Investor Overconfidence Over-extrapolation Bias Mutual Fund Flow and Performance

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We propose a model that examines the effect of mutual fund investors' overconfidence bias and over-extrapolation bias on mutual fund flow and performance. We show that when investors are irrational, contrary to Berk and Green (2004), fund flows no longer eliminate the fund outperformance efficiently. Instead, the fund's future performance can be jointly predicted by a variable representing the mutual manager's skill contained in the past performance, unit value-added (UVA) and a variable representing mutual fund investors' private information in fund flow activities, scaled fee growth (SFG). Specifically, controlling for the UVA, the fund's SFG will positively predict the fund's future performance if the investors are predominantly influenced by over-extrapolation bias and will negatively predict the fund's future performance if the investors are predominantly influenced by the overconfidence bias. And, controlling for the SFG, the fund's UVA will negatively predict the fund's future performance if the investors are predominantly influenced by over-extrapolation bias and will positively predict the fund's future performance if the investors are predominantly influenced by the overconfidence bias. Moreover, the predictive abilities of the UVA and SFG for the fund's future performance covary with investor overconfidence and overextrapolation bias.

We confirm the model predictions using data from actively managed mutual funds in the United States. In addition, we construct the skill-competition measure (SC measure) to capture the 'mispricing' of mutual fund manager skills. We find that a one percent increase in the SC measure will increase fund peer-adjusted net return significantly by 0.18% in the following month. Using market return as a proxy for investor overconfidence, we also show that the predictive abilities of UVA and SFG are stronger when the market return is higher and investors become more overconfident.

Introduction

Berk and Green (2004) applies rational expectation equilibrium in the mutual fund industry to explain the puzzling return-chasing behavior of mutual fund investors. The paper points out that the non-persistent mutual fund performance does not imply that managers lack skill. Instead, the non-persistent performance is the result of mutual fund investors' rational competition for a scarce resource, fund manager skill, which subsequently eliminates fund outperformance with flows.

This process is analogous to investors bidding up the stock prices of firms with better prospects to generate high future cash flows, thereby eliminating any opportunities to earn risk-adjusted returns in such stocks. While extensive studies find that investors in the stock market misprice firms due to various psychological biases, little research has explored the effect of investor irrationality in the mutual fund industry. Specifically, no one has investigated whether mutual fund investors misevaluate manager skills and cause predictability in mutual fund future performance. This study addresses this issue by examining how mutual fund investor overconfidence and over-extrapolation bias affect the investors' investment decisions and fund future performance.

We focus on investor overconfidence and investor over-extrapolation as the psychological biases in this study for two reasons. First, overconfidence is probably the most robust human trait documented in the psychology of judgment (De Bondt and Thaler, 1995; Moore, Tenney, and Haran, 2015). Specifically, Moore, Tenney, and Haran (2015) point out that overprecision, excessive faith in the quality of one's judgment, is a robust feature of overconfidence. Heath and Tversky (1991) finds that people are more confident of their predictions in fields where they have self-declared expertise, holding their actual predictive ability constant. Investors who pursue an actively managed mutual fund instead of index funds are most likely to believe they possess superior abilities in picking out skilled managers and are, therefore, more susceptible to overconfidence bias. Over-extrapolative bias is also pervasive in human judgment and decisions (Barberis and Thaler, 2003; Gilovich, Vallone, and Tversky, 1985; Hirshleifer, 2001; Tversky and Kahneman, 1974). The human brain has a limited information processing power and, therefore, often uses representativeness heuristics as a short-cut when processing large or complicated information. However, this reliance on the representativeness heuristic can cause trend-chasing because people are too ready to recognize a certain pattern (Barber, Shleifer, and Vishny, 1998). As investment decisions are usually difficult and require a large amount of information, investors are more likely to apply the representativeness heuristic and experience over-extrapolation bias when making investment decisions.

Second, many studies have documented the existence of overconfident and over-extrapolating investors in the stock market. Barber (1999) and Barber and Odean (2000) both find that investors trade excessively due to overconfidence, which eventually leads to lower profits. Greenwood and Shleifer (2014) analyzes six surveys on investor expectation and finds that investors form beliefs about future stock market returns by extrapolating past returns. Ertan et al. (2017) discovers investors' extrapolative behavior around earnings announcements. In addition, investor overconfidence and over-extrapolation bias are found to be able to explain several puzzling phenomena in the financial market, such as the predictive ability of price-scaled fundamental variables, excess volatility in the stock market, and momentum, when combined with traditional asset pricing models (Barberis et al., 2015; Daniel, Hirshleifer, and Subrahmanyam, 1998, 2001; Hong and Stein, 1999). As the investor base in the mutual fund industry overlaps heavily with the investor base in the stock market, it is natural to wonder how this investor overconfidence and over-extrapolation bias displayed in the stock market will affect the investment decisions on the mutual funds and the fund's future performance.

In the stock market, investors react to information through stock prices. They reward good investment opportunities with higher market prices and punish bad ones with lower market prices (Berk and van Binsbergen, 2017). Investor irrationalities can affect investors' trading behavior, which will directly affect the return of the assets. Comparatively, the mechanism through which investor irrationalities affect the rational expectation equilibrium in the mutual fund industry is quite different. The price for a skilled manager in the mutual fund industry is relatively fixed (the management fee is relatively stable over time), and therefore, investors can only react to information about manager skills through flows. Investors flow into funds with outperformance and flow out of funds with underperformance. In this way, the misevaluation of manager skills due to investor irrationalities can only be observed from mutual fund flows.

To examine the effect of investor overconfidence and over-extrapolation bias on mutual fund flow and performance, we first introduce a generalization of the Berk and Green (2004) model, where we assume that mutual fund investors can observe private information in addition to fund historical return when making an investment decision. This private information can be viewed as information that is not readily available and that investors need to spend extra effort and resources to obtain. As discussed in Daniel, Hirshleifer, and Subrahmayam (1998), if an investor overestimates his ability to generate information or to identify the significance of existing data that others neglect, he will underestimate the forecast error of signals or assessments with which he put more effort on and overestimates their precision. Additionally, if investors over-extrapolate fund past performance, they believe that past fund performance can predict fund future performance more accurately than it actually does. Thus, we assume that mutual fund investors with extrapolation bias will overestimate the precision of the manager skill information contained in the fund's past performance.

The model shows that when mutual fund investors are overconfident about their private information, or over-extrapolation fund past performance, or both, their assessment of manager skill will deviate from the rational expectation of manager skill. As a result, fund flow can no longer eliminate fund outperformance effectively. Instead, fund future performance can be predicted by a linear combination of unit value-added, which is the fund value-added scaled by fund past size, and scaled fee growth, which is the incremental dollar fee scaled by fund past size. Value-added is calculated as the product of the fund's benchmark-adjusted raw return and fund size following Berk and van Binsbergen (2017). UVA then represents how much dollar return the manager generates for each dollar under management, thereby measuring manager skill. The SFG, which is calculated as the product of the fund's dollar flow and the expense ratio, represents investors' reaction to the information about fund manager skills.

