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Style rotation and performance persistence of mutual funds

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Abstract

Most academic studies on performance persistence in monthly mutual fund returns do not find evidence for timing skills of fund managers. Furthermore, realized returns are undoubtedly driven by the investment style of a fund. We propose a new holdings-based measure of style rotation to investigate the relation between performance persistence and changes in style. For a large sample of U.S. domestic equity mutual funds we find that top and bottom performing decile portfolios, sorted on past one-year returns and risk-adjusted excess performance from a 4-factor model, are subject to a higher degree of style rotation than middle deciles. Style inconsistent funds with high values for the style rotation measure in turn exhibit less persistence in decile rankings over subsequent years than style consistent funds. Hence, it is important for delegated portfolio management to consider style rotation when selecting managers based on past performance.

Keywords: mutual fund, performance persistence, style rotation.

JEL Classification: G11, G20

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1. Introduction

Most studies on performance persistence conclude that, on average, fund managers lack market or style timing skills. Examples are Kon (1983), Chang and Lewellen (1993), Coggin, Fabozzi, and Rahman (1993), and Daniel, Grinblatt, Titmann and Wermers (1997). An exception is the analysis of daily returns by Bollen and Busse (2001) that provides some evidence of timing skills. Not only do changes in style fail to provide superior risk-adjusted returns but they also pose a major challenge for an investor who delegates portfolio management. We define a new measure of style rotation based on the history of Morningstar Style Box coordinates. In contrast to style rotation (or style drift) measures using return-based style analysis or tracking error, this methodology is based on the characteristics of reported portfolio holdings. Thus, instead of estimating changes in the allocation to stocks of different style from returns, we infer style and style changes from the fundamental portfolio characteristics.

We apply our new holdings-based measure to study the relation between fund performance and style rotation. The advantage of our new measure is that we no longer infer the degree of style rotation from the same return history that is used to evaluate fund performance. For a large sample of U.S. domestic equity mutual funds we first establish that funds with superior relative excess returns tend to be more subject to style rotation. In a first step, we rank funds into deciles based on past returns net of management fees and risk-adjusted excess returns from a 4-factor model and find that the average style rotation measure of top and bottom deciles are significantly larger (two to four times) than for middle deciles. In a second step, instead of evaluating past returns, we observe changes in decile rankings over two subsequent time windows. The results provide

evidence that, except for the extreme deciles, the dispersion in decile rankings over two subsequent periods is higher for funds with high style rotation measures. Moreover, style inconsistent funds are more likely to switch between top and bottom deciles than style consistent funds.

The good news for an investor trying to pick a skilled mutual fund manager is that there appears to be a higher degree of persistence among style consistent funds. On the downside, a substantial number of top performing funds are subject to a high degree of style rotation. For delegated portfolio management, our analysis implies that an investor needs to take into account style rotation when picking managers based on past performance. Otherwise, he may end up with a style inconsistent fund that no longer aligns with his broader asset allocation and future returns might show big swings in relative performance rankings.

The remainder of the paper is organized as follows. We first introduce our holdings-based style rotation measure and compare it to alternative measures. Two examples motivate the choice of our measure. Next, we introduce the sample of U.S. domestic equity mutual funds and summarize the evidence on how style rotation is related to fund characteristics and style. The main section studies the impact of style rotation on performance and performance persistence. Finally, we draw some conclusions for delegated portfolio management.

2. Measuring Style Rotation

We propose a new holdings-based style rotation measure to analyze the performance persistence of fund managers. Alternative return-based measures compare fund returns to the returns of an index, style benchmark, or a set of characteristics-based portfolios such as the size and book-to-market deciles of Fama and French (1993) or the sorts on momentum in Carhart (1997). The new holdings-based measure relies on the fundamental characteristics of the stock positions in the fund portfolio instead of estimating these characteristics from returns. These underlying fund portfolio characteristics are computed by Morningstar to assign funds to the nine investment styles in the Morningstar Style Box. After describing the computation of the new style rotation measure we use two examples to illustrate the differences and value added compared to existing indicators of style rotation.

A New Holdings-Based Style Rotation Measure

The Morningstar Style Box has been developed to provide investors with a visual tool for analyzing funds. The Style Box has two dimensions. The vertical axis quantifies the average firm size of the fund's stock positions. The horizontal axis measures the combined value and growth score. Morningstar computes the value score using price-to-projected earnings, price-to-book, price-to-sales, price-to-cash flow, and dividend yields. Growth is determined by growth in long-term projected earnings, book value, sales, cash flow and historical earnings. Note that the two components projected earnings and projected earnings growth are forward looking. The details with respect to the weighting

of the size and value-growth scores and their transformation into Style Box coordinates can be found in Morningstar (2004).[2]

The two dimensions size and value-growth are well founded in the academic literature. The price-earnings and size effects discovered by Basu (1977) and Banz (1981) are incorporated in the three-factor model of Fama and French (1992, 1993). Chan, Chen, and Lakonishok (2002) conclude that size and book-to-market describe well the style of mutual funds.

Instead of directly interpreting the coordinates of a fund, Morningstar simplifies the classification further by defining nine size/value-growth squares in the Style Box. To give some insight into style rotation, Morningstar's web site contains also the history of style box assignments over the past few years.

The new holdings-based measure we propose in this paper uses the exact Style Box coordinates provided by Morningstar. We compute the determinant of the covariance matrix of the quarterly size and value-growth scores of the fund, i.e. the product of the variances for the size and value-growth scores minus the square of the covariance between the size and value-growth scores. We normalize the determinant by dividing by 100,000 to get numbers that typically range between 0 and 5. A high style rotation measure means that the fund manager tries to improve fund performance by rebalancing the portfolio weights in favor of stocks with other characteristics along the size and/or value-growth dimensions. A small score indicates that the fund manager sticks to his

[2] Morningstar normalizes the raw size and value-growth scores to a scale from -100 to 400. The graphical illustration of the Style Box further trims the very rare values of funds below 0 and above 300 and shows only this area.

current style. When comparing style consistency of funds over a longer time period, the measure could be implemented using a (e.g. three-year) rolling window.

Alternative Measures

The proposed rotation measure based on Morningstar Style Box coordinates differs from traditional return-based style rotation measures. Tracking error measures the standard deviation of the differences between the fund returns and the returns on a benchmark portfolio. The benchmark can be defined as a predetermined stock market index, such as the S&P 500, or a style benchmark.

Sharpe's (1992) return-based style analysis uses a set of benchmark indices, such as the Russell style indices, and determines the loadings on each of the benchmark indices. The R^2 from the return-based style analysis can be interpreted as the fraction of the variation in fund returns that is attributed to its style, and $[1 - R^2]$ may serve as a measure of style consistency as in Brown and Harlow (2002).

Alternatively, the loadings on the benchmark indices in the return-based style analysis are recalculated using a rolling window (a three-year window is a common choice). Those time-dependent loadings can be used to compute tracking error or to determine style benchmark turnover. Style benchmark turnover estimates how much rebalancing is required to replicate the loadings on the style benchmark indices that change over time.[3] As is the case with simple portfolio turnover, a fund may have a high benchmark turnover

[3] The style benchmark turnover sums the differences in the loadings of the coefficients when shifting a three-year rolling window through time and divides the sum of those differences by two to avoid double counting.

and remain style consistent by picking stocks with similar characteristics and moving constantly within a relatively limited area around its declared investment style. However, the same portfolio turnover could occur with a fund that slowly drifts away from its declared fund objective. For the same reason, our measure is also not based on average quarterly changes in the size and value-growth scores.

