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Abstract

Capacity constraints limit the profits of some investment strategies, while other strategies are more scalable. We develop a dollar-weighted return measure that parses the factor timing by investors and a strategy's capacity constraints. We find that actively managed funds exhibit significant capacity and timing effects, while index funds display only timing effects. A portfolio's liquidity, investment style, and distribution policy are important in explaining variation in capacity constraints. The analysis demonstrates that capacity and timing effects are important in analyzing portfolio manager skill and the cost of active investing.

1. Introduction

Active portfolio management is a search for alpha in which the portfolio manager seeks to identify investment opportunities that more than compensate for their risks. To generate alpha in a portfolio is to exploit a "mispricing" through the lens of theoretical equilibrium models. Indeed, one tenet of most economic equilibrium models is that the profit-seeking actions of market participants compete away these abnormal profit opportunities. In this sense, there is an implied capacity constraint to any active portfolio management strategy: as more dollars seek out the same alpha-generating opportunities, those opportunities are depleted. This paper empirically examines the existence and nature of capacity constraints in active portfolio management.

Open-end mutual funds present an opportunity to examine potential capacity constraints because investors have the ability to add to or withdraw cash from the fund throughout the fund's existence. We begin by observing that the reported returns of an open-end mutual fund generally differ from the realized returns that each shareholder experiences during their investment period in the fund. This difference arises from two primary sources. First, a "timing" effect results from the factor timing of the individual shareholder's investment (or disinvestment) in the fund shares. Second, a "capacity" effect arises from the return the fund is able to earn on the incremental dollar investment in the fund's underlying strategy. In this sense, a fund's return can be considered a function of the underlying return-generating technology (i.e., the portfolio manager's "skill") and the interaction of capacity constraints inherent in the return-generating technology with the size of the assets employing that technology.

We derive a dollar-weighted average performance measure as a means to decompose the impact of the size of assets under management on fund performance into timing and capacity effects. In the model, the timing component reflects any correlation in the timing of fund flows and the realizations of a multi-factor model of expected fund returns. After controlling for timing, any residual difference represents a fund-specific effect arising from the correlation of flows and the underlying active strategy's "alpha." If managers fall short of their benchmark returns when exposed to flow, then we interpret this as an impact of capacity constraints in active portfolio management.

Relying on a database of open-end domestic equity mutual funds, we show that both capacity and timing effects are economically significant and distinct drivers of performance, averaging negative impacts of 50 and 70 basis points, respectively, per year across the sample. Variation in capacity effects is driven by investment style and the capitalization of the active strategy's underlying holdings. Fund policies which encourage or inhibit flows also matter. Front-end loads suppress both timing and capacity effects. Management fees (excluding 12b-1) are significant in explaining capacity, while marketing fees (12b-1) explain timing. Passively managed funds (i.e., index funds) display only the timing effect of fund flows; they show no significant capacity effects.

This paper is structured as follows: Section 2 motivates the analysis and reviews the related literature. Section 3 develops a methodology to parse the difference between dollar-weighted return and time-weighted returns into timing and capacity components. Section 4 describes the data and empirical methods, while Section 5 presents the results for the timing and capacity effects and cross-sectional analysis. Section 6 offers a summary and conclusions.

II. Background and review of existing literature

Capacity constraints in active portfolio management are commonly accepted to exist in practice, but they are not directly examined in the extant literature. Instead, prior empirical research has focused on the role of liquidity costs and the scale economies of fund operations rather than the capacity constraints of alpha-generating technologies. The branch of the literature that focuses on the liquidity cost aspect of flows argues that flow is costly to investors' performance because their flows are essentially "poorly timed" (Braverman, Kandel, and Wohl, 2005; Frazzini and Lamont, 2008) or their flows lower the funds' returns by causing the fund's managers to engage in costly transactions (Edelen, 1999; Dubofsky, 2010; Rakowski, 2010). Similarly, transaction costs are the focus of the diseconomies of scale in Edelen, Evans, and Kadlec (2008), where larger fund size is associated with lower performance through the increased trading costs associated with the fund having to use larger trade sizes. Chen, et al. (2004) find that mutual fund performance deteriorates with increases in fund size, but associate these scale diseconomies with fund management and fund sponsor operational characteristics and cost structures.

Berk and Green (2004) propose a rational model of the capital market where funds flow to opportunities and perceived managerial skill. Through a fund sponsor's marketing efforts, they are able to attract flows to their funds with good performance track records. However, as more assets are attracted to investments with limited capacity, the alpha-generating performance does not persist. Thus, their model leads to both poor observed timing on the part of fund investors, as well as negative capacity effects in active portfolio management. Our analysis provides new empirical evidence for both of these effects. Although prior empirical studies provide some evidence that is consistent with Berk and Green (2004), we are the first to investigate the issue in a setting that separates the timing and capacity components of fund flows and measure both effects simultaneously.

Our paper further differs from the existing empirical studies of fund size and fund performance in several key respects. First, we are interested in the capacity for an active investment strategy to generate value, not just the marginal impact of transaction costs arising from fund flows. Capacity constraints transcend transaction costs and liquidity issues arising from fund flows. For example, flows out of a fund are potentially degrading to performance due to their transaction costs, but should benefit the fund's performance by moving it farther from its strategy's capacity constraint. Second, instead of examining the scalability of fund operations, we focus on the scalability of the underlying investment strategy by associating capacity effects with the characteristics of the underlying assets of the investment strategy. Finally, our analysis suggests that it is important to decompose the relationship between fund returns and fund size into timing effects of flows and capacity effects. Fund sponsor policies, such as marketing and distribution policies can be associated with both timing and capacity effects, while the characteristics of the investment strategy's underlying assets should be associated only with capacity effects. Such decomposition can refine the assessment of portfolio manager skill (Wermers, 2000).

3. Time-weighted return vs. dollar-weighted return

This section develops a method to measure dollar-weighted average returns in a manner where we may estimate the impact of the timing and capacity effects of fund flow on performance. The dollar-weighted average return uses weights that reflect the cumulative percentage change in the size of the fund due only to fund flows. One particularly desirable property of the dollar-weighted average return measure is that it is equal to the traditional time-weighted average return in the absence of any flows to the fund.

1.1. Calculation of average returns

Consider a portfolio ("fund") with assets of A_{t-1} at the end of period *t*-1 and the beginning of period *t*. Suppose that these assets experience a rate of return of r_t over period *t*. Average returns to a portfolio or fund from time 1 to time *t* are given by:

$$\bar{r} = \sum_{t=1}^{T} w_t \times r_t \, , \tag{1}$$

where w_t is the weight applied to each period's return in the average return calculation. Because all equations are fund-specific, we exclude a fund-specific subscript when possible without a loss of clarity. A fund's time-weighted average return employs equal weights, where $w_t = \frac{1}{T}$ for all *t*, so that the time-weighted average fund return is:

$$TWA = \sum_{t=1}^{T} \frac{1}{T} \times r_t = \frac{1}{T} \sum_{t=1}^{T} r_t \, . \tag{2}$$

By equally weighting each period's returns, the time-weighted average does not reflect the interaction, if any, between the size of a portfolio and the portfolio's returns. A dollar-weighted return allows the examination of this potential interaction. One method for dollar-weighting is to use unadjusted total net assets as each period's weights. However, this approach does not distinguish changes in fund size due to fund returns from changes in fund size due to fund flows. Indeed, this approach would result in a dollar-weighted average return that is different than the time-weighted average return even for a passive portfolio that has zero fund flows.