When investors are predominantly influenced by overconfidence bias, unit value-added can positively predict the fund's future performance, and scaled fee growth can negatively predict fund future performance in a multiple regression that includes both unit value-added and scaled fee growth. Controlling for scaled fee growth, a higher unit value-added implies high manager skill and will positively predict fund future performance due to investors' relative overreaction to private information and under-reaction to the information contained in fund past performance. When controlling for unit value-added, a higher positive scaled fee growth implies a larger positive deviation from the supply of capital under the rational case due to investors' overreaction to the private information. Similarly, a lower negative scaled fee growth implies a larger negative deviation from the supply of capital under the rational case due to investors' overreaction to the private information. In this way, controlling for unit value-added, scaled fee growth will negatively predict fund future performance.

On the other hand, when investors are predominantly influenced by over-extrapolation bias, unit value-added can negatively predict fund future performance in a multiple regression that includes both unit value-added and scaled fee growth. In addition, scaled fee growth can negatively predict fund future performance if overconfidence is slightly weaker compared to over-extrapolation bias and positively predict future performance if overconfidence is predominated by over-extrapolation bias. Controlling for scaled fee growth, a higher unit value-added implies high manager skill and will negatively predict fund future performance due to investors' relative overreaction to the information contained in fund past performance. Controlling for fund past performance, the predictive direction of scaled fee growth will depend on whether the relative overreaction to the private information caused by investor overconfidence is higher than the relative underreaction to investors' prior belief about manager skill. If investor overconfidence is weak, both prior information and the private information about manager skill are relatively underweighted, and therefore scaled fee growth positively predicts future performance.

However, if investor overconfidence is strong enough to the point where the flows are driven more by the relative overreaction to the private information than by the relative underreaction to the prior belief, scaled fee growth will negatively predict future performance.

In addition, the model shows that the predictive ability of fund unit value-added and fund scaled fee growth are correlated with investor overconfidence bias and investor over-extrapolation bias. As investors become more overconfident about their private information, they will underweight the manager skill information contained in the fund's past performance more. Therefore, the predictive power of unit value-added becomes more positive due to investors' increased under-reaction to the information in the past performance. In addition, the predictive power of scaled fee growth becomes more negative due to investors' increased overreaction to his private information. The same logic applies to the effect of investor over-extrapolation bias. As the investor over-extrapolate fund past performance more, he will overweight the manage skill information contained in the fund past performance more and under-react more to the private information. In this way, the predictive power of unit value-added become more negative and the predictive power of scaled fee growth becomes more positive.

Using U.S. actively managed mutual fund data, we test the model by regressing fund future performance on fund unit value-added and fund scaled fee growth, controlling for other factors that could affect fund future performance. The results show that the coefficient for unit value-added is significantly positive, and the coefficient for scaled fee growth is significantly negative in the multiple regression. This result suggests that mutual fund investors are not entirely rational and are dominated by overconfidence when making an investment decision on mutual funds. Holding the scaled fee growth constant, a one percent increase in unit value-added constructed using the trailing 12-month peer-adjusted net return will lead to a 0.01% increase in the fund's peer-adjusted net return next month. Holding the unit value-added constant, a one percent increase in fund scaled fee growth will lead to a 0.54% decrease in the fund's peer-adjusted net return next month.

These results are different from previous studies that examine the predictive ability of past fund performance or past fund flow in that, according to our model, the future fund performance has to be predicted using both a variable that represents past fund performance and a variable that represents flow activities at the same time. Even if a mutual fund has a skilled manager and generates a high performance during this period, this does not necessarily predict high performance in the future since investors could compete away the outperformance generated by this skilled manager. Therefore, when predicting future fund performance with the fund's past performance or past flows alone, the predictive ability of one variable will be significantly tempered by the other. In this way, the best predictor of fund future performance must contain both the fund's past performance and the fund's flow activities.

Therefore, we further construct a variable, skill-competition measure (SC measure), that combines fund unit value-added and fund scaled fee growth. According to our model, this SC measure should be able to positively predict fund future performance. To construct this predictor, we first estimate the coefficients for fund value-added and fund fee-added using the previous two years' observations of all mutual funds. We then construct the SC measure with the estimated coefficients, realized fund unit value-added, and realized fund scaled fee growth of the month. Next, we sort mutual funds into decile portfolios at the end of each month. The strategy that longs the funds with the highest SC measure and shorts funds with the lowest SC measure can generate a significant 0.22% peer-adjusted net return every month. A similar strategy that is implemented with trailing Carhart alpha as the performance measure can generate a significant 0.3% monthly Carhart alpha.

In addition, our model predicts that the predictive power of fund unit value-added and fund fee-added co-vary with investor sentiment. To be more specific, the predictive power of fund unit value-added is positively correlated with investor overconfidence and negatively correlated with investor over-extrapolation bias; the predictive power of fund scaled fee growth is negatively correlated with investor overconfidence and positively correlated with investor over-extrapolation bias. Using aggregate market return as the proxy for investor overconfidence, we confirm that the predictive power of fund unit value-added and fund scaled fee growth co-move significantly with investor overconfidence in the direction predicted by our model.

This study provides a new perspective on the application of rational expectation equilibrium in the mutual fund industry. In contrast with the conclusion in Berk and Green (2004), we find that fund future performance is predictable when mutual fund investors are not fully rational. This paper also points out that the key to identifying funds with persistent performance is not picking out skilled managers but finding misevaluated funds. Even though it is rational for investors to chase fund performance according to Berk and Green (2004), it does not necessarily mean that they chase fund performance efficiently. Using both theoretical modeling and empirical testing, we find that when investors are not fully rational, fund future performance can be predicted by fund unit value-added and fund scaled fee growth. In addition, the predictive directions of unit value-added and scaled fee growth depend on the relative strength of investor overconfidence and over-extrapolation bias when investors make mutual fund investment decisions.

This paper is not the first to study how investors allocate investment between funds based on available information. Berk and Green (2004) develops a parsimonious model and explains several puzzling phenomena in the mutual fund industry, e.g. mutual fund investors' return-chasing behavior, the non-persistent mutual fund performance, and high fund manager income. Berk and Green (2004) points out that the non-persistence of mutual fund performance is the result of a rational expectation equilibrium where investors rationally anticipate the value of a scarce resource, mutual fund manager skill in this case, and compete away any abnormal return generated by this resource through mutual fund flows. As the possessor of the scarce resource, mutual fund managers collect all the rent as their own rewards, thus the high income.