Idzorek and Bertsch (2004) provide a critique of tracking error and style benchmark turnover as a measure of style rotation and propose an alternative measure called style drift score. This score requires a return-based style analysis for a rolling window. Then, for each style benchmark index *k* (for $k = 1$ to K) of the return-based style analysis the variance of its loadings, c_k, over time (from $t = 1$ to T) is computed. Denoting this variance as σ_k^2, the style drift score is defined as the square root of the sum over these variances.

$$\text{Style Drift Score} = \sqrt{\sum_{k=1}^{K} \sigma_k^2}, \text{ where } \sigma_k^2 = \text{Variance}\{c_{k,1}, c_{k,2}, \dots, c_{k,T}\}$$

Our style rotation measure differs from this style drift score as it is a holdings-based instead of a return-based measure. The advantage is that any change that pushes the borders of the size and value-growth ranges has an immediate effect.

Examples

The prospectus of the Dodge & Cox Stock fund (ticker DODGX), established in 1965, describes the investment objective as "the fund seeks long-term growth of principal and income. Under normal circumstances, the Fund will invest at least 80% of its total assets

in common stocks including those securities of foreign issuers included in the S&P 500." The fund compares its returns to the S&P 500 and has outperformed the index over the past 1, 5, and 10 years.[4] However, the S&P 500 explains only 64.3% of the variation in the monthly returns of the fund over the data period June 1999 to December 2005. Using Sharpe's (1992) return-based style analysis with the 3-month Treasury bills and the four style indices Russell 1000 Value, Russell 1000 Growth, Russell 2000 Value, and Russell 2000 Growth as the asset classes, the R^2 with the style benchmark increases to 88.7%. The tracking errors relative to the S&P 500 and this style benchmark are 9.2% and 4.9%, respectively. Still, the fund has a low annual expense ratio with an average of 0.54% over the sample period, moderate annual turnover ratios between 8% and 32%, and average quarterly changes along the two dimensions size (an average change in size score of 5.4) and value-growth (6.6) that compare to the median quarterly changes of all funds in our sample.

The seemingly conflicting evidence of relatively high tracking error and low turnover is explained by the steady style drift away from the fund's initial style. The value of the rotation measure (0.66) ranks among the top 15% in our sample of U.S. equity mutual funds. In March 2001, Morningstar changed the fund's style box classification from medium growth to large growth, and in December 2005 to large blend. The top graph of Figure 1 shows the quarterly coordinates within the Morningstar Style Box and the return-based style analysis using a 36-months rolling window. For comparison purposes, we include the S&P 500 and Russell 1000 Value indices.[5] Not surprisingly, the Vanguard

[4] "Dodge & Cox Funds Prospectus," www.dodgeandcox.com, p.11.

[5] In Figures 1 and 2, we approximate the style rotation of the Russell 1000 Value, the S&P 500, and the Russell 2000 Growth portfolios by the returns of the Evergreen Market

500 Index fund that we use to approximate the style changes of the S&P 500 shows little movements and has a very low style rotation measure of 0.008. Table 1 summarizes the style rotation proxies.

[Figure 1 about here]

[Table 1 about here]

The Target Small Capitalization Growth fund (TASGX) "seeks maximum capital appreciation by investing in the common stocks of 'emerging growth' companies. […] Under normal conditions, at least 80% of assets will be invested in common stocks of issuers with market capitalizations of less than $2.5 billion […]." [6] The last column of Table 1 lists again the same fund characteristics and measures of style consistency as before. The tracking error relative to the self-declared benchmark, the Russell 2000 Growth index, is 9.6%. The style benchmark resulting from a return-based style analysis using a 36-months rolling window explains 91.3% of the fund's return variation. The tracking error relative to this style benchmark is 6.3%. Its average quarterly changes in the size score (4.6) and style score (6.8) are similar to the Dodge & Cox Stock fund. However, the annual turnover which ranges from 69% to 239% and the average annual expense ratio of 0.90% are substantially higher. Yet, as the top part of Figure 2 illustrates, the fund sticks closely to its investment style small-cap growth and the latitude of rotation remains limited. Applying return-based style analysis and computing the style drift score of Idzorek and Bertsch (2004) yields 21.8, a value almost twice as large as the 12.1 for

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Index Value fund, the Vanguard 500 Index fund, and the Vanguard Small Cap Growth Index fund.

[6] "Prospectus: The Target Portfolio Trust," www.prudential.com, p. 4.

the Dodge & Cox Stock fund. Also the benchmark turnover of 11.8% exceeds the one of the Dodge & Cox Stock fund of 5.2%. The style benchmark turnover, which measures how much rebalancing is necessary to achieve the weights of the asset classes in the style benchmark, is also roughly twice as large (11.8 versus 5.2). However, the fund oscillates around its declared fund style and the rotation measure is indeed much lower at 0.03.

[Figure 2 about here]

These two examples illustrate that traditional measures of deviations from an index or style benchmark may fail to capture the degree of style rotation.

3. Sample Description

Morningstar introduced the current 10-factor model to assess the coordinates within the Morningstar Style Box in May 2002.[7] Morningstar provides data on the coordinates for U.S. equity mutual funds back to June 1999. Thus, we use the period from June 1999 to December 2005 to compute our holdings-based style rotation measure. Some funds have complete time series of Style Box coordinates on a monthly basis. At the beginning of the dataset, however, most funds report their holdings on a quarterly basis to Morningstar. Therefore, the frequency we choose is quarterly, which is also motivated by the fact that

[7] The initial Morningstar model, introduced in 1992, determined the value-growth coordinate from the two ratios price-to-earnings and price-to-book alone. Similarly, the Lipper classification methodology for U.S. diversified equity funds computes style (L-measure) from price-to-earnings ratios, price-to-book ratios, and three-year sales-per-share growth. For details on the Lipper Classification Methodology see www.lipper.com, "Client Services", Methodologies & Definitions".

the Securities Exchange Commission (SEC) requires mutual funds to file quarterly holdings since May 2004.[8]

For each fund we keep the share class with the earliest inception date and match with the CRSP Survivorship-Free Mutual Fund Database to retrieve monthly returns and fund characteristics such as annual turnover and expenses. We use monthly returns net of management fees from January 1998 to December 2005 to evaluate the performance persistence of managers. We eliminate all funds that have portfolio holdings below $1 million, less than 80% equity holdings, or less than 10 stock positions in any given quarter over the sample period. This reduces the sample from 4,586 to 3,799 funds with total net assets of all funds in existence at the end of 2005 of 3,816 billion. This corresponds to 77.2% of the total market capitalization of U.S. equity mutual funds.[9] When computing the style rotation measure, we further require at least 12 quarterly observations and eliminate funds with more than 4 missing quarters between the beginning of the sample period (or the inception date) and the end of the sample period (or end date of the fund). The sample of funds with a valid style rotation measure contains 2,342 funds with total net assets of 2,751 billion, which corresponds to 55.7% of the U.S. equity mutual funds at the end of 2005, or 68.4% when excluding the 919.58

[8] Effective May 10, 2004, Registered Investment Companies are required to file form N-Q at the end of the first and third fiscal quarter with the Securities Exchange Commission (SEC), in addition to the semi-annual form N-CSR.

