{TEVCBeta}_{jt} = a_0 + b_1\mathrm{R}_{jt-1} + b_2\mathrm{TESD}_{jt-1} + b_3\mathrm{SD}_{jt-1} + b_4\mathrm{MR}_t + b_5\mathrm{TO}_{jt} + b_6\mathrm{Size}_{jt} + \varepsilon_{jt} \tag{8}$$

where:

$\mathrm{RVCBeta}_{jt}$ = significant return 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;
TO_{jt} = portfolio turnover of fund j in period t;
Size_{jt} = standardized capitalization of fund j in period t;
$\mathrm{TEVCBeta}_{jt}$ = significant tracking error variance contribution beta for 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. If managers engage in tournament behavior, prior returns influence their decisions to change the risk of their funds and a negative relation is expected between returns and risk. 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. Eq. (7) includes the return standard deviation, and Eq. (8) includes both the return standard deviation and tracking error standard deviation at the start of each period as independent variables.

The market index return is used as a control variable and is expected to be positively related to the risk measures. When the market is increasing (decreasing), investors are more willing to assume more (less) risk. 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) caution that larger funds may tend to engage in less risk adjustment than smaller funds; therefore, size (corrected for growth over time) is also included as a control variable.

3.2.3. Robustness test: Mean reversion of return variance and tracking error variance

Eqs. (7) and (8) consider only funds that intentionally trade to change risk. Now we consider the entire sample of mutual fund trades. If a fund's trades cause the return variance and tracking error variance to be mean reverting, then the change in return standard deviation ($\Delta\mathrm{SD}_t$) and tracking error standard deviation ($\Delta\mathrm{TESD}_t$) should be negatively related to the start-of-period return standard deviation and tracking error standard deviation, respectively. We examine this relation by estimating Eqs. (9) and (10), which are described in the following section.

3.2.4. Robustness test: Prior performance and changes to return variance and tracking error variance

We investigate how 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. The tournament hypothesis predicts a negative relation between prior period returns and changes to fund risk as measured by ΔSD and ΔTESD. Consistent with Chevalier and Ellison (1997), it is expected that funds underperforming (outperforming) their competitors will increase (decrease) the risk of their funds.

To achieve this, we estimate Eqs. (9) and (10):

$$\Delta\mathrm{SD}_{jt} = (a_0 + b_1\mathrm{R}_{jt-1} + b_2\mathrm{SD}_{jt-1} + b_3\mathrm{MR}_t + b_4\mathrm{TO}_{jt} + b_5\mathrm{Size}_{jt} + \varepsilon_{jt})/1000 \tag{9}$$

$$\Delta\mathrm{TESD}_{jt} = (a_0 + b_1\mathrm{R}_{jt-1} + b_2\mathrm{TESD}_{jt-1} + b_3\mathrm{SD}_{jt-1} + b_4\mathrm{MR}_t + b_5\mathrm{TO}_{jt} + b_6\mathrm{Size}_{jt} + \varepsilon_{jt})/1000 \tag{10}$$

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;
TO_{jt} = portfolio turnover of fund j in period t;
$Size_{jt}$ = standardized capitalization of fund j in period t;
$\Delta TESD_{jt}$ = 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.

Eq. (9) includes the return standard deviation, and Eq. (10) includes both the return standard deviation and the tracking error standard deviation at the start of each period. The control variables are the same as those previously used in Eqs. (7) and (8).

3.2.5. Additional robustness tests

Five additional tests shed light on the robustness of the results. We examine the impact of multicollinearity in the logistic regression; whether the results change if continuous dependent variables replace the respective logistic risk measures; whether the results are sensitive to quarterly or semiannual mutual fund reporting; the effect of excluding index funds and using 36 months of returns to calculate variances.

4. Empirical results

4.1. Descriptive statistics

Table 1 presents descriptive statistics for the 2836 funds involving 49,673 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 more funds flowed into the industry. The period over which we examine the funds' trades is most commonly either 90 days (66%) or 180 days (27%). The distributions of return and tracking error standard deviations are less skewed than those of the corresponding variances, which supports our use of standard deviations in our subsequent analyses. The standard deviations of returns and tracking errors at the start of a trading period are highly correlated (0.780) as are the changes to these over the trading period (0.845). The distribution of the correlations between the returns of a mutual fund and the market has an average (median) of 0.849 (0.888).