Berk and Green (2004) provides a new understanding of the mutual fund industry, and from then on, multiple studies test and provide further evidence supporting the Berk and Green (2004) model. Berk and van Binsbergen (2015) redefines manager skill based on the Berk and Green (2004) model and identify persistent manager skill up to ten years in the industry. Pastor, Stambaugh, and Taylor (2015) tests the decreasing return to scale assumption in the Berk and Green (2004) model and find a significant decreasing return to scale at the industry level, while there is no significant result identified at the fund level. Our research is related to these studies in that the model developed in this study is based on the framework of Berk and Green (2004). However, instead of working under a pure rational assumption, we introduce investor overconfidence and over-extrapolation bias as a source of irrationality into the original model and provide interesting implications for fund flow and future performance.

There has been extensive evidence of investor behavioral biases in the stock market while very few studies have been done on the mutual fund industry, albeit these two markets share a large overlapping investor base. Sirri and Tufano (1998) attributes the convex flow performance relationship in the mutual fund industry to search cost and limited attention. Solomon, Soltes, and Sosyura (2014) finds that mutual fund flows can be significantly affected by media coverage on a fund's holdings, suggesting the existence of an attention bias among mutual fund investors when allocating capital. Bailey, Kumar, and Ng (2011) uses US discount brokerage investors sample and constructs proxies for several behavioral biases, such as limited attention, home bias, and overconfidence. Their study finds that biased mutual fund investors trade funds more frequently, tend to time their buys and sells badly, and prefer high-expense funds and active funds rather than index funds.

In comparison with the purely empirical approach of these studies, our research starts with a behavioral model of irrational mutual fund investors and further supports our model with empirical tests. In addition, this study is, to our knowledge, the first to investigate the effect of both investor overconfidence and over-extrapolation bias on mutual fund flow and future performance. Moreover, our study examines the interaction effect between investor overconfidence and investor over-extrapolation bias on investment decisions. The results from our study provide guidance on which psychology bias is more dominant in investors' investment decision process.

The study by Roussanov, Ruan, and Wei (2022) is the study that is closest to ours. The authors of that study model the behavior of return-chasing mutual fund investors and find that these investors tend to be overly optimistic about the average skill of fund managers. Our paper differs from theirs in a couple of ways. First, we model irrational mutual fund investors who are affected by both over-extrapolation bias and overconfidence bias. As a result, we are able to provide more insight into how the interaction between different psychological biases can impact investors' investment decisions. Secondly, we developed the SC measure, which can be used to identify fund manager skills that are "mispriced" by the market. We find that mutual funds with high skill-competition measures tend to outperform their benchmarks in the future.

Our research also contributes to the literature on mutual fund performance persistence. Carhart (1997) finds that most of the performance persistence ("hot hand" phenomenon) identified in previous studies can be largely explained by the momentum factor in individual stocks. Later, Cohen, Coval, and Pastor (2005), Kacperczyk, Sialm, and Zheng (2005), and Avramov and Wermers (2006), find predictability in performance even after controlling for momentum. However, Fama and French (2008) and Barras, Scaillet, and Wermers (2009) apply advanced methodologies and find little evidence of performance persistence. According to the model in this study, the fund's future performance cannot be correctly predicted without considering both the fund's past performance and past flow activities. The measure constructed based on our model, which includes both the fund's past performance (unit value-added) and fund flow activities (scaled fee growth), can significantly predict fund future risk-adjusted net return.

In addition, Glode, et. al (2016) finds that the return predictability for mutual funds is time-varying and mutual fund returns are only predictable after high market returns. This evidence is consistent with our model prediction that the predictive ability of unit value-added and scaled fee growth comove with investor irrationality. After a period of high market returns, investors are likely to be more overconfident about their ability due to the self-attribution bias. Therefore, the predictive ability of unit value-added, a variable that is highly correlated with fund past performance, will increase (become more positive), controlling for scaled fee growth.

Finally, our study is also related to the strain of research on the 'smart money' effect. Gruber (2011) and Zheng (1998) find that mutual fund flow can positively predict future fund performance in the short term and therefore argue that the money is 'smart'. However, Sapp and Tiwari (2004), Wermer (2003) and Lou (2012) later find that the smart money effect can be fully explained by temporary price pressure and stock return momentum. On the other hand, Frazzini and Lamont (2008) argues that high mutual fund flows represent high investor sentiment, and fund flows are dumb in the long run. Yang (2020) also finds that excessive flows can negatively predict fund future performance. Flows in our study represent irrational investors' reactions to the information about the fund manager skill. According to our model, the predictive ability of fund flow for fund future performance cannot be correctly specified without taking current fund performance into consideration. Instead of examining fund flow being 'smart' or not, we are essentially testing whether fund flows are fully rational and reacting to information efficiently. When controlling for fund past performance with unit value-added, fund flow can represent the investors' aggregate relative overreaction or underreaction to the private information and prior belief.

The rest of the paper is organized as follows: Section we present the theoretical model and its implications. Section II describes the data and methodology used in empirical tests. Section III reports the results of empirical tests. Section IV concludes the paper.

I. The Model

We consider a model with three dates, $t = 0, 1, 2$. All investors can choose between an actively managed mutual fund and an index fund that has the same risk as the actively managed mutual fund (benchmark). As discussed in the introduction, this model is aimed to examine how mutual fund investors irrationality affects fund future performance. We introduce both investor over-extrapolation and overconfidence as the source of irrationality in the model.

Let $\mathrm{V_t}$ denotes the per period dollar amount of money the manager can extract from the capital market after cost at time *t.* Following Berk and van Binsbergen (2017), we call $\mathrm{V_t}$ value-added and use it as the manager skill measure,

$$\mathrm{V_t} = \mu + \varepsilon_t, \tag{1}$$

, where μ is the unobserved true manager skill and ε_t is a normally distributed noise term with mean zero and variance σ_ε^2. Mutual fund investors can learn about μ through realized fund performance and their private signal about the manager skill.

Let q_{t-1} be the assets under management of the fund at date t – 1. Fund true benchmark-adjusted dollar return at time *t* is

$$\mathrm{R_t} = V_t - q_{t-1} f \tag{2}$$

and fund benchmark adjusted net return at time *t* is,

$$\mathrm{r_t} = \frac{R_t}{q_{t-1}} = \frac{V_t}{q_{t-1}} - f, \tag{3}$$

, where f is a fixed percentage management fee charged by the mutual fund.

A. Timing

At time 0, mutual fund investors have a prior belief that a manager's true ability $\mu = \mu_0 + \omega$ and is normally distributed with mean μ_0 and variance σ_0^2.

At time 1, mutual fund investors observe the benchmark-adjusted net return of the actively managed portfolio, r_1 and a private signal about manager skill, S_1. Mutual fund investors obtain the private information through their own investigation and research. We assume that $S_1 = \mu + \xi$ and is also normally distributed,

$$S_1 \sim N(\mu, \sigma_s^2) \tag{4}$$

It is more convenient to use precision instead of variance in the following analysis. Therefore, we further define $v_0 = 1/\sigma_0^2$, $v_\varepsilon = 1/\sigma_\varepsilon^2$, $v_s = 1/\sigma_s^2$.