[9] The numbers are from Investment Company Institute (2007). Total net assets (TNA) under management by U.S. equity mutual funds are 4,393.75 billion at the end of 2005 (Data Section 1, Table 3), of which 919.58 billion are classified as equity world (Data Section 1, Table 4).

billion classified as equity world.[10] 5.7% of the sample funds are classified as index funds.

Style Rotation and Fund Characteristics

Figure 3 illustrates the average (over time) size and value-growth score of the fund's stock positions in our sample of 3,799 U.S. domestic equity mutual funds. It is evident that the majority of funds are clustered around the S&P 500 index, and to a lesser extent around the Russell 1000 Value and Growth, and the Russell 2000 Value and Growth indices. The same multimodality for this bivariate density remains if we exclude the roughly six percent index funds from the sample. Note that although the size and value-growth coordinates theoretically vary between -100 and 400, almost all the density mass is in the 300 × 300 square. For this reason, the Morningstar Style Box trims both dimensions at 300.

[Figure 3 about here]

Table 2 sorts the 2,342 funds for which we compute a style rotation measure into quintiles by mean size and mean value-growth scores. For every cell in the quintile table we report the number of funds and medians for the number of stock positions, total net assets, turnover, expense ratio, quarterly changes in size and value-growth scores, and our holdings-based style rotation measure.

[10] The number of observations of our sample compares favorably to the recent study on U.S. equity mutual funds by Cremers and Petaijisto (2007).

Expense ratios are slightly higher for the growth categories and for small stock funds. Funds investing in medium size deep growth stocks have the largest expense ratios. Turnover is generally larger for growth stock funds. For example, the funds investing in medium size deep value stocks have a turnover of 119.0% while the median deep growth fund has a turnover of 245.5%.

Funds in the cells giant value (415.5) and very small blend (188.3) hold the largest number of stock positions in their portfolio. The large number of stocks in the giant value category is not surprising since 52 out of the 122 funds are index funds (39% of all the index funds in our sample) and likely a few closet S&P 500 index funds fall into this cell. Hence, the giant value (0.008) and giant blend (0.095) cells have the lowest average style rotation scores because funds track mostly the Russell 1000 Value, MSCI US Prime Market Value, or the S&P 500 index. Similarly, a substantial number of funds in the very small blend cell (0.098) targets the Russell 2000 or MSCI US Small Cap 1750 benchmark indices.

Obviously, there is a positive association between the style rotation measure and the average quarterly changes in size and value-growth scores. However, it happens frequently that for similar average quarterly changes the style rotation measure differs. This is for example the case when the giant deep value funds (Δ size score 5.5, Δ value-growth score 8.5, style rotation 0.239) are compared to the small growth cell (Δ size score 5.2, Δ value-growth score 8.3, style rotation 0.502). A mutual fund can change quite a lot in both dimensions every quarter without being a heavy style rotator as the two examples in the previous section illustrate.

[Table 2 about here]

The scatter plot in Figure 4 further illustrates that our style rotation measure is not directly related to turnover. Funds often exhibit relatively high turnover ratios but still do not strategically shift their style over time. Other funds drift away from their initial style in small increments and keep annual turnover low.

[Figure 4 about here]

4. Style Rotation and Performance Persistence

Next, we apply our holdings-based style rotation measure to explore how fund performance is related to the degree of style rotation. Two major methodologies have been applied in the literature to identify fund managers with superior skill. Either an investor compares the average (risk-adjusted) returns over a long time horizon or she ranks fund managers into quantiles (most often deciles) and evaluates which fund managers persistently rank in top performing quantiles over subsequent time periods. For U.S. domestic equity mutual funds, Hendricks, Patel, and Zeckhauser (1993) and Brown and Goetzmann (1995) document persistence in abnormal one-year returns. Grinblatt and Titman (1992), Elton, Gruber, and Blake (1996), and Carhart (1997) find evidence of persistence at longer horizons.

Our results underline the importance for investors to take into account style rotation when evaluating the performance of fund managers. When looking at average past performance, we find that fund managers ranking in top (and bottom) deciles tend to be

less style consistent. Using the second methodology of comparing decile rankings over two subsequent periods, we find that funds with a high style rotation measure exhibit less persistence in remaining in a given decile ranking when compared to style consistent funds.

Style Rotation and Persistence in Returns

We start by analyzing whether funds with superior performance exhibit a different behavior in terms of style rotation. To sort mutual funds into performance categories we follow the methodology of Hendricks, Patel, and Zeckhauser (1993) and Carhart (1997) and use lagged one-year returns. This will allow us to compare our results and to separate the effect of style rotation. First, at the end of each year, we sort mutual funds into deciles based on the annual mean returns over the past year (formation year). We use reported returns net of operating expenses but before deducting any sales charges. In a second step, we form ten equally-weighted decile portfolios that we hold over the next year and compute their monthly returns. The decile 1 portfolio contains the funds with the biggest annual returns over the past year, and decile 10 the worst performing funds. At the end of each year, we repeat the two steps and combine the monthly returns to obtain a return time series for each decile portfolio from 1999 to 2005. Funds that disappear during the year are included in the portfolio until they exit the data base. The ten monthly time series are then used to estimate the following Carhart (1997) 4-factor model:

$$r_{i,t} = \alpha_i + b_i RMRF_t + s_i SMB_t + h_i HML_t + p_i PR1YR_t + e_{i,t}.$$

RMRF is the excess return of the market portfolio over the risk-free rate. It is computed as the difference between the CRSP (Centre for Research in Security Prices) value-weighted market portfolio (aggregating the returns on all stocks on NYSE, AMEX, and Nasdaq) over the 1-month Treasury bill rate. SMB and HML are the returns on the factor-mimicking portfolios for size and book-to-market as defined by Fama and French (1993). SMB (small minus big) measures the difference in returns between stocks of firms with small and large market capitalizations, where the breakpoint between small and big is the median NYSE market value of equity at year end. HML (high minus low) denotes the difference in the average return of stocks with a high book-to-market minus the average return on low book-to-market stocks. High (low) book-to-market portfolios are formed by the stocks in the top (bottom) 30% of the NYSE stocks. PRlYR is the one-year momentum factor of Carhart (1997). PR1YR quantifies the difference in average returns of recently successful stocks minus the average return of stocks with low returns over the prior 12 months. The data for these four factors are obtained from Kenneth French's web site.[11] The innovation $e_{i,t}$ is that part of the model that cannot be explained by the factors. The fraction of the variance in the decile portfolio returns that can be explained by the 4-factor mode is measured globally by the coefficient of determination R^2.

[Table 3 about here]

Table 3 reports the intercept, the loadings on the four factors, the coefficient of determination R^2, and the median style rotation score for each decile along with the corresponding standard errors in brackets below. For the median alphas and factor

[11] See http://mba.tuck.dartmouth.edu/pages/faculty/ken.french, section "Data Library". The site also provides further details on the construction of the factor returns.

loadings we draw similar conclusions as Carhart (1997) for our sample period from 1999 to 2005. Out-of-sample 4-factor alphas do not exhibit any persistence and, in our results, even the median monthly alpha for the bottom decile funds (0.18% for decile 10) is not significantly different from the median for top decile funds (0.22% for decile 1).[12] Thus, risk-adjusted returns can mostly be explained by the exposure to the four factors market risk, size, book-to-market, and momentum.[13] The loadings on the market excess return RMRF are close to one, the values for SMB are substantially higher for the top deciles, and the top decile fund returns are positively correlated with the one-year momentum factor PR1YR (0.41 for the decile 1) while the bottom decile fund returns are negatively correlated (-0.38 for decile 10). Compared to Carhart's (1997) results the factor loadings for HML are slightly higher.[14] The R^2 of the regressions range from 0.84 to 0.98.