Our analysis focuses on capacity and timing effects due to flows. Therefore, we isolate the impact of flows by adjusting the weights each period by the change in assets due only to flows as follows. Consider a flow of f_t into (or out of) the fund at the end of period *t*. In percentage terms, the fund has increased in size due to flows by:

$$\phi_t = \frac{f_t}{A_{t-1}\left(1+r_t\right)}. \tag{3}$$

For our dollar-weighted average return calculation, we use the previous period's percentage flow to adjust the weight that is applied to each period's return. To do so, consider $\hat{w}_t$ to be the non-normalized dollar weight in period *t*. Setting the initial non-normalized weight arbitrarily to one, we set the remaining periods' non-normalized weights by the percentage flows, so that,

$$\hat{w}_1 = 1$$

$$\hat{w}_t = \hat{w}_{t-1}\left(1+\phi_{t-1}\right), \text{ for } t > 1. \tag{4}$$

We normalize each period's weight so that they sum to one, as given by,

$$w_t = \frac{1}{\sum_{t=1}^{T} \hat{w}_t} \hat{w}_t . \tag{5}$$

Therefore, our dollar-weighted average fund return is:

$$DWA = \frac{1}{\sum_{t=1}^{T} \hat{w}_t} \sum_{t=1}^{T} \hat{w}_t \times r_t . \tag{6}$$

To illustrate the dollar weight calculation, consider a fund that experiences inflows of 20% of the fund's size at the end of the first year and outflows of 10% of the fund's size in the second year. In this case, $\hat{w}_1 = 1.00$, $\hat{w}_2 = 1.20$, and $\hat{w}_3 = 1.08$, so that the dollar-weights are $w_1 = 30.5\%$, $w_2 = 36.5\%$, and $w_3 = 32.9\%$. Compared to the time-weighted average return, returns in periods with larger assets due to flows receive proportionally more weight in the dollar-weighted average return.[1]

Note that if there are no flows to the fund, equations (2) and (6) are identical, yielding equal time- and dollar-weighted average returns. This property makes it possible to compare the dollar-weighted and time-weighted averages and draw conclusions about their differences. Define the total dollar-time difference to be the dollar-weighted average return net of the time-weighted average return, given as:

$$Diff_{Total} = DWA - TWA \,. \tag{7}$$

1.2. Isolating the capacity effect from the timing effects of fund flows

Any non-zero difference in $Diff_{Total}$ is due to two possible consequences of flow: (1) flow is well (poorly) timed such that the $Diff_{Total}$ is greater (less) than zero; and/or (2) flow reveals capacity constraints in active management such that $Diff_{Total}$ is less than zero. Therefore, we must decompose the components of $Diff_{Total}$ in order to assess the sources of any difference between the dollar- and time-weighted average returns.

Consider a fund in which returns are given by an *N*-factor model, where $r_{i,t}$ is the return to the *i*th factor in period *t*,

$$r_t = \alpha_t + \sum_{i=1}^{N} \beta_i r_{i,t} + e_t \,. \tag{8}$$

Note that α_t is written as a function of time (with a subscript *t*). This unconventional notation emphasizes the possibility that the fund's alpha varies through time as the size of the fund varies

[1] We thank the editor, Charles Jones, for suggesting this derivation of our dollar-weighted average return measure and the illustrative example.

through time. That is, if there are capacity constraints or capacity effects, the alpha is not constant through time, but varies conditional on changes in the size of assets under management.

Using the dollar-weights in equation (5) and the factor return model in equation (8), the dollar-weighted arithmetic average for this portfolio can be re-written as,

$$DWA = \sum_{t=1}^{T} w_t \times \alpha_t + \sum_{t=1}^{T} w_t \times \sum_{i=1}^{N} \beta_i r_{i,t} + \sum_{t=1}^{T} w_t \times e_t \ . \tag{9}$$

Using the same dollar-weights from this portfolio, define this portfolio's *benchmark* dollar-weighted average return as:

$$DWA_{Benchmark} = \sum_{t=1}^{T} w_t \times \sum_{i=1}^{N} \beta_i r_{i,t} \ . \tag{10}$$

Similarly, define the benchmark time-weighted average return as:

$$TWA_{Benchmark} = \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{N} \beta_i r_{i,t} \ . \tag{11}$$

The timing effect in flows can be measured by the difference between the dollar- and time-weighted average returns, as given by:

$$Diff_{Timing} = DWA_{Benchmark} - TWA_{Benchmark} \, . \tag{12}$$

Capacity effects can be estimated from the residual of the total dollar-time difference net of the factor benchmark dollar-time difference,

$$Diff_{Capacity} = Diff_{Total} - Diff_{Timing} \ . \tag{13}$$

Equation (13) reduces to:

$$
\begin{aligned}
Diff_{Capacity} &= Diff_{Total} - Diff_{Timing} \\
&= \left[\sum_{t=1}^{T} w_t \times r_t - \frac{1}{T} \sum_{t=1}^{T} r_t \right] - \left[\sum_{t=1}^{T} w_t \times \sum_{i=1}^{N} \beta_i r_{i,t} - \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{N} \beta_i r_{i,t} \right] \\
&= \left[\sum_{t=1}^{T} w_t \times \left(\alpha_t + \sum_{i=1}^{N} \beta_i r_{i,t} + e_t \right) - \frac{1}{T} \sum_{t=1}^{T} \left(\alpha_t + \sum_{i=1}^{N} \beta_i r_{i,t} + e_t \right) \right] \\
&\qquad - \left[\sum_{t=1}^{T} w_t \times \sum_{i=1}^{N} \beta_i r_{i,t} - \frac{1}{T} \sum_{t=1}^{T} \sum_{i=1}^{N} \beta_i r_{i,t} \right] \\
&= \sum_{t=1}^{T} \left(w_t - \frac{1}{T} \right) \times \alpha_t .
\end{aligned} \tag{14}
$$

If there are capacity effects, these would be reflected in the covariance between the fund's size at the beginning of period *t* and α_t, resulting in a non-zero difference between the dollar- and time-weighted average α_t and/or e_t.[2]

We assume that capacity constraints are revealed by changes in assets due only to flows. For example, if a fund's assets increase or decrease in size due to flow, we would consider the possibility of capacity effects. However, because we use flow-adjusted dollar-weights in our calculation of the dollar-weighted average, we have assumed no capacity effects when a fund increases or decreases in size due to returns on its existing asset base. This allows our analysis to focus only on the changes in fund size driven by fund flows, and provides an important distinction between our model and related methods such as the calculation of a fund's IRR (Dichev, 2007; Friesen and Sapp, 2007). Note that, if there are no flows, then $Diff_{Timing}$ and $Diff_{Capacity}$ are both zero (i.e., there are no estimated timing or capacity effects). Similarly, if all differences in the dollar-weighted average (DWA) and time-weighted average (TWA) returns appear in the benchmark returns, then there is only a timing effect and no capacity effect.

[2] We are assuming independence between the error term and the level of assets since we have allowed the alpha to capture scale or capacity effects.

Examples of the calculation of DWA and TWA returns, as well as the parsing into capacity and timing components are provided in Appendix A.

4. Data and methodology

4.1. Data description

4.1.1. Fund analysis: portfolio level

We rely on the CRSP Survivorship Free Mutual Fund (CRSP) database to collect data on fund returns and characteristics. The fund characteristics that we include are turnover, cash holdings, ICDI investment objective, and total net assets (TNA). We require funds to have at least 60 contiguous months of returns. Though monthly TNA data do not occur consistently within the database until 1991, most funds have at least two TNA observations per year prior to 1991, occurring semi-annually. Rather than discarding these funds, we calculate the missing monthly observations based on the return of the fund, assuming zero flows between the reported monthly TNA observations.[3] Turnover and Cash holdings are averages of monthly, quarterly, or annual observations over each five-year period. We group domestic equity funds by their ICDI investment objective. In order to examine the impact of active management on returns, we classify all passively managed index funds as a separate category, using the index fund indicator from the Morningstar Principia Pro database. In order to focus on funds that hold only equity securities appropriate to our factor model, we limit our analysis to equity funds classified as Aggressive Growth, Growth & Income, or Long-term Growth. The ICDI code first appears in 1992. Therefore, for funds that exist until 1992 and receive an ICDI code at that time, we assign the 1992 code to all prior observation of that fund. Funds that exist only before 1992 are discarded.

[3] We repeat all analysis using only post-1991 data on monthly flows and obtain similar results.