In the model, we allow investors' perceived signal precision to be different from the true signal precision due to different psychological biases. At time 1, mutual fund investors' perceive signal precision for V_1 and S_1 are denoted as v'_ε and v'_s, respectively. Specifically, we assume that overconfident mutual fund investors overestimate the quality of their private signal (Daniel, Hirshleifer, and Subrahmanyam, 2001). Therefore, when investors are overconfident, their perceived precision of S_1, v'_s, is higher than the true signal precision, v_s. On the other hand, if investors over-extrapolate past returns, they believe that fund past returns predict fund future returns more accurately than they actually do. In this way, when investors over-extrapolate fund past performance, their perceived precision of V_1, v'_ε, is higher than the true precision of V_1, v_ε.[1]

We further assume that $\mathrm{Cov}(\varepsilon_t, \varepsilon_s) = 0$ for $t \neq s$, $\mathrm{Cov}(\varepsilon_t, \xi) = 0$ for $t = 1, 2$, $\mathrm{Cov}(\varepsilon_t, \omega) = 0$ for $t = 1, 2$ and $\mathrm{Cov}(\xi, \omega) = 0$.

After observing the fund past performance and a private signal about manager skill, mutual fund investors update their belief about manager skill and flow in or out of the mutual fund. Since at time t, q_{t-1} and f are all known to the investors, after observing the net return r_1, the investors are able to back out V_1. Let • denote $\mathbb{I}$ or $\mathbb{R}$, where $\mathbb{I}$ refers to an irrational expectation and $\mathbb{R}$ to a rational one. When $v'_\varepsilon = v_\varepsilon$ and $v'_s = v_s$, • denotes $\mathbb{R}$. Otherwise, • denotes $\mathbb{I}$. Using the Bayesian updating rule from DeGroot (1970), the updated belief about manager skill is,

$$\mathbb{E}^{\bullet}[V_2|r_1, S_1] = \mathbb{E}^{\bullet}[V_2|R_1, S_1] = (\frac{v_0}{v'})\mu_0 + (\frac{v'_\varepsilon}{v'})V_1 + (\frac{v'_s}{v'})S_1, \quad (5)$$

where $v' = v_0 + v'_\varepsilon + v'_s$.

At time 2, mutual fund investors receive a net return of r_2.

B. Mutual Fund Flows

[1] Since fund net return $r_t = \frac{V_t}{q_{t-1}} - f$, investors' over-extrapolating past return, r_1, is equivalent to over-extrapolating V_1.

Following Berk and Green (2004), we assume that investors supply the capital with infinite elasticity to a fund if they have a positive excess expected return for the fund, given the observed signals and investors' perceived signal distribution.

We first solve for investor flows as a function of the private signal and the date 1 return performance. Since all mutual fund investors are identical in our model, instead of solving for individual investment, we only need to solve for the aggregate mutual fund dollar flow at time $\mathrm{t} = 1$.

Due to the competitive supply of capital,

$$\mathbb{E}^{\bullet}[r_2|r_1, S_1] = 0 \tag{6}$$

Therefore, using equations (4) and (8),

$$\mathbb{E}^{\bullet}\left[\frac{V_2}{q_1} - f\middle|r_1, S_1\right] = 0 \tag{7}$$

Since fund size before time 2 are all observable and f is also observable, we can rewrite equation (9),

$$\mathbb{E}^{\bullet}[V_2|V_1, S_1] = q_1 f \tag{8}$$

From equation (7) and equation (10), we have,

$$q_1 f = \frac{\upsilon_0}{\upsilon'}\mu_0 + \frac{\upsilon_\varepsilon'}{\upsilon'}V_1 + \frac{\upsilon_s'}{\upsilon'}S_1 \tag{9}$$

Replace V_1 and S_1 with $V_1 = (r_1 + f)\mathrm{q}_0$ and $\mathrm{S}_1 = (s_1 + f)q_0$. Since $\mathbb{E}^{\bullet}[r_1] = 0$, $q_0 f = \mathbb{E}^{\bullet}[R_1] = \mu_0$. Then,

$$q_1 f = q_0 f + \frac{\upsilon_\varepsilon'}{\upsilon'}r_1 q_0 + \frac{\upsilon_s'}{\upsilon'}s_1 q_0 \tag{10}$$

Lemma 1*: At time* $t = 1$*, fund flow is a linear function of the fund net return,* r_1*, and the private signal,* s_1*.*

$$q_1 - q_0 = \frac{v_\varepsilon'}{v'f} r_1 q_0 + \frac{v_s'}{v'f} s_1 q_0 \tag{11}$$

Funds with positive perceived net returns receive inflows and funds with negative net returns experience outflows. In addition, a positive private signal increases fund dollar flow and a negative one reduces fund dollar flow. These results are similar to the results in Berk and Green (2004), where mutual fund flows react to information through flows rationally.

C. Fund Future Performance

Given the dollar flow derived in equation (11), we can solve the expected fund future performance.

Lemma 2*: At time* $t = 1$*, the expected fund future performance given the information investors received and investors' belief about the distribution of the information is*

$$\mathbb{E}[r_2 q_1 | r_1, S_1] = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} r_1 q_0 + \left(\frac{v_s v'}{v v_s'} - 1\right)(q_1 - q_0) f, \tag{12}$$

where $\mathrm{v} = \mathrm{v}_0 + \mathrm{v}_\varepsilon + v_s$.

From equation (13), we can see that the expected fund future value-added is a linear combination of fund value-added last period and fund incremental dollar fee received last period. Since investors care more about fund return instead of fund value-added in reality, we rewrite equation (12) into equation (13) and discuss model results for expected fund future return instead of expected fund future value-added.

$$\mathbb{E}[r_2|x_1, S_1] = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} \frac{r_1 q_0}{q_1} + \left(\frac{v_s v'}{v v_s'} - 1\right) \frac{(q_1 - q_0)f}{q_1} \tag{13}$$

The $\mathbb{E}[r_2|r_1, S_1]$ in equation (15) is different from the one in equation (6) and does not necessarily equal to zero. $\mathbb{E}[r_2|r_1, S_1]$ is the rational fund expected performance at time 2 given the information investors received and investors' belief about the distribution of the information at time 1. To simplify the discussion in the rest of the paper, we call $\frac{r_1 q_0}{q_1}$ unit value-added and $\frac{(q_1 - q_0)f}{q_1}$ scaled fee growth---the additional fee collected by the fund above that at date 0, scaled by the later size of the fund.