Our main focus is on the median holdings-based rotation measure reported in the last column of Table 3. The top and bottom decile portfolios show substantially higher median style rotation measures than the middle deciles. The median style rotation of the top decile 1 of 0.69 with a standard error of 0.10 is statistically significantly different from the median deciles 2-9 at the 5% level. Similarly, the worst performing funds in decile 10 exhibit a median style rotation score (0.78) that is also significantly different (at the 5% level) from deciles 2-9. The order of magnitude of the median style rotation score

[12] The difference in alphas between decile 1 and decile 10 over the formation years (in-sample) ranges from 2.60% to 4.55% p.a. and the values are significantly different at the 1% level in all periods.

[13] These results compare to Table III (page 64) in Carhart (1997). He reports a significant difference at the 5% level between the alphas of deciles 1 and 10. However, the difference is almost entirely driven by the lowest performing funds (decile 10). When comparing the alphas of deciles 1 and 9 the difference is not statistically significant. More specifically, he reports an average return difference of 29 basis points per month and 20 basis points is the difference between the bottom deciles 9 and 10.

[14] The differences range from 0.02 for decile 1 to 0.30 for decile 9.

of top performing funds (decile 1) relative to the values of average performing funds (deciles 3-8) is two to three times. The same observation holds for the funds with the lowest performance.[15] In conclusion, the performance of funds which ranked in top (and bottom) deciles sorted on the previous year's returns can mostly be explained by exposure to factor risk (as shown previously in the literature), but in addition these funds are subject to a higher degree of style inconsistency.

Next, instead of ranking funds based on their lagged one-year returns net of operating expenses, we sort funds into deciles based on alpha estimates from the Carhart (1997) 4-factor model. The alphas are computed as the intercept from the 4-factor regression over the past three years (we require a minimum of 30 monthly observations to be included in the sample). As before, we rank funds at the end of each year, this time based on the average risk-adjusted excess returns measured by alpha, and hold the equally-weighted decile portfolios for one year. Then, we form one series of monthly returns for each decile. Table 4 reports the 4-factor regression results for these decile portfolios together with the median rotation measure. While the negative relation between loadings on the momentum factor and decile ranking becomes weaker, the median style rotation score is still pronounced in the top and bottom deciles. The median style rotation of top performing funds in decile 1 (0.63) is statistically significantly different (at the 5% level) from the median style rotation of all deciles except the bottom funds in decile 10. The average degree of style rotation for decile 10 (0.54) is significantly different from deciles

[15] To make sure that this result is not driven by index funds we repeat the same decile portfolio exercise without index funds. We find the same nonlinear relationship between decile ranking and median style rotation score.

4-9. Hence, the finding that the average style rotation of top and bottom performing decile portfolios exceeds the middle deciles holds independent of whether funds are sorted on lagged one-year reported returns or risk-adjusted excess returns.

[Table 4 about here]

Style Rotation and Persistence in Rankings

So far, we have analyzed the relation of style rotation and fund returns (net of management fees and risk-adjusted) over several years. An alternative methodology that has been proposed to study performance persistence is to compare decile rankings over two subsequent time windows. We compare the change in rankings of average returns and risk-adjusted excess returns over subsequent one-year and two-year windows during our sample period 1998 to 2005. As our ultimate goal is to study the impact of style rotation on the analysis of performance persistence we then split the sample of funds in two parts: Funds with a style rotation measure above the median and relatively style consistent funds with a value below the median of the full sample. We introduce a simple statistic to test for differences between the two subsamples.

At the end of each year we sort funds into deciles based on their annual performance. We then compare the decile rankings over two subsequent years to observe whether a fund ranked in decile i in the previous year, say the top decile $i = 1$, remains in decile $j = 1$ over the next year. We construct a contingency table that shows the transition probabilities that a fund ranks in decile j next year (subsequent ranking) conditional on the ranking in decile i over the previous year (initial ranking). The bar chart in Figure 5

illustrates the conditional probabilities of all possible pairs (subsequent rankings | initial ranking) over two subsequent years. The top graph plotting funds with above median style rotation measures compares to the finding by Carhart (1997). There is evidence for persistence among top and bottom performing funds over two years, the phenomena coined by Hendrick, Patel, and Zeckhauser (1993) as "hot hands" and "icy hands". At the same time, funds that switch between the two extreme deciles are also frequent. The picture changes for style consistent funds with a low rotation measure in Panel B. A much larger fraction of funds is clustered along the diagonal axis indicating funds that remain in the same decile over two subsequent years. Thus, it appears that once style inconsistent funds are discarded the persistence in fund returns increases.

[Figure 5 about here]

We formally assess the relation between style rotation and performance persistence by testing, for each of the ten deciles separately, if funds with high style rotation measures on average deviate more from their initial ranking than funds with low style rotation. To do this, we compute absolute deviations from the initial ranking for the two style rotation categories and form a student like test statistic, as defined in Table 5. This test statistic is asymptotically normally distributed under the null hypothesis, a result that we use given the large number of observations per decile.[16] An investor is particularly concerned about funds that are ranked in a low performing decile and remain in those deciles over the next

[16] The number of observations per decile ranges from 127 (in the case of returns over two years) to 829 (one-year returns). For this type of test, the number of observations is sufficiently large (more than 20-30 observations) to use the asymptotic distribution. For smaller samples this test can be implemented by bootstrapping critical values.

period and funds that rank in top deciles initially but drop down to lower deciles in the subsequent period.

To allow a direct comparison to the findings of Carhart (1997), Figure 5 plots the conditional transition probabilities for the decile rankings based on average reported returns over two subsequent one-year periods. We repeat the analysis for two-year windows and for risk-adjusted excess returns computed as the alpha from the 4-factor regression. Table 5 reports the mean absolute changes in rankings and the statistic that tests whether for a given initial decile ranking the dispersion of high style rotation funds exceeds the dispersion of low style rotation funds. The column headings in the top line describe the criteria used to rank funds: (1) one-year average returns, (2) one-year alphas, (3) two-year average returns, and (4) alphas over two-year periods.

[Table 5 about here]

When we consider one-year reported returns net of management fees, as in Figure 5 and Carhart (1997), we find that in 5 out of 10 deciles (deciles 3, 5-7, and 9) the dispersion in rankings for high style rotation funds is significantly larger than for low style rotation funds at the 1% level. In addition, the differences for deciles 4 and 8 are statistically significant at the 5% level. The differences are amplified if we consider the ranking of returns over two subsequent two-year windows. In this case, all deciles from 1 to 8, except decile 4, are significant at least at the 5% level. Moreover, the lack of higher dispersion for high style rotation funds for initial decile rankings 9 and 10 is not good news either for an investor. If a fund is initially ranked in a bottom performing decile then a higher dispersion is preferable as it would mean a higher probability to move up to

a higher decile in the next period. When considering risk-adjusted excess returns, i.e. alphas from the Carhart (1997) 4-factor model, the higher dispersion for high style rotation funds is no longer statistically significant for the two top deciles 1 and 2. However, the differences in dispersion observed for middle deciles 3-7 are significant at the 1% level. For two-year windows the difference in the persistence in alphas between high and low style rotators fades away, however, at this time horizon also the overall performance persistence vanishes.