Since any analysis of capacity applies at the portfolio level, rather than the fund class level, we initially aggregate observations from multiple share classes of the same portfolio. Because we wish to capture any effects arising with changes in fund size and age over our sample period, we use a panel data set of non-overlapping "fund-periods" in which one observation is calculated for each fund over each 60-month period. Therefore, for a fund that appears for two 60-month periods, the first month of the second fund-period is 60 months after the first month of the first fund-period. We have a total of 2,139 unique funds (portfolios) and 3,582 fund-periods in our sample. Our sample data begin in the first quarter of 1979.[4] A fund remains in the sample until it ceases to exist or is merged into a new fund. Our data end in December 2006. We require a full 60 months of data for each portfolio-period, and therefore the latest a fund could have entered our sample is December 2001. The average fund enters our sample in June 1997. A fund is eligible for our sample on the first month in which its TNA reach \$10 million. The TNA may drop below \$10 million in subsequent months and the fund will remain in our sample. However, a fund that never reaches \$10 million or that does not exist for five years beyond that point is not represented in our sample.[5] Flows are computed by using ending net assets minus return-adjusted beginning net assets and then expressed as percentages of return-adjusted beginning net assets, as in equation (3).

Table 1 reports cross-sectional descriptive statistics regarding the TNA, age, flow, turnover, and cash holdings of each portfolio-period in our sample, organized by investment

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[4] The data on fund returns is available as far back as 1962, but the additional variables used in our analysis extend only to 1979. When our calculations of $Diff_{Total}$ are extended back to 1962 we continue to find similar results.

[5] In retaining funds in our sample we include the most recent data first, as these observations are more likely to have valid data. This results in the elimination of the first years of fund operation for most funds because there are unlikely to be an exact number of 60-month observations. Because DWA and TWA returns differences are driven by younger funds, the elimination of funds' first years biases us against finding differences in DWA and TWA returns.

objectives. The average (median) age of a fund when it enters our sample is 16.0 years (11.0 years). As can be seen in the difference between the number of portfolios and the number of portfolio-periods, the average fund remains in our sample for about 1.5 portfolio periods, or about 7.5 years. The average (median) fund size in our sample is $1.31 billion ($270 million). The average (median) size at the beginning of each portfolio period is $964 million ($177 million).

*** Insert Table 1 about here ***

4.1.2. Fund analysis: fund portfolio and share class level

We next merge several variables from the Morningstar Principia database with our sample to obtain additional data related to a fund's portfolio holdings. In particular, we examine market capitalization and style. Our sample size is decreased because these additional Morningstar variables do not match perfectly with our CRSP sample, and we only have access to Morningstar data back to year 1991. There are 2,330 fund-periods that have valid data from both Morningstar and CRSP over our sample period. From Morningstar we collect an indicator of a fund's portfolio allocation based on market capitalization (small-cap, mid-cap, large-cap) and value versus growth (value, core, growth). The Morningstar "equity style box" assigns funds to a three-by-three matrix based on these two dimensions.

We then disaggregate our merged sample by share class. This allows us to incorporate data from CRSP on expenses (marketing and management fees), share class type (retail or institutional), and distribution (front-end and deferred loads) that differ across classes of the same fund. In this analysis, share classes are now each treated as individual funds, giving us 4,623 observations.

4.2. Methodology

We calculate the time-weighted and dollar-weighted average returns using equations (2) and (6), respectively, and their differences using equation (7). In order to decompose the difference between the dollar- and time-weighted average returns into timing and capacity effects, we build on the empirical factor model of Fama and French (1993), with additional factors developed by Carhart (1997) and Sadka (2006). The factors are size (SMB), value (HML), market (RM-RF), momentum (MOM), and liquidity (LIQ).[6] We estimate the coefficients of the regression,

$$r_t = \alpha_t + \beta_{RM} RM_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{MOM} MOM_t + \beta_{LIQ} LIQ_t + e_t \qquad (15)$$

We re-estimate the factor loadings for each fund every 60-months.[7]

We summarize the regression results in Table 2. The model explains an average (median) of 88.6% (90.8%) of the variation in returns across all objectives. For each fund, we calculate its benchmark return for each month based on the coefficients (estimated over each five-year portfolio-period) and the actual factor returns. Because our benchmark indices are computed solely from our sample data and estimated factor loadings, any differences between DWA and TWA can safely be attributed to time-variation within our sample returns and not to misassumptions about the relationship between our data and an exogenous index return (Chen, Ferson, and Peters, 2006). Based on the factor loadings from this model, we compute the "benchmark" expected returns for each fund in the absence of any influence arising from

[6] The size (SMB), value (HML), market (RM-Rf), and momentum (MOM), factors are drawn from Ken French's website. The market return is the excess market return above the risk-free rate. The liquidity factor (LIQ) is the level of market liquidity as computed by Sadka (2006) and is downloaded via the WRDS database. Additional liquidity factors are examined in Section 5.

[7] Our results remain similar if we estimate the factor loadings over the entire sample period for each fund.

capacity effects. As indicated in equations (9) through (13), the benchmark dollar-weighted average return reflects any "market timing" aspect of flows, while the residual from the difference of the total difference net of the timing effect reflects the "capacity" aspect of flows.

*** Insert Table 2 about here ***

We examine the determinants of the difference and its components by associating the effects with potential explanatory variables. Therefore, we run a panel regression including variables for the size (*SIZE*) of the fund at the beginning of the five-year period, and the fund's age at the end of each five -year period (*AGE*). To examine the impact of trading by the fund manager, we include the fund's average turnover ratio (*TURN*) and the percentage of cash holdings (*CASH*). The opportunity to switch to another fund with low switching costs is measured by *FAMILY*, the number of funds in the fund's family (not including the current fund). In order to correct for the non-normality of our data, all variables mentioned above are measured by their quintile rankings.

Dummy variables are included for index funds and aggressive growth funds. We control year fixed effects by including the year at the beginning of the fund-period (*YEAR*). Because fund flows are indirectly used in the computation of our dependent variables, we do not include them in the regression model.

Our model takes the form:

$$Diff_{i,t} = \gamma_0 + \gamma_1\, SIZE_{i,t} + \gamma_2\, TURN_{i,t} + \gamma_3\, CASH_{i,t} + \gamma_4\, FAMILY_{i,t} + \gamma_5\, AGE_{i,t} + \gamma_6\, YEAR_{i,t} + \gamma_7 Agg.Growth + \gamma_8 Index + \varepsilon_{i,t}. \quad (16)$$

We estimate the model for two dependent variables: the capacity component ($Diff_{Capacity}$), and the component due to timing effects ($Diff_{Timing}$). The analysis is repeated after merging with Morningstar, with the Aggressive Growth and Index indicators replaced with indicators from the

Morningstar equity style box: small-cap, large-cap, value, and growth. We use the market capitalization of the fund's underlying holdings as a proxy for the liquidity of those holdings. We then disaggregate by share class, incorporating variables for management (advisory) fees, marketing (12b-1) fees, as well as indicators for the existence of front or deferred loads. Our expanded model takes the form:

$$Diff_{i,t} = \gamma_0 + \gamma_1\, SIZE_{i,t} + \gamma_2\, TURN_{i,t} + \gamma_3\, CASH_{i,t} + \gamma_4\, FAMILY_{i,t} + \gamma_5\, AGE_{i,t}$$
$$+ \gamma_6\, YEAR_{i,t} + \gamma_7\, SmallCap_{i,t} + \gamma_8\, LargeCap_{i,t} + \gamma_9\, Value_{i,t} + \gamma_{10}\, Growth_{i,t}$$
$$+ \gamma_{11}\, Deferred\ Load_{i,t} + \gamma_{12}\, Front\ Load_{i,t} + \gamma_{13}\, 12b\text{-}1\ Fees_{i,t} + \gamma_{14}\, Mgt\ Fees_{i,t} + \varepsilon_{i,t}. \qquad (17)$$