Table 1
Descriptive statistics for mutual funds, 1991–2006.

	Mean	Median	Standard deviation
Number of fund-periods	49,673		
Number of funds	2836		
Market capitalization ($ million)			
1991–1996	563.6	143.1	1688.5
1997–2001	1216.8	229.2	4355.7
2002–2006	1542.1	320.4	5379.8
Number of stocks in portfolio	148.8	90.0	221.3
Period (days)	117.3	92.0	42.7
Return variance	0.00339	0.00257	0.00338
Return standard deviation (SD)	0.05443	0.05069	0.02065
Δ Return standard deviation (ΔSD)	−0.00010	0.00011	0.00592
Tracking error variance	0.00122	0.00069	0.00208
Tracking error standard deviation (TESD)	0.0297	0.0263	0.01828
Δ Tracking error standard deviation (ΔTESD)	−0.00006	0.00008	0.00552
Market return variance	0.00196	0.00208	0.00080
Correlation (fund and market)	0.849	0.888	0.132
Correlation (TESD and SD)	0.780***		
Correlation (ΔTESD and ΔSD)	0.845***		

Fund tracking error variance is defined as $\text{var}(r_{jt} - r_{mt})$ and fund return variance as $\text{var}(r_{jt})$, where r_{jt} and r_{mt} are the monthly returns of stock j and the market, respectively, calculated over the previous 60 months.
*** Indicates significance at the 1% level.

4.2. Identification of trades that intentionally change return variance and tracking error variance

To determine if there is a relation between the proportion of stocks traded during a period and the stock's return variance contribution, 49,673 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

Table 2
Significant variance contribution betas.

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	49,673	14.3***	7.9***	23.5***	4.4***L
Panel B: Prior risk pentiles					
Low risk[a]	9934	12.9***	6.8***	26.4***	3.5***L
	9935	12.3***	7.2***	22.9***	4.0***L
	9935	13.0***	7.9***	21.8***	4.2***L
	9935	15.2***	8.7***	23.3***	4.7
High risk	9934	18.0***	8.9***	22.9***	5.6***
Panel C: 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***	29.7*** L	2.8***L
1997	3519	15.6***	6.4***	25.0***	4.0***L
1998	3739	14.1***	8.1***	23.5***	5.1
1999	3537	11.4***	10.0***	23.1***	5.2
2000	4327	16.4***	10.7***	25.0***	6.6***
2001	3848	15.2***	10.1***	27.0***	5.0
2002	4191	15.1***	8.3***	24.1***	4.6
2003	4059	13.5***	10.2***	20.0***	4.9
2004	4509	11.2***	9.0***	19.7***	4.3**L
2005	4372	11.9***	4.9	20.0***	2.8***L
2006	1214	12.1***	6.1**	22.2***	3.1***L

The number of statistically significant (10%) return variance contribution betas are generated from 49,673 linear regressions of:
$\text{Trade Value}_j = \alpha + \beta \text{RVC}_j + \varepsilon_j$
where
$\text{Trade Value}_j \equiv \sum_{i=1}^{n} \text{Value stock}_i \text{traded}$;
$\text{RVC}_j \equiv \sum_{i=1}^{n} \left(\text{StockRVC}_i \times \frac{\text{Value stock}_i \text{held}}{\sum_{i=1}^{n} \text{Value stock}_i \text{held}} \right)$;
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;
$\text{Stock RVC}_i = \sum_{k=1}^{n} x_k \text{cov}(r_{it}, r_{kt})$; 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 49,673 fund-periods between January 1991 and June 2006.
[a] Risk is either start-of-period return variance or tracking error variance depending on whether the percentages are for return variance contribution betas or for tracking error variance contribution betas, respectively.
*** Indicates significance at the 1% levels using the cumulative binomial distribution.
** Indicates significance at the 5% levels using the cumulative binomial distribution.
L Denotes occurrences less than what is expected by random.

variance contribution are performed to determine the tracking error variance contribution betas (TEVCBeta). Table 2 reports the pooled count of significant regression coefficients (betas) over the 16-year period. A negative beta indicates trading that reduces the return variance or tracking error variance of a fund's portfolio. Funds exhibiting significant 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.