Our findings on persistence in returns and rankings are robust to various specifications of the style rotation measure. In addition to using the determinant of the covariance matrix between the size and value-growth scores, we also implemented the length of the diagonal of the rectangle that the fund spans with its size and value-growth scores over a given time period, and the norm that adds the size and value-growth ranges.

5. Conclusions

We propose a new style rotation measure that is based on the characteristics of fund portfolio holdings. The measure relies on the exact quarterly coordinates in the Morningstar Style Box that span the two dimensions size and value-growth to characterize the style of the funds' stock positions. This holdings-based style rotation measure is ideally suited to analyze the impact of style rotation on performance persistence as we no longer rely on a measure that uses the same fund return history to infer the degree of style rotation that we already use to evaluate fund performance. We first establish that the average style rotation measure of top and bottom performing U.S.

domestic equity mutual funds is significantly larger than for funds with average performance in the past. Second, we show that the patterns in fund rankings sorted on past performance are affected by style rotation. We find that funds with lower style rotation show a higher degree of persistency in returns net of management fees and in risk-adjusted performance. In particular, funds characterized by high style rotation measures are over-represented among funds that switch between extreme deciles from one period to the next. These findings suggest two implications for delegated portfolio management. First, there appears to be a trade-off between foregoing some of the top performing funds and avoiding style rotators. An investor chasing past performance might end up with a style inconsistent portfolio. Second, investing in funds with a high degree of style rotation may result in disappointments over subsequent periods as large changes in relative performance are more frequent among funds with high style rotation measures. The evidence of our analysis should caution the investor not to rely on past fund performance alone but to incorporate style rotation when selecting fund managers.

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Table 1: Fund characteristics and measures of style consistency.

Measure	Dodge & Cox Stock	Target Small Capitalization Growth
Declared benchmark	S&P 500	Russell 2000 Growth
Annual turnover	8-32%	69-239%
Average expense ratio	0.54%	0.90%
R^2 with declared benchmark	64.3%	87.8%
R^2 with style benchmark	88.7%	91.3%
Tracking error with declared benchmark	9.2%	9.6%
Tracking error with style benchmark	4.9%	6.3%
Style benchmark turnover	5.2%	11.8%
Style drift score	12.1	21.8
Average quarterly change in size score	5.4	4.6
Average quarterly change in value-growth score	6.6	6.8
Style rotation measure	0.66	0.03

Table 2: Summary statistics for size and value-growth quintiles.

Fund characteristics		Deep value	Value	Blend	Growth	Deep growth
# funds	Giant	17	122	110	125	26
# stock positions		63.5	415.5	101.2	74.1	53.5
TNA		1.1	3.0	2.6	2.3	1.3
Turnover		52.0%	61.3%	66.2%	83.6%	80.7%
Expense ratio		1.2%	0.7%	1.1%	1.2%	1.3%
Δ size score		5.5	3.0	4.8	5.3	6.0
Δ value-growth score		8.5	3.9	6.3	6.9	8.4
Style rotation		0.239	0.008	0.095	0.129	0.249
# funds	Large	160	99	102	112	69
# stock positions		80.2	103.0	100.0	69.8	62.2
TNA		2.0	2.9	1.7	2.2	1.1
Turnover		97.8%	67.8%	71.7%	117.0%	145.5%
Expense ratio		1.1%	1.1%	1.1%	1.3%	1.3%
Δ size score		4.9	5.0	5.5	6.2	6.0
Δ value-growth score		6.9	6.4	6.4	8.2	9.2
Style rotation		0.279	0.208	0.167	0.332	0.308
# funds	Medium	127	81	80	59	111
# stock positions		77.5	60.9	80.9	72.0	64.7
TNA		2.2	1.8	1.7	1.6	1.6
Turnover		119.0%	76.0%	121.6%	126.9%	245.5%
Expense ratio		1.3%	1.3%	1.2%	1.3%	1.6%
Δ size score		5.9	6.5	6.7	7.4	9.8
Δ value-growth score		7.3	7.3	7.2	8.6	11.2
Style rotation		0.609	0.338	0.430	0.611	1.244
# funds	Small	88	89	67	68	168
# stock positions		58.3	83.2	122.0	87.1	80.3
TNA		1.2	1.7	1.3	1.5	1.5
Turnover		126.5%	96.3%	138.5%	193.0%	160.1%
Expense ratio		1.3%	1.5%	1.2%	1.3%	1.5%
Δ size score		4.8	4.7	4.8	5.2	6.8
Δ value-growth score		7.7	6.5	6.9	8.3	9.5
Style rotation		0.448	0.261	0.242	0.502	0.606
# funds	Very small	56	92	97	98	119
# stock positions		94.4	114.5	188.3	103.9	95.8
TNA		1.4	2.0	1.9	1.7	1.5
Turnover		67.9%	94.6%	95.4%	144.1%	139.6%
Expense ratio		1.3%	1.4%	1.2%	1.4%	1.5%
Δ size score		4.2	4.1	3.8	4.7	5.1
Δ value-growth score		3.1	6.1	5.9	8.2	8.1
Style rotation		0.429	0.123	0.098	0.318	0.196

[Caption to Table 2]

The table reports medians for all variables. TNA: Total net assets (measured in billions of dollars). Δ size score and Δ value-growth score: average quarterly changes in size and value-growth scores. # stock positions, TNA, turnover, expense ratio, Δ size score, and Δ value-growth score for individual funds are computed as an average over the sample period from June 1999 to December 2005. To be included in the dataset funds need to have in all periods more than 80 % of investment in stocks, TNA larger than 1 million, the number of stocks larger than 10, and at least 12 quarterly observations. Total number of funds: 2,342.

Table 3: Factor loadings along with the median rotation measure for decile portfolios sorted on the previous year's mean returns.

Alpha is estimated as the intercept of the Carhart (1997) 4-factor model, where the four factors are the market excess return RMRF, the small minus big portfolio SMB, the high minus low book-to-market portfolio HML, and the one-year momentum factor PR1YR. Standard errors are in brackets below the coefficient estimates. The column "Median Rotation" shows the median holdings-based rotation measure.

Decile	Alpha	RMRF	SMB	HML	PR1YR	R-Squares	Median Rotation
1	0.22%	1.09	0.57	-0.07	0.41	0.91	0.69
	(0.27)	(0.07)	(0.07)	(0.08)	(0.04)		(0.10)
2	0.16%	1.02	0.45	0.10	0.24	0.94	0.38
	(0.17)	(0.04)	(0.04)	(0.05)	(0.03)		(0.04)
3	0.18%	1.01	0.27	0.18	0.10	0.96	0.35
	(0.11)	(0.03)	(0.03)	(0.03)	(0.02)		(0.03)
4	0.21%	1.02	0.14	0.17	0.06	0.98	0.33
	(0.09)	(0.02)	(0.02)	(0.03)	(0.01)		(0.01)
5	0.17%	0.98	0.04	0.17	0.00	0.98	0.26
	(0.08)	(0.02)	(0.02)	(0.02)	(0.01)		(0.03)
6	0.14%	0.97	0.01	0.13	-0.04	0.98	0.19
	(0.09)	(0.02)	(0.02)	(0.03)	(0.01)		(0.03)
7	0.16%	0.95	0.03	0.15	-0.07	0.95	0.23
	(0.12)	(0.03)	(0.03)	(0.03)	(0.02)		(0.03)
8	0.14%	0.92	0.00	0.17	-0.12	0.92	0.31
	(0.18)	(0.04)	(0.05)	(0.05)	(0.03)		(0.02)
9	0.17%	0.94	0.02	0.20	-0.20	0.87	0.45
	(0.24)	(0.06)	(0.06)	(0.07)	(0.04)		(0.04)
10	0.18%	1.05	0.10	0.14	-0.38	0.84	0.78
	(0.36)	(0.09)	(0.09)	(0.11)	(0.06)		(0.09)

Table 4: Factor loadings along with the median rotation measure for decile portfolios sorted on alpha.