5. Dollar-weighted and time-weighted returns

5.1. Components of the differences in dollar and time-weighted average returns

For the entire sample, the TWA monthly return is 0.80% compared to a DWA monthly return of 0.70%. In simple annualized terms, the dollar- and time-weighted returns are 8.42% and 9.62%, respectively. Time-weighted returns are therefore about 14% greater than dollar-weighted returns, which is clearly economically significant, as providers of investment research on funds are beginning to recognize.[8] Table 3 reports the overall differences in DWA and TWA monthly returns across all funds in our sample, according to investment objective. Our estimates for $Diff_{Total}$ are also consistent with other studies that attempt to compute dollar-weighted returns,

[8] See Morningstar Introduces New Investor Return Data to Capture How the Average Investor Fared in a Fund over a Period of Time: CHICAGO, Oct. 5, 2006 - Morningstar, Inc., a leading provider of independent investment research, today announced it is providing new data for open-end mutual funds and exchange-traded funds to capture how the average investor fared in a fund over a period of time. The new measure, called Morningstar(r) Investor Return(tm), estimates the return earned collectively by all the investors in a fund. Investor return, also known as dollar-weighted return, accounts for all cash inflows and outflows from purchases and sales and the growth in fund assets. It complements the more traditional metric of total return, which measures what investors could have earned had they bought and held the fund, reinvesting all dividends, over a period of time.

such as Friesen and Sapp (2007). Table 3 shows that $Diff_{Total}$ is not driven by a few large outliers. Over 65% of funds in the sample have a negative $Diff_{Total}$.

*** Insert Table 3 about here ***

The average DWA is significantly less than the average TWA in every investment objective, with the exception of Index funds, where the difference is insignificantly different from zero. However, the magnitude of the difference varies across investment objectives. The average difference for aggressive growth funds is much greater than for the other investment objectives.

To examine the timing and capacity effects within the overall differences of DWA and TWA returns, we first compute the benchmark difference returns ($Diff_{Timing}$) using equation (12). $Diff_{Timing}$ estimates the impact due to the timing of flows. The total difference in DWA and TWA return not explained by $Diff_{Timing}$ is due to capacity factors ($Diff_{Capacity}$). Figure 1 shows that capacity effects generally exist in actively managed open-end funds.

*** Insert Figure 1 about here ***

Table 3 also provides the quantitative breakdown of the timing and capacity components of $Diff_{Total}$. Both the capacity ($Diff_{Capacity}$) and timing ($Diff_{Timing}$) effects are significantly less than zero in each category and for the sample at large. For all investment objectives, the magnitude of the timing effect is greater than that of the capacity effect, yet the capacity effect remains statistically significant except for index funds. This suggests that the timing of flows explains most of the difference in DWA and TWA returns, but that capacity issues also exist in active portfolio management.

5.2. Variation in capacity and timing effects across funds

The results of panel regressions for the first model are shown in Table 4. Because DWA returns are less than TWA returns, a negative coefficient estimate implies a greater difference, and therefore a larger capacity or timing component. Many variables act similarly on both the capacity and timing components. We are especially interested in those coefficient estimates that are unique to the capacity component, in order to better understand the characteristics of the fund and its underlying holdings that drive capacity constraints that are distinct from the timing of fund flows.

*** Insert Table 4 about here ***

Table 4 shows that the fund's turnover ratio takes a significant negative coefficient estimate for both capacity and timing components, which is consistent with Edelen, Evans, and Kadlec (2008), and implies that higher turnover is significantly linked to larger capacity constraints and more poorly-timed fund flows. Fund size, cash holdings, and the index fund identifier are significantly related to $Diff_{Capacity}$ but not $Diff_{Timing}$. Larger fund size and greater cash holdings are associated with larger capacity constraints, while index funds face fewer capacity constraints.

The two variables that are significant only for the timing component are the negative coefficient estimate for the size of the fund's family, and the positive estimate for the fund's age.[9] The results are consistent with a larger timing effect resulting from a negative externality of membership in a large fund family. We examine this finding in more detail later, but one

[9] As an alternative to the fund's age, we also examine the tenure of the fund manager for a subset of our funds with this data available. The results for tenure are almost the same as for fund age.

implication is that the relative ease (and benefit) of switching among funds in a family is not without a potential cost due to the poor timing of flows.

5.3. Capacity and timing impacts based on fund portfolio and share class characteristics

Descriptive statistics for share class-level sample data are presented in Table 5, while the corresponding regression results are provided in Table 6. Turnover and family size take similar negative estimates as in our original regressions. Share class size is significantly positively related to the capacity component. We also find that the level of cash holdings is significant in explaining the timing component. Intuitively, a fund manager can reduce exposure to the timing effect of fund flows by holding larger average amounts of cash. Although this may lower the time-weighted returns to the fund, it also decreases the difference between dollar-weighted and time-weighted returns.

Portfolio characteristics are important in explaining both the capacity and timing effects. The market capitalization of the stocks in the fund's portfolio is significantly associated with capacity effects, as large-cap funds face smaller constraints than small-cap funds. Investment style also matters to capacity. Growth funds have significantly negative capacity effects but value funds do not. The findings suggest that capacity has links to two key dimensions of investment strategy — market cap and style. An investment strategy seeking growth from small capitalization companies, for example, tests capacity constraints along both dimensions. The greater capacity constraints related to both liquidity and information in these investment objectives is consistent with evidence documented in recent studies of the performance of managed portfolios (Yan, 2008; Schultz, 2010).

Regarding timing, large-cap funds have significant negative timing effects while small-cap funds do not. Funds with a growth orientation have much more negative timing effects than funds with a value focus. Together, the timing results are consistent with investors' efforts to "chase" returns in funds with large-cap growth strategies.

*** Insert Table 5 about here ***

Management fees (excluding 12b-1) are significant in explaining capacity, while marketing fees (12b-1) explain timing. If management fees proxy for the level of active portfolio management, then the result is consistent with our earlier result for index funds, and indicates that active portfolio management is an important factor in capacity constraints. At the same time, higher 12b-1 fees' link to the poor timing of flows is consistent with marketing that encourages investors to chase hot funds or sectors. The timing result is consistent with the evidence presented by other studies, such as Jain and Wu (2000) and Gallaher, Kaniel, and Starks (2006). Overall, the link between active management, flow environment, and capacity and timing impacts offers insights into understanding the costs of active investing (French, 2008).

The coefficient estimates for front-end loads displayed in Table 6 are significant and positive. This result suggests that the liquidity cost to fund investors from load fees could suppress their flows, and therefore lead to smaller capacity and timing effects. Another interpretation would be that broker advice (as evidenced by the presence of front-end loads), could help investors avoid chasing hot funds or funds with capacity constraints. Overall, these results are consistent with a benefit of broker-mediated distribution, either by suppressing badly timed and capacity-constraining flows, or due to the influence of well-timed broker advice. This could be an example of an intangible broker service that is consistent with recent studies of fund distribution channels (Bergstresser, Chalmers, and Tufano, 2007). Unfortunately, without account-level histories that reveal the exact amount of load fees realized by each investor, we cannot ascertain whether this benefit of load fees is sufficient to recoup the load charge itself.

*** Insert Table 6 about here ***

An alternative method to analyze the impact of a fund's distribution channel is to examine the dollar-weighted performance according to the clientele for each share class. We therefore incorporate the indicator given in the CRSP mutual fund database that specifies if a share class it targeted to retail or institutional investors. Because this indicator is highly correlated with loads and 12b-1 fees, we drop these variables from this section of the analysis. The results (not reported for the sake of brevity) consistently indicate that retail share classes have timing components several times the magnitude of institutional share classes, while the capacity components are virtually identical across classes. In regressions, an indicator for institutional share class takes a significant positive coefficient in explaining the timing component, but not the capacity component, with no major impact on any other variables. This fits well with both intuition and evidence that institutions suffer less from the timing of their capital flows than retail investors (Gompers and Metrick, 2001; Nofsinger and Sias, 2002; Bennett, Sias, and Starks, 2006). In contrast, the lack of any significant difference between retail and institutional classes for the capacity component indicates that the capacity costs imposed on the fund manager are independent of the source of the flow and are more likely the result of the underlying characteristics of the fund's active management strategy.