Proposition 1: *When mutual fund investors are rational, fund future performance is random and cannot be predicted.*

Proof:

When mutual fund investors are rational, $v_\varepsilon' = v_\varepsilon$ and $v_s' = v_s$. Then according to equation (13),

$$\mathbb{E}[r_2|r_1, S_1] = 0 \tag{14}$$

In this case, mutual fund investors react rationally to all information through fund flows and therefore fund future performance cannot be predicted. This result is the same as the one derived in Berk and Green (2004).

END OF PROOF.

Proposition 2: *When mutual fund investors are overconfident but do not over-extrapolate fund past performance, fund future performance is positively predicted by unit value-added and negatively predicted by scaled fee growth in multiple regression.*

Proof:

When mutual fund investors are overconfident about their private information but do not over-extrapolate fund past performance, $v'_\varepsilon = v_\varepsilon$ and $v'_s > v_s$. Then according to equation (13),

$$\mathbb{E}[r_2|r_1, S_1] = \frac{v_\varepsilon}{v}\left(1 - \frac{v_s}{v'_s}\right)\frac{r_1 q_0}{q_1} + \left(\frac{v'' v_s}{v v'_s} - 1\right)\frac{(q_1 - q_0)f}{q_1} \quad (15)$$

$$\beta_1 = \frac{v_\varepsilon}{v}\left(1 - \frac{v_s}{v'_s}\right) > 0 \text{ and } \beta_2 = \left(\frac{v'' v_s}{v v'_s} - 1\right) < 0$$

,where $v'' = v_0 + v_\varepsilon + v'_s$.

END OF PROOF.

As investors are overconfident and overestimate the precision of their private information, they relatively underreact to the information contained in fund past performance while overreacting to the private information when accessing fund future performance. Therefore, controlling for fund scaled fee growth, unit value-added positively predict fund future performance since a high unit value-added suggests a high manager skill, and investors underreact to this information. On the other hand, controlling fund unit value-added, scaled fee growth negatively predicts fund future performance since a high scaled fee growth suggests a high private signal about managerial skill, but investors overreact to this information.

Proposition 3: *When mutual fund investors over-extrapolate fund past performance but are not overconfident about their private information, fund future performance is negatively predicted by unit value-added and positively predicted by scaled fee growth in multiple regression.*

Proof:

When mutual fund investors are overconfident but do not over-extrapolate fund past performance, $\mathrm{v}_{\varepsilon}' > \mathrm{v}_{\varepsilon}$ and $\mathrm{v}_{s}' = \mathrm{v}_{s}$. Then according to equation (13),

$$\mathbb{E}[r_2|r_1, S_1] = \frac{v_\varepsilon - v_\varepsilon^{'}}{v}\frac{r_1 q_0}{q_1} + \frac{v_\varepsilon^{'} - v_\varepsilon}{v}\frac{(q_1 - q_0)f}{q_1} \tag{16}$$

$$\beta_1 = \frac{v_\varepsilon - v_\varepsilon^{'}}{v} < 0 \;\; and \;\; \beta_2 = \frac{v_\varepsilon^{'} - v_\varepsilon}{v} > 0$$

END OF PROOF.

Intuitively, unit value added increases with past performance. Investors overreact to this, so it negatively predicts returns. Fee growth is a proxy for investor inflows, which are increasing with the private signal as well as with past performance. Controlling for unit value added fixes the past performance, so that fee growth incrementally captures variation in the private signal. Trend chasing investors overweight past performance at the expense of the private signal, so fee growth positively predicts returns.

Proposition 4: *When mutual fund investors over-extrapolate fund past performance and are overconfident about their private information, there are two different scenarios.*

1) *If $v_s'/v_s \geq v_\varepsilon'/v_\varepsilon$, which means investors are more overconfident about their private information than over-extrapolating fund past performance, fund future*

performance can be positively predicted by unit value-added and negatively predicted by scaled fee growth in multiple regression.

2) *If $v_s'/v_s < v_\varepsilon'/v_\varepsilon$, which means investors are less overconfident about their private information than over-extrapolating fund past performance, unit value-added negatively predicts fund future performance in a multiple regression including both unit value-added and scaled fee growth. In addition, scaled fee growth positively predict fund future performance if v_s'/v_s is smaller than k and negatively predicts fund future performance if v_s'/v_s is larger than k. if v_s'/v_s equals to k, scaled fee growth cannot predict fund future performance.*

$$k = \frac{v_0 + v_\varepsilon'}{v_0 + v_\varepsilon} \tag{17}$$

Proof:

When mutual fund investors are overconfident about their private information and over-extrapolate fund past performance, $\mathrm{v}_\varepsilon' > \mathrm{v}_\varepsilon$ and $\mathrm{v}_s' > \mathrm{v}_s$. Then according to equation (13),

$$\mathbb{E}[r_2|r_1, S_1] = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'}\frac{r_1 q_0}{q_1} + \left(\frac{v_s v'}{v v_s'} - 1\right)\frac{(q_1 - q_0)f}{q_1} \tag{18}$$

When mutual fund investors suffer from both investor overconfidence and over-extrapolation bias, the prediction direction of unit value-added and scaled fee growth then depend on the relative strength of the two biases.

If $\frac{v_s'}{v_s} \geq \frac{v_\varepsilon'}{v_\varepsilon}$,

$$\beta_1 = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} \geq 0 \text{ and } \beta_2 = \left(\frac{v_s v'}{v_s' v} - 1\right) < 0 \tag{19}$$

If investors are predominated by overconfidence when making an investment decision, they relatively overreact to their private information and underreact to fund past performance. Therefore unit value-added positively predict fund future performance, and scaled fee growth negatively predicts fund future performance. When v_s'/v_s equals to $v_\varepsilon'/v_\varepsilon$, there exists a special case where unit value-added cannot predict fund future performance.

If $\frac{v_s'}{v_s} < \frac{v_0 + v_\varepsilon'}{v_0 + v_\varepsilon}$,

$$\beta_1 = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} < 0 \text{ and } \beta_2 = \left(\frac{v_s v'}{v_s' v} - 1\right) > 0 \tag{20}$$

On the other hand, if investors are strongly dominated by over-extrapolation bias, they relatively overreact to fund past performance and underreact to their private information. Therefore unit value-added negatively predicts fund future performance, and scaled fee growth positively predicts fund future performance.

If $\frac{v_0 + v_\varepsilon'}{v_0 + v_\varepsilon} \leq \frac{v_s'}{v_s} < \frac{v_\varepsilon'}{v_\varepsilon}$,

$$\beta_1 = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} < 0 \text{ and } \beta_2 = \left(\frac{v_s v'}{v_s' v} - 1\right) \leq 0 \tag{21}$$

When the over-extrapolation bias is only slightly stronger than overconfidence in investors' decision process, both unit value-added and scaled fee growth negatively predict fund future performance. In this case, even though investor overconfidence is dominated by over-extrapolation bias, investors' private information is still relatively overweigh compared to the rational case. Therefore fund flows represent investor's overreaction to the private information and negatively predict fund future performance. When v_s'/v_s equals to k, there exists a special case where scaled fee growth cannot predict fund future performance.