The binomial distribution is used to determine whether the frequency of the significant RVCBetas (TEVCBetas) differs from that expected by random occurrence. Panel A of Table 2 shows that both negative and positive significant return variance betas exceed the corresponding 1% cumulative binomial critical values. At 14.3%, almost twice as many funds trade to decrease the fund's return variance[9] compared to the 7.9% that trade to increase the fund's return variance. This indicates that trading to alter a fund's total risk is less common than is implicitly assumed in other studies, such as that of Brown et al. (1996), who classify 50% of funds as risk increasing and 50% as risk decreasing.

Moreover, in Panel A of Table 2, of the 49,673 TEVCBeta regression coefficients, 23.5% are significantly negative, which also exceeds the 1% cumulative binomial critical value. Correspondingly, 4.4% of the coefficients are significantly positive and statistically below the number that would be expected by chance. Therefore, the implicit assumption in previous studies that funds "game" tracking error by increasing or decreasing tracking error variance with similar propensity is not supported empirically. Moreover, funds are more concerned with reducing tracking error variance, while those trading to increase tracking error variance are relatively rare. Indeed, as shown in Panel B, funds in the lowest tracking error variance pentile are 7.5 times as likely to decrease as to increase tracking error variance. This is consistent with funds whose aim it is to reduce tracking error variance achieving this goal over time.

The annual breakdown of RVCBeta and TEVCBeta is shown in Panel C of Table 2. The counts are time variant, but negative RVCBetas (TEVCBetas) occur more frequently than random expectations in all years. The frequency of funds that trade to increase tracking error variance (positive TEVCBetas) is generally lower than random expectation. The proportions of RVCBetas (TEVCBetas) vary gradually over time, and notably, the proportions of negative and positive betas are negatively correlated. That is, when more fund managers trade to increase risk, fewer trade to decrease risk and vice versa. Kempf et al. (2009) report variation in the relation between past performance and managerial risk-taking behavior over time, in response to overall market performance. Our focus on intentional risk-increasing or -decreasing trades supports their finding of time variation in fund manager behavior.

4.3. Trades that intentionally change return variance and tracking error variance—mean reversion and prior returns

The regressions, discussed earlier, statistically identify those funds that deliberately trade 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 Eq. (7) are provided in Table 3. Model 1 includes 10,786 fund-periods with significantly negative or positive RVCBetas. The sample is reduced to 5444 fund-periods when matching prior returns are required for Model 2.

Table 3
Significant return variance contribution betas and prior returns, 1991–2006.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	−1.064***	−1.348***	−1.340***	−1.373***	−1.289***
	(20.83)	(15.79)	(15.60)	(16.29)	(14.25)
$R9_{jt-1}$			0.163		
			(0.53)		
$R6_{jt-1}$				0.122	
				(0.42)	
$R3_{jt-1}$					-0.004
					(0.00)
SD_{jt-1}	0.762	1.686	1.708	1.456	1.324
	(0.62)	(1.22)	(1.25)	(0.89)	(0.70)
MR_t	0.072	0.585**	0.608**	0.599**	0.611**
	(0.17)	(5.89)	(6.24)	(6.05)	(6.21)
TO_{jt}	−1.112***	−0.932***	−0.928***	−0.915***	−0.923***
	(268.11)	(91.54)	(90.45)	(87.83)	(88.84)
$Size_{jt}$	0.989***	1.131***	1.122***	1.157***	1.091***
	(19.86)	(12.73)	(12.50)	(13.25)	(11.70)
N	10,786	5444	5444	5422	5396
Cox and Snell R^2	0.032	0.023	0.023	0.022	0.022
Nagelkerke R^2	0.044	0.031	0.031	0.030	0.030

Logistic regression of:
$RVCBeta_{jt} = a_0 + b_1 R_{jt-1} + b_2 SD_{jt-1} + b_3 MR_t + b_4 TO_{jt} + b_5 Size_{jt} + \varepsilon_{jt}$
where
$RVCBeta_{jt}$ = significant return 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*;
SD_{jt-1} = return standard deviation of fund *j* at the start of period *t*; MR_t = 6-month market return to time *t*;
TO_{jt} = portfolio turnover of fund *j* in period *t*; and
$Size_{jt}$ = standardized capitalization of fund *j* in period t.
*** Indicates significance at the 1% levels.
** Indicates significance at the 5% levels. Wald statistic is given in parentheses.