5.4. Impact of fund family membership on capacity and timing effects

Chen, *et al.* (2004) present evidence that fund performance increases with the size of the fund's family. They argue that membership in a large family leads to economies of scale through savings on commissions and trading costs. In our context, the cost savings they propose might mitigate liquidity or transaction cost-related capacity issues, but are unlikely to mitigate the capacity constraint of alpha-depletion in the underlying active strategy associated with larger assets under management. We do not find any evidence in Tables 4 or 6 that family size impacts capacity constraints in a significant manner.

Our results in Tables 4 and 6 do show, however, that membership in a large fund family is associated with larger timing effects. The reason that a systematically larger timing difference for funds in large families might exist is that investors are often given the option of transferring assets from fund to fund with very low switching costs, providing relative ease of exchange into or out of the family's funds. Our results are consistent with prior studies that show membership in a large family can influence absolute dollar flows to a fund (Nanda, Wang, and Zheng, 2004; Gallaher, Kaniel, and Starks, 2006).

Our findings suggest that a closer examination of family size and fund performance might be necessary. Chen, et al. (2004) link the size of fund family to a fund's (time-weighted average) return. Therefore, it is possible that Chen, et al.'s finding is a result of the larger timing component for funds that are members of large families. Our results indicate that investors may not actually benefit from higher measured time-weighted average returns when in large fund families, as their dollar-weighted average returns tend to be lower.

5.5. Robustness tests

We perform a variety of tests to confirm that our findings are robust to our choice of sample construction, control variables, and regression methods. First, we perform the analysis over the entire sample period, rather than over each five-year period. We also construct each portfolio period starting from the first time-series observation for each fund, rather than building these periods backwards from the last observation for each fund. This does not change our main findings. Similarly, if we use standard errors clustered by year our results do not change. We also obtain similar results when conducting the analysis separately for each decade, as well as for the final 2001-2006 period. This indicates that our results are robust to issues raised with the work of Dichev (2007) by Keswani and Stolin (2008).

Our results are robust to the conversion of all nominal fund returns to real returns (based on the CPIAUCN index from the St. Louis Fed's FRED database). The use of real returns results in both DWA and TWA returns decreasing by about 2.5% per year. However, the TWA-DWA difference remains almost unchanged (1.16% per year for real returns compared to 1.21% for nominal returns), and our regression analysis produces almost identical results when real returns are used. Therefore, it does not appear that correlation between time-varying inflation rates and our flow-driven weights explains our findings.

An alternative method to classify funds' investment objectives and portfolio characteristics is to use our estimated factor loadings as explanatory variables in our regression models. For example, we could use the factor loading for the size factor (SMB) to measure if a fund is more exposed more to the relative returns of small-cap, mid-cap, or large-cap stocks. However the problem is that these factor loadings are strongly correlated with our other explanatory variables, making it difficult to include them all in the same regression model. We therefore re-estimate our regressions with the factor loadings as explanatory variables instead of our Morningstar classification variables.

The coefficient estimates for our factor loadings provide evidence that both components are significantly related to the market factor (*RM-Rf*). However, only the capacity component is significantly related to the size (*SMB*) and liquidity (*LIQ*) factors. The significance of these factors is consistent with our expected contributors to capacity constraints. Likewise, only the timing component is related to the value versus growth (*HML*) factor. Therefore, this factor is related to investor sentiment shifts between growth and value oriented funds.

Because of the importance of the liquidity factor in our interpretation of the capacity component, we also examine additional measures of liquidity for robustness. Our factor for liquidity is based on the level of market liquidity, as computed by Sadka (2006). This captures much of the information present in alternative measures of market liquidity, such as the measure of Pastor and Stambaugh (2003), but is more appropriate for matching to individual funds (Sadka, 2006). An additional proxy for liquidity is the innovation in market liquidity, which can be included in addition to the level of liquidity. When this variable is included in our model it is also significant in explaining the capacity component, taking a similar sign as the variable for the level of liquidity. Because the liquidity innovation does not change our conclusions or essential parameter estimates, we do not report models incorporating it.

In our earlier analysis we do not include variables based on fund flows in our regressions because our dependent variables, $Diff_{Capacity}$ and $Diff_{Timing}$, are themselves indirectly computed from fund flows. This makes a precise interpretation of coefficient estimates for fund flows difficult because larger flows should, by construction, lead to larger values for our dependent variables. Nevertheless, flow variables can still be useful in demonstrating non-linear and asymmetric properties of $Diff_{Capacity}$ and $Diff_{Timing}$. We explore the impact of flows on our model by adding variables for both signed and absolute flows to our regressions. The results are consistent across models and samples, with signed flows taking significant positive coefficients and absolute flows taking significant negative coefficient estimates. Therefore, both the timing and capacity components appear stronger for large and/or negative fund flows. This is consistent with Berk and Green's (2004) model, where investors rationally allocate flows to funds even though they do not appear to earn higher returns, because those flows are themselves influencing the fund's returns.

We include the cash holdings variable in our regression analysis with the intention of capturing the effects that may arise from a fund manager holding cash in response to fund flows. A related concern is that the flows received by the fund each month may influence the factor loadings estimated by equation (8). Specifically, if the fund manager invests new cash (and disinvests cash outflows), then the factor loadings could have a time-varying component that is correlated with flows and, in turn, our dollar weights. We address this by deflating (inflating) each period's factor loadings by the previous period's fund inflows (outflows) up to 50%. Again, this makes very little difference to our results, suggesting that our reported factor loadings are robust in deriving the timing and capacity components for each fund.

A final variation to consider is the use of total net asset dollar-weights to compute DWA returns. As mentioned in Section 3, our DWA measure adjusts each period's weight upward (downward) by the percentage inflow (outflow) in the previous period. We do this in order to restrict ourselves to the analysis of capacity constraints arising from fund flows while avoiding any confounding influence from the appreciation of existing assets under management. However, our analysis can be easily extended to the use weights that are determined by both fund flows and the appreciation of assets under management. This method, the results of which are available in full upon request, lowers the DWA return compared to our flow-adjusted weights approach. The increased difference between TWA and DWA returns results almost entirely in a larger timing component (we find a timing component of -2.42% per year with total net asset weights compared with our reported value of -1.21% with flow-adjusted dollar weights). Unlike the flow-adjusted dollar weights, the total net asset weights present a difficulty in interpreting the results of our regression analysis because variation in the timing component could be driven by either fund flows or the "organic" growth in assets under management. Because the total net asset weights affect only the timing component and have no material effect on the capacity component, we find no evidence that growth in assets under management from returns to existing assets imposes a capacity constraint on the fund.

6. Summary and conclusions

This paper develops a dollar-weighted average return measure that allows the parsing of portfolio returns into timing and capacity components. Our timing component captures the extent to which flows are correlated with the fund's underlying benchmark factor-model returns. The capacity component measures the degree to which the portfolios manager's "alpha" relative to the benchmark index is related to the size of assets deployed in the alpha-generating technology. In actively-managed funds, we find both capacity and timing effects, while passively managed funds display only timing effects.

The capacity effect is related to the liquidity of the fund's holdings and is more negative for funds that are sensitive to market liquidity, such as funds that focus on smaller-capitalization stocks. The timing component is linked to investment style, being more negative for growth as opposed to value funds. Management fees (excluding 12b-1) are significantly related to increased capacity effects, while marketing fees (12b-1) are associated with greater timing effects. In contrast, front-load fees act to suppress both effects, due to either effective broker advice or to the liquidity cost they impose on fund investors.

Our analysis shows that the parsing of timing and capacity effects is critical in understanding how flows and the size of assets under management impact the performance of portfolios and the experience of investors. Capacity constraints in an active strategy influence the performance in both time- and dollar-weighted measures as the assets under management of the strategy change. Our results suggest that biases in estimates of manager skill arise from capacity constraints that are in addition to trading cost or impact cost of flows that are acknowledged in the extant literature.