This model can also incorporate limited attention to some extent. If mutual fund investors have limited attention and ignore the information about manager skill S_1, it is equivalent to the case where investors believe the precision of this skill-related information is zero. In other words, investors' perceived precision of the information, v_s', equals to zero. In this case, the expected fund future performance is not well defined since both the coefficient for unit value-added and the coefficient for scaled fee growth go to infinity. However, we can discuss a less extreme situation where the perceived precision of the information v_s' is smaller than the actual precision, v_s.

If investors over-extrapolate fund past performance and have limited attention, $v_\varepsilon' > v_\varepsilon$ and $v_s' < v_s$. Then according to equation (13),

$$\mathbb{E}[r_2|r_1, S_1] = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} \frac{r_1 q_0}{q_1'} + \left(\frac{v_s v'}{v v_s'} - 1\right) \frac{(q_1 - q_0) f}{q_1}$$
$$\beta_1 = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} < 0 \text{ and } \beta_2 = \left(\frac{v_s v'}{v v_s'} - 1\right) > 0 \tag{22}$$

This result is exactly the same as the result when investors' over-extrapolation bias is stronger than the overconfidence about their private information. The intuition is also the same. Since investors have limited attention and underreact to the received information, they relatively overreact to the information contained in fund past performance. Therefore, fund unit value-added negatively predicts fund future performance, and fund scaled fee growth positively predicts fund future performance.

On the other hand, if investors have limited attention toward fund past performance, then the prediction will be similar to the case when investors' overconfidence about their private information is stronger than their over-extrapolation bias. In this case, the predictive ability of fund unit value-added and fund scaled fee growth on fund future performance will depend on the extent to which the overconfidence dominates over-extrapolation bias.[2]

***Corollary 1**: The incremental predictive ability of unit value-added increases with investor overconfidence, and the incremental predictive ability of scaled fee growth decreases with investor overconfidence.*

$$\frac{\partial \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'}}{\partial v_s'} > 0 \text{ and } \frac{\partial \left(\frac{v_s v'}{v v_s'} - 1\right)}{\partial v_s'} < 0 \tag{23}$$

As investors become more overconfident, they will overreact to the private information more and thus relatively intensify their under-reaction to the skill information contained in fund past performance. In this way, the predictive ability of unit value-added on future fund performance becomes more positive with the increase of investor overconfidence. On the other hand, as investors become more overconfident, the aggregate flow will contain more irrational investor flow caused by the overreaction to investors' private information and therefore intensify the negative predictive power of the scaled fee growth on future fund performance.

***Corollary 2**: The incremental predictive ability of unit value-added decreases with investor over-extrapolation bias, and the incremental predictive ability of scaled fee growth increases with investor over-extrapolation bias.*

[2] For detail discussion, please refer to proposition 4(2).

$$\frac{\partial \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'}}{\partial v_\varepsilon'} < 0 \;\; and \;\; \frac{\partial \left(\frac{v_s v'}{v v_s'} - 1\right)}{\partial v_\varepsilon'} > 0 \tag{24}$$

As investors over-extrapolate past performance more strongly, they will overreact to the fund past performance information more and thus relatively intensify their under-reaction to the skill information contained in their private information. In this way, the predictive ability of unit value-added on future fund performance become more negative with the increase of investor over-extrapolation bias. On the other hand, as investors over-extrapolate past performance more strongly, the aggregate flow will contain more irrational investor flow caused by underreaction to the investors' private information and therefore intensify the positive predictive power of the fund dollar flow on future performance.

D. Performance Benchmark

In our model, we focus on the net return adjusted against a benchmark, r_t. However, it's important to recognize that the benchmark employed in academic contexts may differ from the one utilized by mutual fund investors in practice. A study by Barber, Huang, and Odean (2016) highlights that investors tend to prioritize CAPM alpha over other risk-adjusted performance measures. A more recent work by Ben-David et al. (2022) challenges this previous finding and argues that investors are less sophisticated than previously assumed. This paper finds that investors do not use complicated risk models to adjust fund returns and are more likely to follow simple rules like Morningstar ratings. Given that our investigation revolves around mutual fund investors' investment decisions, it becomes crucial to consider the potential impact of the benchmark mismatch on our findings.

Consequently, we extend our model to encompass scenarios in which the benchmark adopted by mutual fund investors differs from the standard academic benchmark.

We assume that fund net return performance perceived by the investors is $r_t' = x_t - y_t' - f$, where x_t is the gross return, y_t' is the performance of the benchmark that investors have for evaluating return performance, and f is the fee. If investors adjust the market return, then y_t' is the return on the market. If investors adjust for peer returns, then it is the return on peer funds. If investors make no benchmark adjustment, then $y_t' = 0$. The true fund net return performance is $r_t = x_t - y_t - f$, where y_t is the performance of the true benchmark, e.g. benchmark index returns, risk model returns, etc. The gross return is then $x_t = r_t + y_t + f$.

Then solving the model with these extra assumptions, we find that

$$\begin{aligned}\mathbb{E}[r_2|x_1, S_1] = \frac{v_\varepsilon v_s' - v_s v_\varepsilon'}{v v_s'} \frac{r_1 q_0}{q_1} + \left(\frac{v_s v'}{v v_s'} - 1\right) \frac{(q_1 - q_0) f}{q_1} \\ - \frac{v_s v_\varepsilon}{v_s' v} (y_1 - y_1') \frac{q_0}{q_1}\end{aligned} \tag{25}$$

This result differs from the previous result in equation (13) in that the future fund performance is going to be jointly determined by unit value-added, scaled fee-growth and a third part, benchmark difference. Fund future performance can still be jointly predicted by unit value-added and scaled fee growth as long as we control for the benchmark difference between the academia and the mutual fund investors.

E. Empirical Implications

This model provides the following untested empirical implications.

1. The fund's future performance can be predicted when both the fund's past performance and the fund's past flows are taken into consideration.
2. The predictive abilities of the fund's past performance and the fund's past flows depend on the relative strength of different psychological biases.
3. The predictive abilities of the fund's past performance and the fund's past flows also depend on the availability of 'private' information on manager skills.

This model can also be used to gauge market sentiment. The model suggests that, given the predictive abilities of UVA and SFG, we are able to back out which psychological biases are dominating investors' mutual fund investment decisions. This approach can partly address the 'bias zoo' problem in behavioral economic research.

II. Data and Methodology

A. Data

We obtain mutual fund monthly returns and fund characteristics from CRSP mutual fund database. Carhart four-factor monthly returns are obtained from Kenneth French's website. We also collected the benchmark index for each fund from Prof. Cremer's website. Finally, we obtain the Morningstar ratings from Morningstar Direct. Our sample includes 5,905 U.S. actively managed equity funds between 1990 and 2020. Table 1 reports summary statistics of these observations.