The coefficient on the SD_{jt-1} variable is insignificant in all models. If managers of funds with high (low) return variance intend to reduce (increase) the funds' return variance, this relation will be negative, and conversely, will be positive if managers of high (low) return variance funds seek to increase (decrease) return variance. While our method focuses on intended trades, we note the possibility that random trades might produce a significantly negative relation through mean reversion. However, this possibility is not supported by the absence of a significant negative relation in our results. The coefficients for prior returns are insignificant for 9, 6, and 3 months and do not support the tournament hypothesis in which underperforming fund managers increase risk.

Table 4 provides results for analogous logistic regressions where the dependent variable is TEVCBeta using values that are significantly positive or negative. In Model 1, the 13,531 significant TEVCBetas are obtained from the sample of 48,449[10] fund-periods, while in Model 2 the 6782 significant TEVCBetas are obtained from the 24,727 fund periods. The coefficient on the start-of-period tracking error standard deviation is significantly positive in all models. It is, therefore, inconsistent with mean reversion of tracking error variance.

Cognizant of the result in Panel B of Table 2, the positive coefficient on $TESD_{jt-1}$ in Table 4 provides further support for the conclusion that funds with low tracking error variances are deliberately seeking to reduce tracking error variance further. This is consistent with the expectation that funds that 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 in the relation between intentional changes to tracking error variance and prior return.

In Tables 3 and 4, the RVCBeta and TEVCBeta are respectively significantly positively related to market return. This is consistent

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

[10] Refer to Table 5, Model 1.

Table 4
Significant tracking error variance contribution betas and prior returns, 1991–2006.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	−2.420***	−2.886***	−2.882***	−2.858***	−2.886***
	(77.82)	(52.51)	(52.36)	(51.04)	(51.85)
$R9_{jt-1}$			0.074		
			(0.08)		
$R6_{jt-1}$				0.011	
				(0.00)	
$R3_{jt-1}$					-0.073
					(0.22)
$TESD_{jt-1}$	6.109***	6.091*	5.942*	5.946*	6.734**
	(7.27)	(3.60)	(3.34)	(3.34)	(4.32)
SD_{jt-1}	9.783***	12.673***	12.799***	12.386***	11.93***
	(23.62)	(20.58)	(20.47)	(19.05)	(17.78)
MR_t	0.387*	0.986***	0.999***	0.959***	0.974***
	(3.36)	(11.02)	(11.04)	(10.10)	(10.24)
TO_{jt}	−2.049***	−2.024***	−2.022***	−2.032***	−2.036***
	(485.27)	(229.70)	(229.12)	(228.78)	(228.19)
$Size_{jt}$	0.983***	1.230***	1.224***	1.225***	1.255***
	(13.95)	(10.76)	(10.62)	(10.57)	(11.09)
N	13,531	6782	6782	6742	6723
Cox and Snell R^2	0.053	0.051	0.051	0.050	0.050
Nagelkerke R^2	0.090	0.086	0.086	0.085	0.085

Logistic regression of:
$TEVCBeta_{jt} = a_0 + b_1 R_{jt-1} + b_2 TESD_{jt-1} + b_3 SD_{jt-1} + b_4 MR_t + b_5 TO_{jt} + b_6 Size_{jt} + \varepsilon_{jt}$
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*;
TO_{jt} = portfolio turnover of fund *j* in period *t*; and
$Size_{jt}$ = standardized capitalization of fund *j* in period t.
*** Indicates significance at the 1% levels.
** Indicates significance at the 5% levels.
* Indicates significance at the 10% levels. Wald statistic is given in parentheses.

with our expectation that better performing markets increase the fund managers' appetite for risk. We also find that turnover is negatively related to both RVCBeta and TEVCBeta. Therefore, contrary to the concern that more actively managed funds have a greater tendency to increase risk, it appears they more commonly trade to reduce risk. Fund size is positively related to RVCBeta and TEVCBeta, suggesting that larger funds intentionally adjust risk more than smaller funds.

4.4. Dependence of changes to tracking error variance on changes to return variance

Of the 11,008 fund-periods with significant RVCBetas and 13,842 fund-periods with significant TEVCBetas reported in Table 2, 6127 fund-periods exhibit both significant RVCBetas and TEVCBetas.[11] That is, with statistical confidence, these funds trade to simultaneously alter return variance and tracking error variance. This finding indicates that some fund managers simultaneously alter both risks, although not necessarily in the same direction.