Alpha is estimated as the intercept of the Carhart (1997) 4-factor model, where the four factors are the market excess return RMRF, the small minus big portfolio SMB, the high minus low book-to-market portfolio HML, and the one-year momentum factor PR1YR. Standard errors are in brackets below the coefficient estimates. The column "Median Rotation" shows the median holdings-based rotation measure.

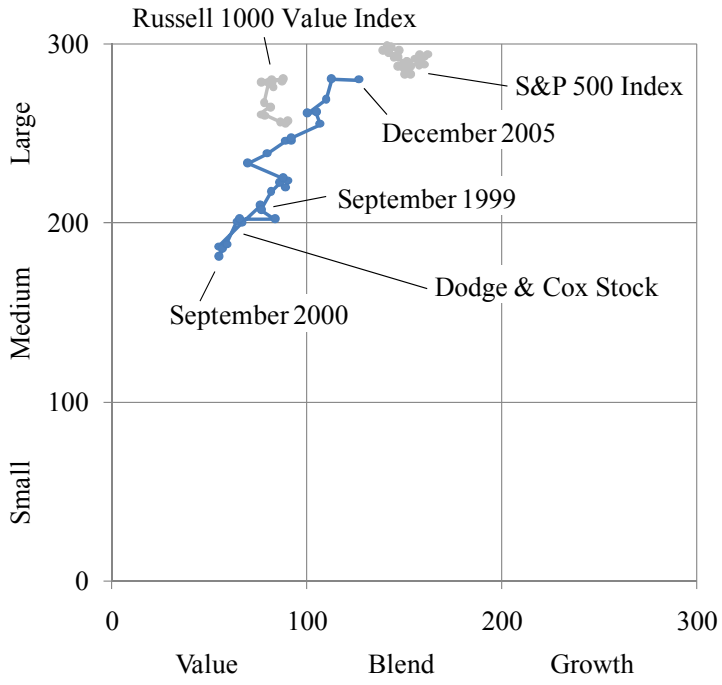
Decile	Alpha	RMRF	SMB	HML	PR1YR	R-Squares	Median Rotation
1	0.15%	1.22	0.40	-0.28	0.10	0.94	0.63
	(0.23)	(0.06)	(0.06)	(0.07)	(0.04)		(0.08)
2	0.12%	1.08	0.28	0.02	0.07	0.97	0.34
	(0.12)	(0.03)	(0.03)	(0.04)	(0.02)		(0.04)
3	0.13%	1.04	0.21	0.07	0.04	0.98	0.36
	(0.10)	(0.03)	(0.03)	(0.03)	(0.02)		(0.03)
4	0.14%	1.00	0.15	0.13	0.01	0.98	0.31
	(0.09)	(0.02)	(0.02)	(0.03)	(0.01)		(0.03)
5	0.16%	0.96	0.08	0.18	-0.02	0.98	0.26
	(0.08)	(0.02)	(0.02)	(0.03)	(0.02)		(0.02)
6	0.18%	0.96	0.09	0.21	-0.01	0.97	0.26
	(0.10)	(0.02)	(0.02)	(0.03)	(0.02)		(0.02)
7	0.14%	0.92	0.06	0.24	-0.02	0.96	0.29
	(0.11)	(0.03)	(0.03)	(0.03)	(0.02)		(0.02)
8	0.19%	0.90	0.08	0.28	-0.03	0.93	0.29
	(0.10)	(0.03)	(0.03)	(0.04)	(0.02)		(0.02)
9	0.22%	0.91	0.06	0.25	-0.03	0.93	0.28
	(0.14)	(0.04)	(0.04)	(0.04)	(0.02)		(0.03)
10	0.22%	0.92	0.16	0.29	-0.04	0.87	0.54
	(0.20)	(0.05)	(0.05)	(0.06)	(0.03)		(0.09)

Table 5: Dispersion in the in decile rankings over two subsequent periods.

The columns headed "Low" and "High" report the mean absolute deviation in rankings from one period to the next. The statistic given by $\frac{mean(high) - mean(low)}{\sqrt{variance(high) + variance(low)} \times \sqrt{1/n(high) + 1/n(low)}}$ tests whether the dispersion is higher for funds with a high degree of style rotation relative to funds with low style rotation. The statistic is asymptotically normally distributed. *, **, and *** indicate statistical significance from a one-sided test at the 10%, 5%, and 1% level, respectively.

Decile	1-year returns			1-year alphas			2-year returns			2-year alphas		
	Low	High	Test	Low	High	Test	Low	High	Test	Low	High	Test
1	3.36	3.51	0.50	3.92	3.00	-2.64	2.31	3.81	3.03***	3.86	4.04	0.36
2	2.95	3.08	0.59	3.52	3.47	-0.21	2.44	3.17	2.24**	3.75	3.64	-0.32
3	2.41	2.88	2.77***	2.70	3.13	2.47***	2.30	2.88	2.14**	3.18	3.21	0.11
4	2.19	2.41	1.74**	2.33	2.80	3.50***	2.29	2.26	-0.19	2.53	2.72	1.01
5	1.96	2.57	5.92***	2.17	2.56	3.44***	1.61	2.32	4.43***	2.23	2.72	2.98***
6	1.88	2.35	4.54***	2.10	2.56	4.21***	1.58	2.13	3.61***	2.19	2.52	1.89**
7	2.08	2.42	2.81***	2.33	2.83	3.77***	1.56	2.65	6.15***	2.34	2.52	0.88
8	2.43	2.69	1.69**	2.96	3.00	0.27	2.43	3.06	2.40**	3.18	3.10	-0.31
9	2.69	3.21	2.50***	3.51	3.45	-0.26	2.90	3.14	0.65	3.63	3.49	-0.47
10	3.79	3.76	-0.11	3.64	3.92	0.92	3.81	3.68	-0.20	4.34	4.30	-0.09

Figure 1: Morningstar Style Box coordinates and return-based style analysis for the Dodge & Cox Stock fund.