Our results also shed light on the differences between active and passive (index) portfolio manager performance in that active management faces capacity constraints to alpha-generating technology (French, 2008). Timing effects measure the "passive" component of flow-induced costs. Although this component is determined largely by the actions of fund investors, it can be influenced by a fund sponsor's marketing policies. Our capacity component is a more direct measure of the fund manager's ability to dynamically respond to fund flows. Consistent with this characterization, we find that capacity effects are strongly related to the liquidity of a fund's holdings. Our parsing of the difference between dollar and time-weighted returns provides a useful starting point for any future modeling of fund performance in light of the capacity constraints imposed by fund flows. Further exploration of the forces that drive the behavior of investors is necessary to determine the optimal fund policy for managing the timing of fund flows. Similar to the gains from prior empirical research that decomposes fund performance (Wermers, 2000), our capacity component can be used as the basis for the development of measures of fund manager skill after adjusting for the exogenous actions of fund investors.

Our results suggest that capacity effects transcend the open-end fund vehicle and apply more generally to active portfolio management. That is, even closed-end funds or actively managed separate accounts might be affected if the total assets under management for the strategy's underlying alpha-generating technology have placed the strategy near its capacity constraints. Our analysis shows that flow and capacity policies of a portfolio manager or fund sponsor can affect the performance of a portfolio or its investors. For example, an active fund with flow constraints could have less of a combined effect than a passive fund without flow constraints. Closures of actively-managed funds are consistent with sponsors' recognition of capacity constraints to active management that we have measured.

We also believe that our results can shed light on issues related to "factor- capacity" constraints. In this paper, we find that portfolio strategies that face little or no capacity constraints, such as passive strategies, have differences in dollar- versus time-weighted returns, though they show no average fund-specific capacity effect. While we have interpreted the difference in dollar- and time-weighted returns to a multi-factor benchmark as a "timing" component, we note that this effect could be a market-wide or factor-related capacity constraint. In this case, if the size of assets under management becomes large enough across funds within the same market segment (represented by the same exposure to the benchmark factors), then those asset prices could be bid up to the point that the average returns to those factors are decreased. Given that our focus is on the capacity constraints in the alpha-generating capability of active managers, we have not attempted to distinguish between a "timing" effect and a "factor-capacity" constraint and we leave this issue for future research.

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Figure 1: Timing and capacity components

This figure presents the median capacity and timing components for each investment objective. The capacity component represents the difference between dollar-weighted and time-weighted returns due to the capacity constraints imposed by flow, while the timing component represents the difference between dollar-weighted and time-weighted average returns due to the timing of flows. Components are reported as median annualized percentages for our sample of 3,582 open-end domestic equity mutual funds over 5-year estimation periods from 1979 to 2006.

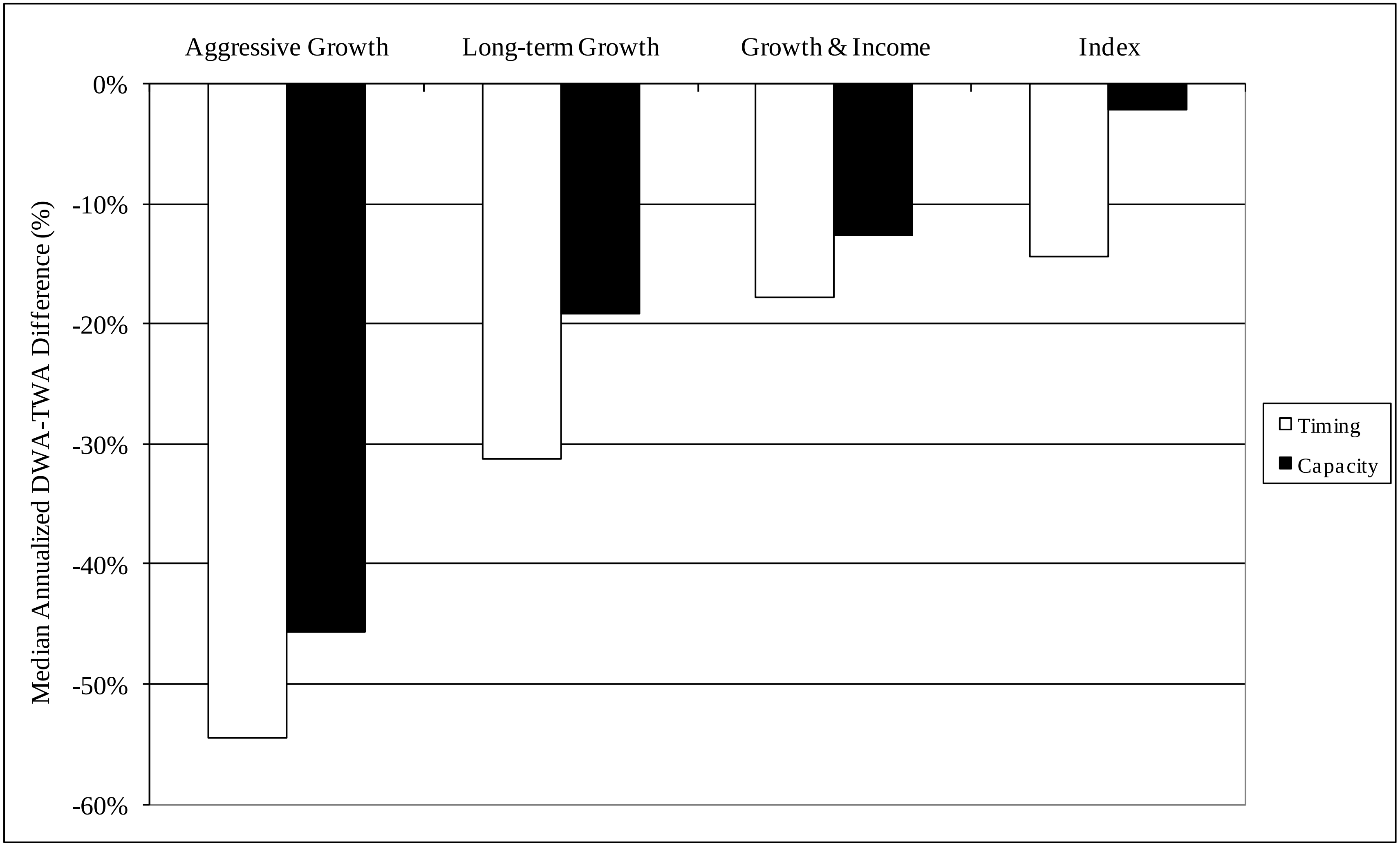

Table 1:
Descriptive statistics

Average statistics (followed by medians in italics) are reported for a sample of 3,582 open-end domestic equity mutual fund portfolio-periods drawn from the CRSP Survivorship Free Mutual Fund database. Each portfolio-period observation is estimated from monthly data over a 5-year period with multiple classes of the sample fund combined to form one portfolio. The sample period of begins January 1979 and ends December 2006. We required each portfolio to have 60 months of contiguous returns data. *Size* is the fund's Total Net Assets in $millions. *Age* is in years, *Flow* (%) is the annual cash flow to the fund each period. *Turnover* is the fund's turnover ratio, as reported by CRSP, and *Cash* is the percentage of the fund's holdings invested in cash and cash equivalents.