5. Robustness tests

5.1. Return variance and tracking error variance—mean reversion and prior returns

Table 5 reports the regression results for Eq. (9), where the change in 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 48,449 fund-periods.[12] As before, in order to incorporate the tournament hypothesis, prior returns are needed, and Model 2 uses the subsample of 24,727 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. Rather, our results more closely resemble those of Elton et al. (2010). 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. As expected, the market return control variable is significantly positively related to the change in return standard deviation. Contrary to our earlier result that focused on intentional risk changes, fund size is negatively related to risk. Turnover appears to be weakly positively related to risk.

Table 6 reports the regression results for Eq. (10), where the change in the tracking error standard deviation is the dependent variable. Model 1 uses 48,441 fund-periods, but the sample is reduced to 24,725 fund-periods for Model 2. A highly significant negative coefficient associated with the start-of-period tracking error standard deviation indicates 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

[11] The number of fund-periods differs from Tables 3 and 4 because we do not lose observations through matching control variables.

[12] We lose observations because we match the control variables. Furthermore, the number of observations in Models 2–5 varies slightly, depending on the number of matching return months available.

Table 5
Change to return variance—prior returns and risk mean reversion, 1991–2006.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	4.202***	3.985***	4.047***	4.093***	4.074***
	(14.29)	(9.95)	(10.10)	(10.20)	(10.18)
$R9_{jt-1}$			0.913***		
			(3.40)		
$R6_{jt-1}$				1.523***	
				(6.62)	
$R3_{jt-1}$					1.134***
					(7.16)
SD_{jt-1}	−63.134***	−61.110***	−61.112***	−61.780***	−61.452***
	(−49.10)	(−33.08)	(−33.09)	(−33.24)	(−32.65)
MR_t	8.55***	8.964***	9.133***	9.232***	9.240***
	(36.90)	(29.97)	(30.12)	(30.45)	(30.54)
TO_{jt}	−0.009	0.203*	0.215*	0.211*	0.218*
	(−0.10)	(1.74)	(1.84)	(1.80)	(1.88)
$Size_{jt}$	−1.366***	−1.316***	−1.378***	−1.392***	−1.398***
	(−4.88)	(−3.51)	(−3.67)	(−3.71)	(−3.74)
N	48,449	24,727	24,727	24,578	24,532
Adjusted R^2	0.088	0.090	0.090	0.092	0.091

Regression of:
$\Delta SD_{jt} = (a_0 + b_1 R_{jt-1} + b_2 SD_{jt-1} + b_3 MR_t + b_4 TO_{jt} + b_5 Size_{jt} + \varepsilon_{jt})/1000$
where
Δ 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;
TO_{jt} = portfolio turnover of fund j in period t; and
$Size_{jt}$ = standardized capitalization of fund j in period t.
*** Indicates significance at the 1% levels.
* Indicates significance at the 10% levels. The t-statistic is given in parentheses.

the explanatory power of the model.[13] The size and significance of the coefficients on the control variables of market return, fund turnover, and size are similar to the results shown in Table 5.

It is possible that the analyses we present in Tables 3 and 4 are based on funds that experience large changes to return and tracking error variance as a consequence of using fund-periods with statistically significant RVCBetas and TEVCBetas. Funds with large changes to return and tracking error variance may produce results that differ from those we report in Tables 5 and 6. Accordingly, we repeat these analyses firstly using only the top and bottom pentiles and secondly using only the top and bottom deciles of the dependent variables in Eq. (9) and Eq. (10), and obtain similar results. In summary, irrespective of whether return variance or tracking error variance is used, the results support risk mean reversion but are not consistent with the tournament hypothesis.

5.2. Multicollinearity in logistic regression

The SD_{jt-1} and $TESD_{jt-1}$ terms in Eq. (8) are highly correlated.[14] This may lead to erroneous conclusions regarding the statistical significance of the independent variables and incorrect estimates of the coefficients in the logistic regression reported in Table 4. Our large sample size reduces this potential, but nonetheless, we repeat this regression twice, omitting each term in turn. The coefficient on $TESD_{jt-1}$ increases, with increased statistical significance when the SD_{jt-1} term is omitted. When the $TESD_{jt-1}$ term is omitted, the coefficient on SD_{jt-1} also increases in size and statistical significance, in effect taking the place of $TESD_{jt-1}$. Accordingly, we are satisfied that our qualitative interpretation remains valid.