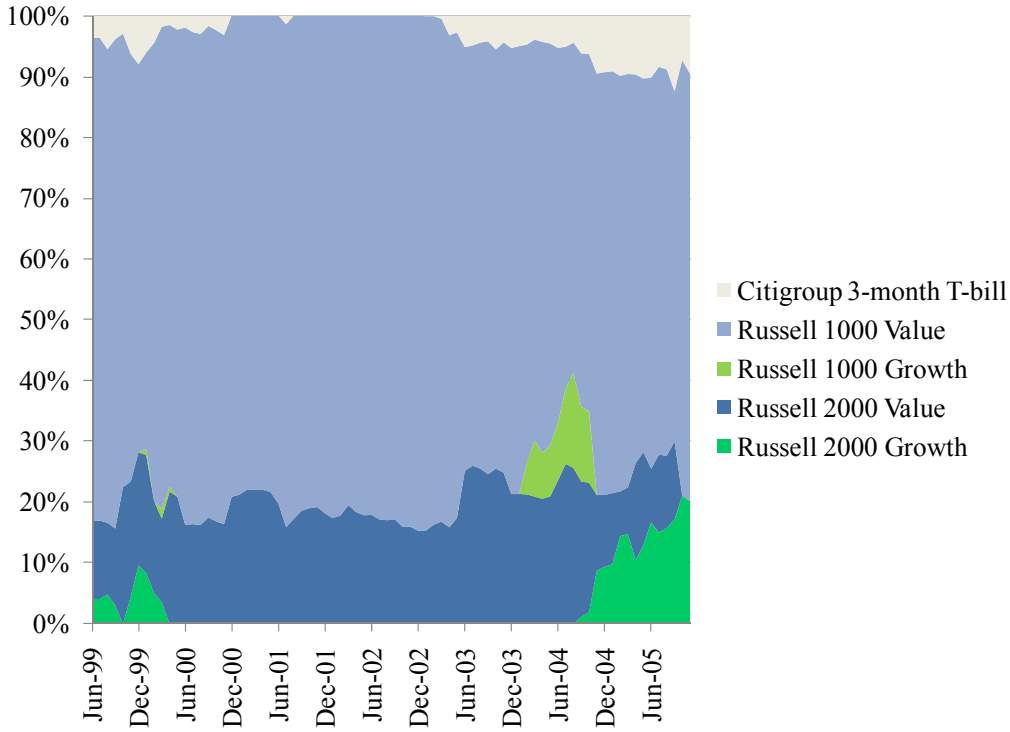
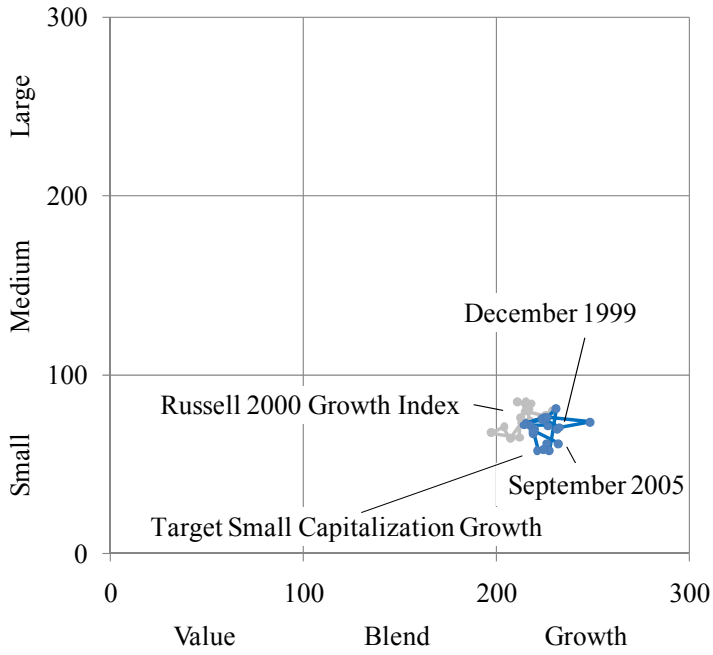


Figure 2: Morningstar Style Box coordinates and return-based style analysis for the Target Small Capitalization Growth fund.



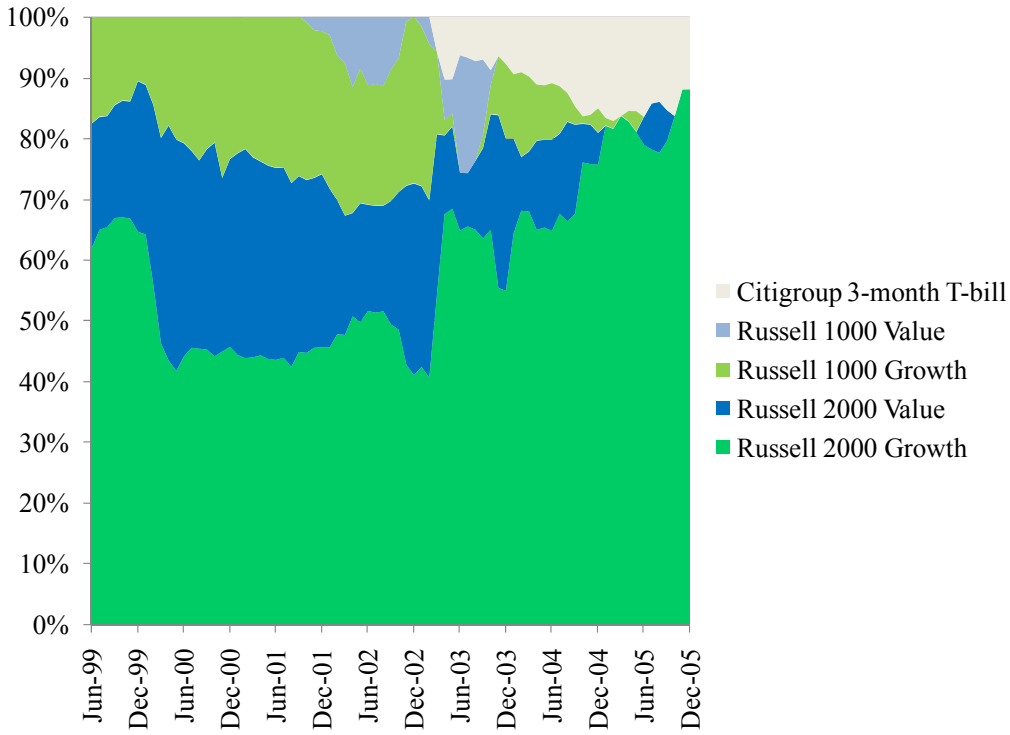


Figure 3: Size and value-growth kernel density estimate.