	Size		Age		Flow (%)		Turnover (%)		Cash (%)		*N* (portfolio – periods)
Aggressive Growth	706.67	*236.59*	12.90	*10*	93.32%	*2.42%*	123.93%	*90.09%*	7.19%	*4.57%*	1,102
Long-term Growth	1,343.13	*253.38*	16.48	*11*	5.73%	*-0.56%*	112.18%	*73.66%*	4.83%	*3.35%*	1,515
Growth & Income	1,701.85	*292.75*	20.62	*13*	103.91%	*-0.72%*	66.96%	*57.07%*	4.37%	*3.07%*	776
Index	2,993.92	*591.70*	10.39	*9*	20.99%	*10.43%*	20.12%	*11.40%*	2.47%	*1.78%*	189
Full Sample	1,283.14	*253.05*	15.93	*11*	6.84%	*0.02%*	97.72%	*67.18%*	5.52%	*3.60%*	3,582

Table 2:
Benchmark regressions of fund performance

This table presents average coefficient estimates for equity factors in our sample of monthly mutual fund returns. The model is estimated for 3,582 portfolio-periods constructed by aggregating all share classes of each fund over each 5-year period. Share classes are weighted by total assets and we require 60-months of contiguous return data for each portfolio-period. Average *t*-statistics are given in parentheses.

$$r_t = \alpha_t + \beta_{RM} RM_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{MOM} MOM_t + \beta_{LIQ} LIQ_{tt} + e_t$$

	Intercept	*RM*	*SMB*	*HML*	*MOM*	*LIQ*	R^2
Aggressive Growth	0.0689	0.9935	0.6134	0.0220	0.1284	1.8900	85.79%
	(0.2655)	(11.9178)	(6.6336)	(0.5803)	(1.8437)	(0.4878)	
Long-term Growth	0.1906	0.990	0.1068	-0.0418	0.0227	1.0295	88.72%
	(0.8067)	(16.830)	(0.7975)	(-0.2545)	(0.4226)	(0.2922)	
Growth & Income	0.1862	0.9450	-0.0711	0.1385	0.0311	0.2494	91.46%
	(1.3952)	(26.819)	(-2.5966)	(1.8316)	(0.5575)	(0.1013)	
Index	0.0644	1.0004	0.0538	0.0858	0.0539	0.7638	97.86%
	(1.4405)	(74.975)	(-4.5257)	(1.7947)	(1.0559)	(0.2504)	
Full Sample Means	0.1534	0.9342	0.1943	0.0443	0.0605	1.0475	88.64%
	(0.8400)	(18.2224)	(1.4601)	(0.8151)	(0.9888)	(0.2873)	

Table 3:
Capacity and timing effects

This table presents statistics on capacity and timing effects in the differences between dollar-weighted and time-weighted arithmetic average returns. The sample covers 3,582 portfolio-periods constructed by aggregating all share classes of each fund over each 5-year period. Share classes are weighted by total assets and we require 60-months of contiguous return data for each portfolio-period. Figures are simple annualized percentage returns. * and ** indicate significant differences from zero, at the 5% and 1% levels, respectively.

	DWA - TWA Difference ($Diff_{Total}$)				*Capacity Component ($Diff_{Capacity}$)*				*Timing Component ($Diff_{Timing}$)*			
	Mean	*St. Dev.*	*Median*	*% <0*	*Mean*	*St. Dev.*	*Median*	*% <0*	*Mean*	*St. Dev.*	*Median*	*% <0*
Aggressive Growth	-1.79%**	4.24%	-0.95%	74.82%	-0.83%**	1.90%	-0.46%	73.87%	-0.97%**	3.58%	-0.55%	66.33%
Long-term Growth	-1.19%**	3.59%	-0.52%	65.73%	-0.44%**	1.23%	-0.19%	68.58%	-0.75%**	3.18%	-0.31%	59.74%
Growth & Income	-0.61%**	3.01%	-0.32%	59.44%	-0.30%**	1.37%	-0.13%	67.78%	-0.28%**	2.54%	-0.18%	56.70%
Index	-0.47%	2.83%	-0.19%	52.38%	0.02%	0.44%	-0.02%	55.56%	-0.49%**	2.67%	-0.14%	54.50%
Full Sample	-1.21%**	3.69%	-0.63%	66.83%	-0.50%**	1.49%	-0.21%	69.35%	-0.70%**	3.17%	-0.34%	60.83%

Table 4: Determinants of capacity and timing effects

This table present coefficient estimates of the model:

$$Diff_{i,t} = \gamma_0 + \gamma_1 SIZE_{i,t} + \gamma_2 TURN_{i,t} + \gamma_3 CASH_{i,t} + \gamma_4 FAMILY_{i,t} + \gamma_5 AGE_{i,t} + \gamma_6 YEAR_{i,t} + \gamma_7 Agg.Growth + \gamma_8 Index + \varepsilon_{i,t}. \quad (18)$$

We estimate the model for two dependent variables: the capacity component ($Diff_{Capacity}$), and the component due to timing effects ($Diff_{Timing}$). Variables include the size (*SIZE*) of the fund at the beginning of the 5-year period, the fund's age (*AGE*), the fund's average turnover ratio (*TURN*), and the percentage of cash holdings (*CASH*). *FAMILY* is the number of funds in the fund's family (not including the current fund).All independent variables mentioned above are measured by their quintile rankings. Dummy variables are included for index funds and aggressive growth funds. Fixed effects are included based on the year at the beginning of the fund-period (*YEAR*). Shares classes are aggregated for each fund and observations are measured for each portfolio over 5-year periods. There are a total of 3,582 portfolio-period observations. *T*-values using hesteroscedasticity and autocorrelation consistent (White, 1980) standard errors are reported in parentheses.

	Capacity Component ($Diff_{Capacity}$)		Timing Component ($Diff_{Timing}$)	
	Estimate	*T*-Value	Estimate	*T*-Value
Intercept	-1.87	(-1.87)	-3.65	(-1.63)
Size	-0.45*	(-2.48)	-0.56	(-1.45)
Turnover	-1.11**	(-7.44)	-1.71**	(-4.75)
Cash	-0.30*	(-2.04)	0.46	(1.38)
Family	0.17	(1.03)	-1.92**	(-5.16)
Age	0.21	(1.46)	1.52**	(4.41)
Year	0.07	(1.70)	0.15	(1.70)
Ag. Growth	-2.93**	(-5.74)	-2.34*	(-2.25)
Index	1.56**	(3.18)	0.59	(0.33)
R^2	4.26%		2.73%	

* and ** indicate statistical significance at the 5% percent and 1% levels, respectively.

Table 5: Descriptive statistics at share class level

Average statistics (followed by medians in italics) are reported for a sample of 4,623 open-end domestic equity mutual funds drawn from the CRSP Survivorship Free Mutual Fund database and the Morningstar Principia database. Share classes are treated as separate funds.

	$Diff_{Total}$	Timing Component	Timing Component % < 0	Capacity Component	Capacity Component % < 0	Mgt. Fee	12b-1 Fee	% with 12b-1 Fee	%with Front Load	% with Deferred Load	*N*
Small-Cap Growth	-1.74	-0.69	63.83%	-1.05	74.64%	1.27	0.31	58.00%	28.27%	37.42%	481
	-0.98	*-0.48*		*-0.54*		*1.23*	*0.23*				
Small-Cap Core	-1.15	-0.62	73.64%	-0.52	69.87%	1.15	0.29	54.39%	25.52%	37.66%	239
	-0.77	*-0.55*		*-0.33*		*1.12*	*0.10*				
Small-Cap Value	-1.47	-0.79	73.39%	-0.68	75.23%	1.13	0.24	49.08%	27.52%	29.36%	218
	-1.09	*-0.66*		*-0.44*		*1.10*	*0.00*				
Mid-Cap Growth	-1.90	-1.00	59.15%	-0.90	74.31%	1.12	0.32	60.07%	31.98%	40.48%	541
	-0.75	*-0.35*		*-0.47*		*1.10*	*0.22*				
Mid-Cap Core	-1.19	-0.55	60.49%	-0.64	68.52%	1.09	0.31	57.41%	33.95%	40.12%	162
	-0.52	*-0.21*		*-0.25*		*1.10*	*0.15*				
Mid-Cap Value	-0.57	-0.20	52.70%	-0.38	77.93%	1.02	0.29	53.15%	27.48%	33.78%	222
	-0.50	*-0.08*		*-0.28*		*1.00*	*0.11*				
Large-Cap Growth	-1.85	-1.38	66.61%	-0.47	71.90%	1.02	0.36	62.68%	31.84%	44.98%	1096
	-1.04	*-0.83*		*-0.24*		*1.00*	*0.25*				
Large-Cap Core	-1.05	-0.77	60.13%	-0.28	72.50%	0.88	0.26	54.08%	33.29%	32.89%	760
	-0.58	*-0.36*		*-0.15*		*0.90*	*0.08*				
Large Cap Value	-0.67	-0.42	53.54%	-0.26	64.16%	0.88	0.33	55.97%	28.98%	39.60%	904
	-0.31	*-0.15*		*-0.13*		*0.90*	*0.19*				
Full Sample	-1.34	-0.82	61.63%	-0.52	71.27%	1.02	0.31	57.45%	30.50%	38.81%	4623
	-0.74	*-0.43*		*-0.24*		*1.01*	*0.19*				