5.3. Intentional return variance and tracking error variance changes using continuous dependent variables

By using a logistic regression model to test the relation between statistically significant RVCbetas, TEVCbetas, and the explanatory variables, we reduce our sample size. Since this procedure may reduce the power of our analysis, we perform additional analyses using a two-stage process. First, we repeat our suite of regressions using Eq. (4), to obtain the statistical confidences that the RVCbeta (TEVCbeta) are different from zero and code these as either positive or negative according to the sign of the coefficient. We interpret these as probabilities that a fund's trades were conducted to intentionally increase (positive) or decrease (negative) the return (tracking error) variance. Second, we use these values as regressands to reestimate Eqs. (7) and (8). In effect, we have derived continuous dependent variables and use our entire sample.

These supplementary regressions produce qualitatively similar results to the logistic regressions we report in Tables 3 and 4. They confirm that we have not biased our analyses by focusing only on trades statistically identified as intended to change fund risk.

5.4. Impact of pooling different trading periods

In our analyses, we pooled the trades of funds that report their holdings quarterly and semiannually. The trades of funds that report quarterly are sampled more frequently than those reported semiannually; however, the latter are more likely to have larger changes in their holdings. This heterogeneity may bias the results. Accordingly, we repeat our analyses using homogenized subsamples of quarterly and semiannual trading periods. The results for each subsample are qualitatively similar to those from our pooled sample.

5.5. Excluding index funds and using 36 months of returns to calculate variances

By excluding index funds from our analyses we can focus on funds that are actively managed and may be more likely to exhibit tournament behavior. This constraint reduces our sample from 49,673 to 47,504 fund-periods, but qualitatively the results remain the same. Accordingly, we conclude that the small number of index funds in our sample plays a negligible role in the results.

It is possible that fund managers place more emphasis on recent data and pay more attention to variances and covariances calculated over a shorter period. Similar to Elton et al. (2010), we use 36 months of return data to recalculate return and tracking error variances, covariances, and variance contributions. Comparing the continuous dependent variable described in Section 5.3 produced using 60 months and 36 months to calculate variance contributions, we find correlations of 0.89 for return variance and 0.84 for tracking error variance.[15] Accordingly, when we repeat our analyses using these variances and covariances, we generate results qualitatively equivalent to those in Tables 2–6.

[13] The standardized coefficients (not shown) on start-of-period tracking error standard deviation indicate that it contributes to 23% of the explained change in the tracking error standard deviation compared with less than 6% for prior returns.

[14] As indicated in Table 1, SD and TESD have a correlation of 0.780, which is significant at 1%.

[15] Seventy percent of the fund-periods we statistically identify as trading to either increase or decrease tracking error variance when we calculate variance contribution using 36 months are similarly classified using 60 months. For return variance, the corresponding proportion is 68%. However, many fund-periods classed as trading to increase or decrease risk on one calculation miss the statistical cut of 90% confidence on the other. If the statistical confidence requirement is reduced from 90% to 80% (two-tailed), then these proportions increase to 84% for both risk measures.

Table 6
Change to tracking error variance—prior returns and risk mean reversion, 1991–2006.

	Model				
	(1)	(2)	(3)	(4)	(5)
Intercept	4.826***	4.544***	4.647***	4.691***	4.681***
	(17.43)	(12.21)	(12.47)	(12.59)	(12.60)
$R9_{jt-1}$			1.223***		
			(4.86)		
$R6_{jt-1}$				1.681***	
				(7.84)	
$R3_{jt-1}$					1.357***
					(9.22)
$TESD_{jt-1}$	−71.960***	−71.142***	−73.365***	−75.007***	−73.896***
	(−30.22)	(−22.92)	(−23.39)	(−23.96)	(−23.76)
SD_{jt-1}	−5.973***	−7.46***	−5.983**	−5.864**	−7.080***
	(−2.85)	(−2.78)	(−2.22)	(−2.17)	(−2.64)
MR_t	3.272***	3.213***	3.417***	3.435***	3.405***
	(14.93)	(11.51)	(12.11)	(12.18)	(12.10)
TO_{jt}	−0.196**	−0.091	−0.076	−0.073	−0.064
	(−2.45)	(−0.84)	(−0.71)	(−0.67)	(−0.59)
$Size_{jt}$	−2.547***	−2.245***	−2.360***	−2.371***	−2.341***
	(−9.59)	(−6.41)	(−6.72)	(−6.76)	(−6.71)
N	48,441	24,725	24,725	24,576	24,530
Adjusted R^2	0.077	0.074	0.075	0.078	0.077