The average size of mutual funds in our sample is 1388.88 million, while the median fund size is only 218.10 million. The average monthly net flow is 0.88%. The average fund age is 289.26 months (24.11 years), and 56% of the funds have either a front-end or back-end load. On average, U.S. actively managed mutual funds have an annual expense ratio of 1.21%. The monthly net returns of mutual funds are on average positive (0.78% per month). However, both the peer-adjusted net return and Carhart alpha are slightly negative (-0.01% peer-adjusted net return and -0.03% Carhart alpha per month). This confirms that the mutual fund industry, on average, does not generate risk-adjusted returns after the fee. The loadings on Carhart four factors are 0.9592, 0.1584, -0.0010, and -0.0047, respectively, suggesting that mutual funds, on average, hold the market portfolio with a slight tilt towards small stocks. Overall, our sample is comparable to previous studies.

B. Mutual Fund Performance

In the model, r_t is the benchmark-adjusted net return at time *t* and appears on both the left-hand side and right-hand side of the equation (13). Therefore, to avoid the serial correlation problem in the empirical tests, we use the model-free benchmark, the peer-group net return, as the benchmark for mutual fund performance in equation (13). Funds targeting the same benchmark index tend to have similar risks and styles. To construct the peer-group net return, we first obtain the mutual fund benchmark index from Prof. Cremer's website[3]. Then peer-group net return is calculated as the equal-weighted net return of all

[3] Prof. Cremer provides funds’ benchmark indices from 1979 to 2020. (https://activeshare.nd.edu/data/)

mutual funds that target the same benchmark index. Finally, fund peer-group-adjusted net return (PA) is calculated as follow.

$$\alpha_{\mathrm{i,t}}^{\mathrm{PA}} = R_{i,t}^{N} - \bar{R}_{i,t}^{peer} \tag{26}$$

, where R_{it}^{N} is the net return of fund *i* at month *t* and $\bar{R}_{i,t}^{peer}$ is the average net return of all mutual funds that target the same index as fund *i* at month *t*.

We also use Carhart model return as the benchmark when performing the portfolio tests, where there is less concern on the serial correlation in the estimation process of Carhart alpha. Following the convention in mutual fund literature, we regress monthly fund net returns on Carhart four-factors returns to estimate mutual fund factor loadings. We use a 24-month rolling regression window. Then Carhart model adjusted return (Carhart alpha) of fund *i* at month *t* is calculated as follow.

$$\begin{aligned}\alpha_{\mathrm{i,t}}^{\mathrm{Carhart}} = (R_{it}^{N} - R_{rf,t}) - \hat{\beta}_{\mathrm{mktrf,i}} * \left(R_{mkt,t} - R_{rf,t}\right) - \hat{\beta}_{smb,i} * R_{smb,t} \\ - \hat{\beta}_{\mathrm{hml,i}} * R_{hml,t} - \hat{\beta}_{\mathrm{umd,i}} * R_{umd,t}\end{aligned} \tag{27}$$

, where R_{it}^{N} is net return of fund *i* at month *t*, $\hat{\beta}_{\mathrm{mktrf,i}}$, $\hat{\beta}_{smb,i}$, $\hat{\beta}_{\mathrm{hml,i}}$, and $\hat{\beta}_{\mathrm{umd,i}}$ are the estimated factor loadings from the rolling regression, $R_{mkt,t}$, $R_{smb,t}$, $R_{hml,t}$, and $R_{umd,t}$ are the realized factor returns at month *t*, and $R_{rf,t}$ is the 1-month T-bill rate in month *t*.

D. Methodology

D.1. Testing the Model

According to **Proposition 2 – Proposition 4**, when investors are not fully rational, fund future performance can be predicted by unit value-added and scaled fee growth in a multiple regression. Therefore, we first constructed Unit Value-added and Scaled Fee growth measures as follow.

$$Unit\ Value\text{-}added_{i,t}(UVA_{i,t}) = \frac{\sum_{j=0}^{k} MTNA_{i,t-j} \times \alpha_{i,t-j}^{B}}{MTNA_{i,t}} \tag{28}$$

$$Scaled\ Fee\ Growth_{i,t}(SFG_{i,t}) = \frac{\left(MTNA_{i,t} - MTNA_{i,t-k}\right) \times f}{MTNA_{i,t}} \tag{29}$$

,where $\alpha_{i,t-j}^{B}$is the fund benchmark adjusted net return for fund *i* at month *t-j*, $MTNA_{i,t}$ and $MTNA_{i,t-k}$ are the fund asset under management for fund *i* at month *t* and month *t-k*, respectively. Therefore, $\sum_{j=0}^{k} MTNA_{i,t-j} \times \alpha_{i,t-j}^{B}$ represents the value created by the fund manager and $\left(MTNA_{i,t} - MTNA_{i,t-k}\right) \times f$ represents the incremental dollar fee collected during past *k* months.

We double-sort all mutual funds by unit value-added and scaled fee growth measured over the past 12 months into 25 (5 unit value-added groups × 5 scaled fee growth groups) portfolios. Then we examine the equal-weighted portfolio performance of these 25 portfolios in the next month.

If the investors are predominantly influenced by overconfidence, the portfolio return should increase with unit value-added quintile within each scaled fee growth quintile and decrease with the scaled fee growth quintile within each unit value-added quintile. On the other hand, if the investors are predominantly influenced by over-extrapolation bias, the portfolio return should decrease with the unit value-added quintile within each scaled fee growth quintile and increase with the scaled fee growth quintile within each unit value-added quintile. If the investors experience a slightly stronger over-extrapolation bias than overconfidence, the portfolio return should decrease with the unit value-added quintile within each scaled fee growth quintile and also decrease with the scaled fee growth quintile within each unit value-added quintile. If the investors are rational, we should not observe any return patterns for these 25 portfolios.

We also conduct panel regression of monthly fund performance on past unit value-added and past scaled fee growth, controlling for other fund characteristics. Based on our model, we would expect to see a significant positive coefficient for fund unit value-added and a significant negative coefficient for fund scaled fee growth if investors are predominantly influenced by overconfidence. However, if investors are predominantly influenced by over-extrapolation bias, we would expect to see a significant negative coefficient for fund unit value-added and a significant positive coefficient for fund scaled fee growth. If investors experience slightly stronger over-extrapolation bias compared to overconfidence, we would expect to see a significant negative coefficient for fund unit value-added and a significant negative coefficient for fund scaled fee growth.