Table 6: Determinants of capacity and timing effects, by share class

This table present coefficient estimates of the model:

$$Diff_{i,t} = \gamma_0 + \gamma_1 SIZE_{i,t} + \gamma_2 TURN_{i,t} + \gamma_3 CASH_{i,t} + \gamma_4 FAMILY_{i,t} + \gamma_5 AGE_{i,t} + \gamma_6 YEAR_{i,t} + \gamma_7 SmallCap_{i,t} + \gamma_8 LargeCap_{i,t} + \gamma_9 Value_{i,t} + \gamma_{10} Growth_{i,t} + \gamma_{11} Deferred\ Load_{i,t} + \gamma_{12} Front\ Load_{i,t} + \gamma_{13} 12b\text{-}1\ Fees_{i,t} + \gamma_{14} Mgt\ Fees_{i,t} + \varepsilon_{i,t} \quad (19)$$

We estimate the model for two dependent variables: the capacity component ($Diff_{Capacity}$), and the component due to timing effects ($Diff_{Timing}$). Variables include the size (*SIZE*) of the fund at the beginning of the 5-year period, the fund's age (*AGE*), the fund's average turnover ratio (*TURN*) and the percentage of cash holdings (*CASH*). *FAMILY* is the number of funds in the fund's family (not including the current fund). Expense ratios are decomposed into *12b-1* (Marketing) and non-12b-1 (Management) fees. All independent variables mentioned above are measured by their quintile rankings. Dummy variables are included if most of the fund's portfolio is invested in stocks of specific style categories: Small-Cap, Large-Cap, Value, and Growth, as identified by Morningstar's Equity Box Indicator. Dummy variables indicate if a fund charges any type of front-end load or deferred load. Shares classes are treated as separate funds and observations are measured for each portfolio over 5-year periods. Data are from the CRSP mutual fund database and style classifications are from Morningstar Principia Pro. There are a total of 4,623 observations. *T*-values using hesteroskedasticity and autocorrelation consistent (White, 1980) standard errors are reported in parentheses.

	Capacity Component ($Diff_{Capacity}$)		Timing Component ($Diff_{Timing}$)	
	Estimate	*T*-Value	Estimate	*T*-Value
Intercept	-7.36**	(-9.40)	-15.35**	(-6.44)
Size	0.42*	(2.08)	0.06	(1.27)
Turnover	-1.06**	(-6.90)	-1.34**	(-4.75)
Cash	0.29	(0.50)	1.55**	(5.52)
Family	-0.23	(-1.09)	-1.52**	(-5.67)
Age	-0.41*	(-2.26)	0.99	(1.53)
Year	0.33**	(9.88)	0.88**	(7.98)
Small Cap	-1.27	(-0.98)	0.18	(0.11)
Large Cap	1.68**	(2.44)	-2.60*	(-2.21)
Value	0.21	(0.60)	2.62*	(3.64)
Growth	-1.71**	(-3.76)	-2.35*	(-2.11)
Deferred Load	1.71	(1.73)	3.18	(0.81)
Front Load	1.31**	(2.43)	2.50**	(3.09)
12b1 Fee	-0.66	(-1.40)	-3.27**	(-4.68)
Mgt. Fee	-0.56**	(-3.26)	-0.67	(-1.74)
R^2	5.19%		5.06%	

* and ** indicate statistical significance at the 5% and 1% levels, respectively.

Appendix A: Calculation of DWA returns and the capacity and timing components.

This appendix provides numerical examples to illustrate the calculation of dollar- and time-weighted average returns and the decomposition of the difference between these averages into timing and capacity effects. Example 1 establishes a base case in which all of the difference arises from timing of investor flows with respect to the fund's underlying factor benchmark, while example 2 illustrates a case in which the fund's alpha is negatively correlated with the size of the fund.

Example 1

A_0 = \$1,000 (starting TNA)

f_1 = \$98,900 (inflows in period 1)

f_2 = \$0 (no flows in period 2)

r_1 = 10% (the fund's return in period 1)

r_2 = 0% (the fund's return in period 2)

From equation (3) we have:

$$\phi_1 = 98{,}900/1{,}100 = 8{,}990.91\%$$

$$\phi_2 = 0\%.$$

From equation (4) we have:

$$\hat{w}_1 = 1.0000$$

$$\hat{w}_2 = 90.9091$$

From equation (5) we have:

$$w_1 = 1.0000 /(1.0000+90.9091) = 0.01088$$

$$w_2 = 90.9091/(1.000+90.9091) = 0.98912.$$

Therefore, equation (6) results in a dollar-weighted average return of:

$$DWA = (0.01088)(.10) + (0.98912)(0) = 0.109\%.$$

The dollar-weighted return is heavily weighted toward the second period, when returns are zero. From equation (2), the time-weighted average return is equally-weighted between the two periods, giving the first period's higher returns relatively more weight than given in the dollar-weighted measure, so that:

$$TWA = (10\% + 0\%)/2 = 5.000\%.$$

Using equation (7), the total dollar-time weighted difference is:

$$Diff_{Total} = 0.109\% - 5.000\% = -4.891\%.$$

To calculate the components of the difference, assume returns are given by a one-factor model:

$$r_t = \alpha_t + Br_t + e_t.$$

Furthermore, assume that we have an index fund with no tracking error so, $\beta = 1$ and $\alpha_1 = \alpha_2 = 0$. Using the dollar-weights from this portfolio, this portfolio's *benchmark* dollar-weighted average return is:

$$DWA_{Benchmark} = (0.01088)(1)(.10) + (0.98912)(1)(0) = 0.109\%.$$

The benchmark's time-weighted average return is:

$$TWA_{Benchmark} = 0.5[(1)(.1) + (1)(0)] = 5\%$$

Using the benchmark's time- and dollar-weighted average returns yields a timing effect of:

$$Diff_{Timing} = 0.109\% - 5.000\% = -4.891\%.$$

The corresponding capacity effect for this fund is:

$$Diff_{Capacity} = -4.891\% - (-4.891\%) = 0.000\%.$$

Therefore, when there is no variation in the fund's alpha, the timing and capacity decomposition attributes all of the difference in dollar- and time-weighted averages to a timing effect.

Example 2

Suppose now that the market returns are 8% in period 1 and 2% in period 2. The flows, weights, and fund returns are the same as in example 1. The estimated alpha over the entire sample period is still zero, but now α_1 = 2% and α_2 = -2%. Using the dollar-weights from this portfolio, this portfolio's *benchmark* dollar-weighted average return is:

$$DWA_{Benchmark} = (0.01088)(1)(.08) + (0.98912)(1)(0.02) = 2.065\%$$

The benchmark dollar-weighted returns put a large weight in period 2 when market returns are 2%. The benchmark's time-weighted average return is:

$$TWA_{Benchmark} = 0.5[(1)(.08) + (1)(0.02)] = 5.000\%.$$

Therefore, the portfolio's timing effect is:

$$Diff_{Timing} = 2.065\% - 5.000\% = -2.935\%.$$

This represents the drag on performance due to weighted factor realizations that effectively are poorly timed. In other words, the factor realizations (i.e., market returns) are negatively correlated with the dollar-weighted measure's time-varying weights. The capacity effect is:

$$Diff_{Capacity} = -4.891\% - (-2.935\%) = -1.956\%.$$

This represents the drag on performance due to a dollar-weighted alpha over the entire period that is unequal to the time-weighted alpha over the entire period. After accounting for flows that are badly timed with respect to the factor realizations, the residual dollar-weighted alpha is still less than the time-weighted alpha, indicating that the fund's alpha is (negatively) correlated with the size of the assets under management.