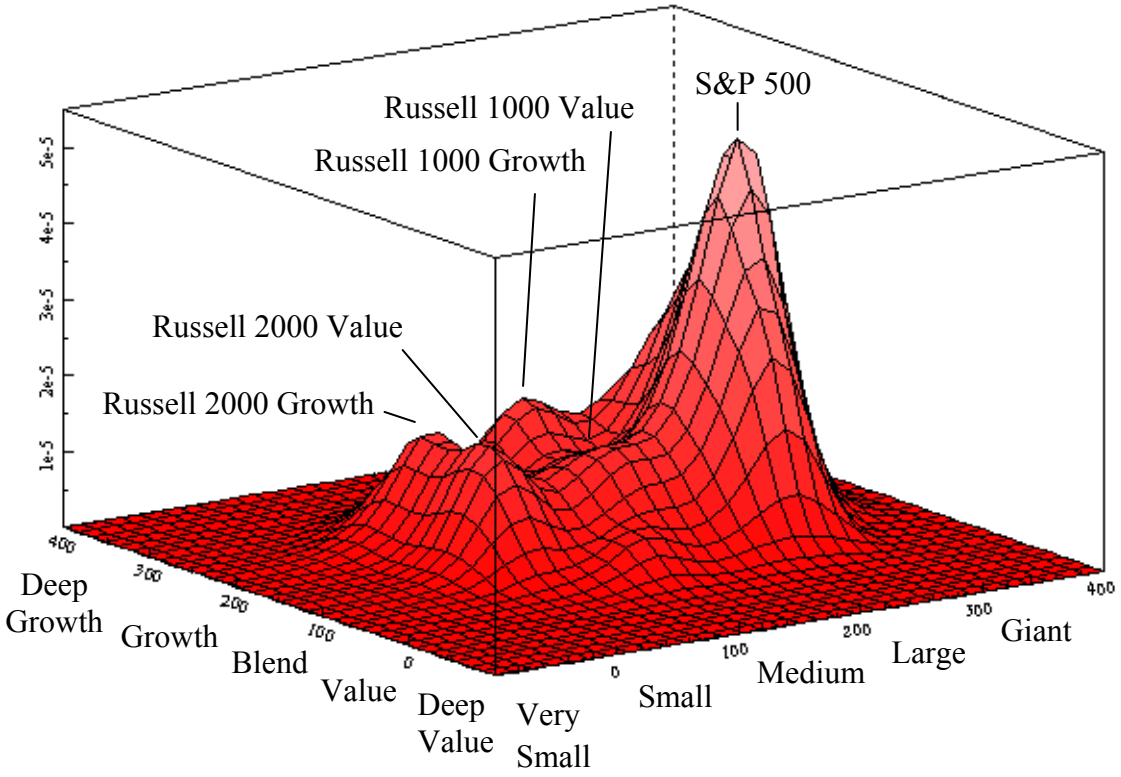


Figure 4: Style rotation versus turnover.

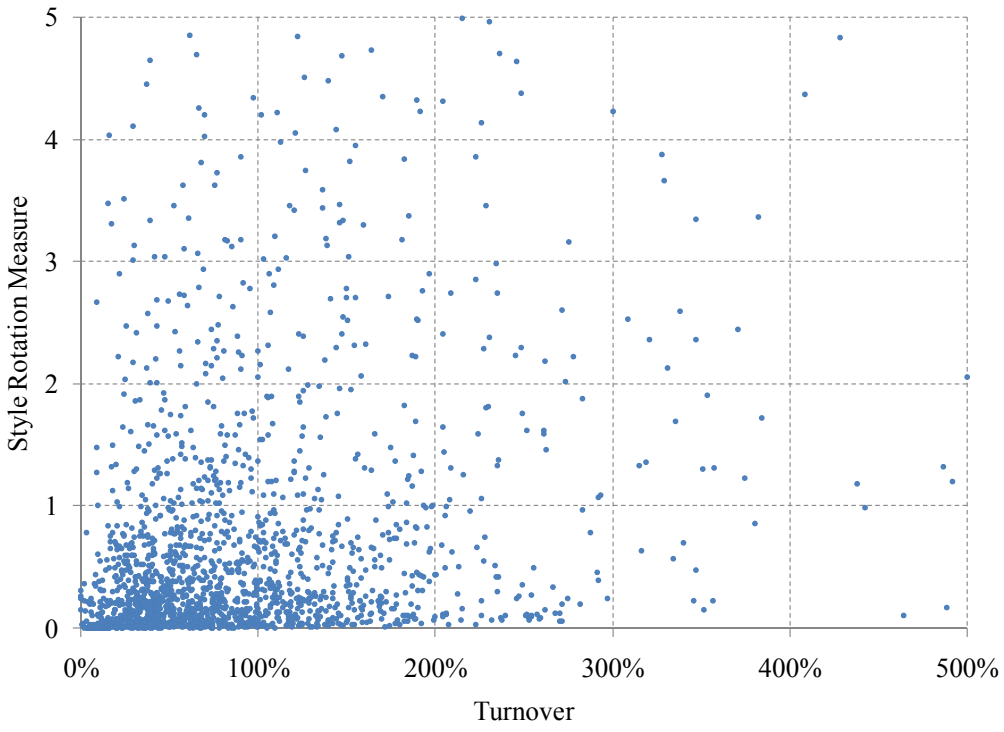
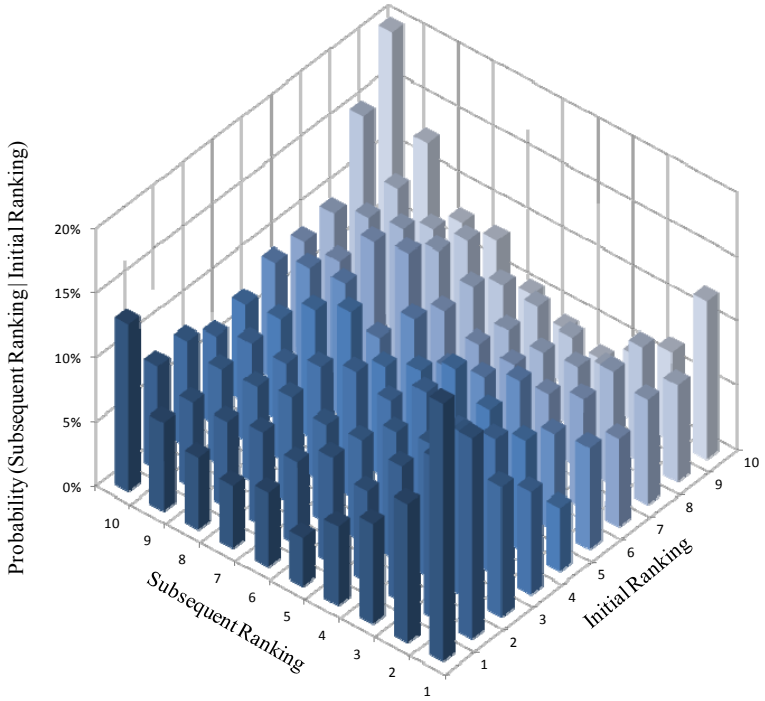
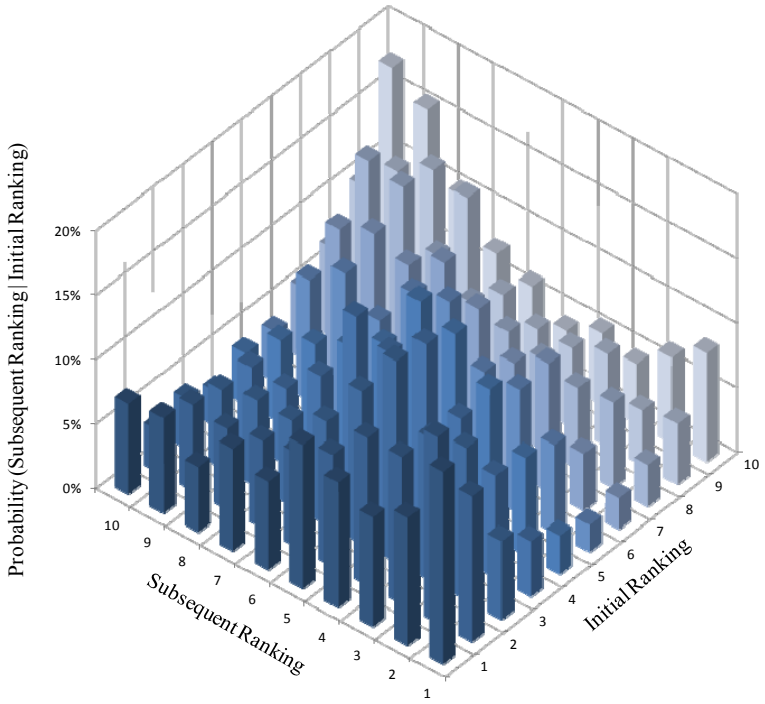


Figure 5: Transition probabilities for performance deciles over one year.

A: Funds with an above median rotation measure.



B: Funds with a below median rotation measure.



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