Regression of:
$\Delta TESD_{jt} = (a_0 + b_1 R_{jt-1} + b_2 TESD_{jt-1} + b_3 SD_{jt-1} + b_4 MR_t + b_5 TO_{jt} + b_6 Size_{jt} + \varepsilon_{jt})/1000$
where
$\Delta TESD_{jt}$ = change in tracking error standard deviation of fund j over period t; 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;
TO_{jt} = portfolio turnover of fund j in period t; and
$Size_{jt}$ = standardized capitalization of fund j in period t.
*** Indicates significance at the 1% levels.
** Indicates significance at the 5% levels. The t-statistic is given in parentheses.

6. Conclusions

Trading by a fund alters the composition of the assets in its portfolio and changes its return variance and tracking error variance. Managers may deliberately attempt to reduce the risk of their fund by actively purchasing low risk stocks or avoiding buying high risk stocks, or by using the opposite strategy to increase risk. The methodology developed in this study allows the identification of fund managers trading to deliberately change the risk of the fund and distinguishes these risk changes from those attributed to mean reversion. Funds that we statistically identify as trading to change return variance or tracking error variance do not exhibit risk mean reversion.

When fund managers trade with the intention to alter risk, we find that the dominant behavior in funds with low tracking error variance is to further reduce risk. Indeed, we find that, with statistical significance, 26.4% of the funds in the lowest pentile of start-of-period tracking error variance deliberately trade to decrease tracking error variance, while only 3.5% trade to increase this risk. Our finding does not preclude tournament behavior by fund managers, although the prevalence of funds that trade to reduce tracking error variance suggests it may be a secondary consideration among those that track the index.

Focusing on funds that deliberately trade to change their risk, we find no evidence of a relation between past performance and intended changes to return variance or tracking error variance. These results avoid the ambiguity of previous investigations of tournament behavior that do not distinguish deliberate from inadvertent risk changes. Overall, our method allows a more precise examination of tournament behavior without the confounding effect of risk mean reversion.

References

Brown, K.C., Harlow, W.V., Starks, L.T., 1996. Of tournaments and temptations: an analysis of managerial incentives in the mutual fund industry. Journal of Finance 51, 85–110.
Busse, J.A., 2001. Another look at mutual fund tournaments. Journal of Financial and Quantitative Analysis 36, 52–73.
Chen, H.L., Pennacchi, G.G., 2009. Does prior performance affect a mutual fund's choice of risk? Theory and further empirical evidence. Journal of Financial and Quantitative Analysis 44, 745–775.
Chevalier, J., Ellison, G., 1997. Risk taking by mutual funds as a response to incentives. Journal of Political Economy 105, 1167–1200.
Cullen, G., Gasbarro, D., Monroe, G.S., 2010. Mutual fund trades and the value of contradictory private information. Journal of Banking and Finance 34, 378–387.
Elton, E.J., Gruber, M.J., Blake, C.R., Krasny, Y., Ozelge, S., 2010. The effect of holdings data frequency on conclusions about mutual fund behavior. Journal of Banking and Finance 34, 912–922.
Goriaev, A., Nijman, T.E., Werker, B.J.M., 2005. Yet another look at mutual fund tournaments. Journal of Empirical Finance 12, 127–137.
Huang, J., Sialm, C., Zhang, H., 2009. Risk Shifting and Mutual Fund Performance. <http://ssrn.com/abstract=1108734>.
Kempf, A., Ruenzi, S., Thiele, T., 2009. Employment risk, compensation incentives, and managerial risk taking: evidence from the mutual fund industry. Journal of Financial Economics 92, 92–108.
Koski, J.L., Pontiff, J., 1999. How are derivatives used? Evidence from the mutual fund industry. Journal of Finance 54, 791–816.
Schwarz, C.G., 2009. Mutual fund tournaments: The sorting bias and new evidence. <http://ssrn.com/abstract=1155098>.
Taylor, J., 2003. Risk-taking behavior in mutual fund tournaments. Journal of Economic Behavior & Organization 50, 373–383.