The regression controls for fund age measured by the natural logarithm of age (in months), fund size measured by the natural logarithm of asset under management (in millions) at the month-end before the measurement period for unit value-added and scaled fee growth, lagged expense ratio, a load indicator that equals to 1 if any share class of the fund includes a front or rear load, portfolio size by the number of stocks in the portfolio, and standard deviation of fund net return over the past year. We also include the time-fixed effect in the regression and cluster the standard error on both time and fund. The regression is as follow,

$$\mathrm{\alpha}_{\mathrm{i,t}}^{\mathrm{PA}} = a_t + \beta_1 UVA_{i,t-1} + \beta_2 SFG_{i,t-1} + Controls_{i,t-1} + \varepsilon_{i,t} \tag{30}$$

, where $\alpha_{i,t}^{PA}$ is the peer-adjusted net return for fund *i* at month *t*, $UVA_{i,t-1}$ and $UFA_{i,t-1}$ are calculated using equation (28) and equation (29) over the past 12 months. The results are reported in Table 3.

D.2. Predicting Fund Future Performance

Based on **Lemma 1** and equation (15), we can construct a fund performance predictor, skill-competition measure (SC measure), as follow,

$$\mathrm{SC}_{i,t} = \widehat{\beta_{1,t}} UVA_{i,t} + \widehat{\beta_{2,t}} SFG_{i,t} \tag{31}$$

where, $\widehat{\beta_{1,t}}$ and $\widehat{\beta_{2,t}}$ are the coefficients estimated using regression (30) on past two-year observations of all mutual funds. This SC measure should be able to positively predict fund future performance.

We examine the predictive ability of SC measure using both portfolio and regression approaches. We first construct decile portfolios based on SC measure at each month-end and examine the long-short portfolio performance in the next month. Even though, in reality, we cannot short mutual funds, this trading strategy approach can still provide a straightforward indication of how well the SC measure predicts mutual fund performance. The results are reported in Table 4.

Next, we conduct the panel regression of future fund performance on the SC measure, controlling for other factors that could potentially affect the fund's future performance. The controls are the same as the ones included in equation (30). We also include the time-fixed effect in the regression and cluster the standard error on both time and fund. The regression is as follow,

$$\alpha_{i,t}^{PA} = \alpha + \beta\, SC_{i,t-1} + Controls_{i,t-1} + \varepsilon_{i,t} \quad (32)$$

The results are reported in Table 5.

D.3. Overconfidence vs. Over-extrapolation

Corollary 1 states that as investors become less overconfident, the coefficient for unit value-added decreases, and the coefficient for scaled fee growth increases. This implies that the coefficient for unit value-added is positively correlated with investor overconfidence, and the coefficient for scaled fee growth is negatively correlated with investor overconfidence. Similarly, **Corollary 2** implies that the coefficient for unit value-added is negatively correlated with investor over-extrapolation bias, and the coefficient for scaled fee growth is positively correlated with investor over-extrapolation bias.

We use the aggregate market return as proxies for investor overconfidence. Barber and Odean (2002) finds that high past return can make investors become more overconfident and thus trade more aggressively. Statman, Thorley, and Vorkink (2006) and Griffin, Nardari, and Stulz (2007) also identify strong positive relations between market returns and future trading activities. Therefore, we use market return during the measurement period as the proxy for investor overconfidence.

To test **Corollary 1**, we conduct the following regression.

$$\begin{aligned}\alpha_{i,t}^{PA} = \alpha + \beta_1 UVA_{i,t-1} + \beta_2 SFG_{i,t-1} + \lambda_1 UVA_{i,t-1} \times OC_{t-1} \\ + \lambda_2 SFG_{i,t-1} \times OC_{t-1} + OC_{t-1} + Controls_{i,t-1} + \varepsilon_{i,t}\end{aligned} \quad (33)$$

where OC_{t-1} is the proxy for investor overconfidence at time *t-1*.

Corollary 1 predicts a positive λ_1 and a negative λ_2 respectively if OC_{t-1} represents investor overconfidence. The controls are the same as the ones included in equation (30). We cluster the standard error on both time and fund.

There is yet a good proxy for investor over-extrapolation bias. Therefore, we are not able to test our **Corollary 2** in this paper.

III. Results

A.1 Testing the Model

To test the predictive abilities of unit value-added and scaled fee growth, we first double-sort funds into 25 portfolios based on fund unit value-added and fund scaled fee growth measured over the past 12 months. Then we examine the future performance of these 25 portfolios. The results are reported in Table 2. Panel A reports the fund's monthly peer-adjusted net returns for portfolios sorted by trailing 12-month unit value-added and scaled fee growth constructed using peer-adjusted net returns. Panel B reports the fund's monthly Carhart alpha for portfolios sorted by trailing 12-month unit value-added and scaled fee growth constructed using Carhart alphas.

From Panel A, we can see that the fund's monthly performance increases with the increase of past unit value-added within each scaled fee growth quintile. The top quintile mutual funds can generate 0.37% to 0.58% more peer-adjusted net returns than the bottom quintile mutual funds in the next month. The portfolios constructed using Carhart alphas as the performance measure yield similar results. Top quintile mutual funds earn 0.12% to 0.39% more Carhart alpha than the bottom quintile mutual funds. In addition, the fund's monthly performance mostly decreases with the increase of fund fee-added within each fund value-added quintile. The top quintile mutual funds underperform bottom quintile funds by 0.10% to 0.13% in peer-adjusted net return and 0.15% to 0.19% in Carhart alpha. The results are economically and statistically significant.

These results are consistent with **Proposition 2 - Proposition 4**, which state that when investors are only overconfident about their private information or when they are more overconfident about their private information than they over-extrapolate fund past returns, fund unit value-added positively predicts fund future performance and fund scaled fee growth negatively predicts fund future performance.

Next, we conduct a regression of fund future performance on fund unit value-added and fund scaled fee growth constructed controlling for fund characteristics according to equation (29). The unit value-added is constructed using the peer-adjusted net returns, and the results are reported in Table 3. Column (1) and Column (2) are consistent with the portfolio results and confirm the prediction in **Proposition 2 - Proposition 4**. Fund unit value-added significantly positively predicts future performance, and fund scaled fee growth significantly negatively predicts future performance in the multiple regression. A one percent increase in unit value-added will lead to a 0.01% increase in fund peer-adjusted net return in the next month and a one percent increase in fund scaled fee growth will lead to a 0.59% decrease in fund peer-adjusted net return in the next month. Including fund characteristics as controls does not eliminate the predictive power of fund unit value-added and scaled fee growth.

These results are both complementary to and different from the results in previous studies about fund performance persistence and the smart money effect. The unit value-added in our model is analogous to the fund performance, and the scaled fee growth is analogous to the dollar flow examined in previous studies. On the one hand, our results confirm the existence of funds with persistent performance and the predictive ability of funds past dollar flow (hence the smart money effect). On the other hand, these results also suggest that the predictive power of fund past performance and fund past dollar flow were not correctly specified in previous studies. As both fund past performance and fund past dollar flow are critical in determining fund future performance, the predictive ability of one factor, when used as the predictor for fund future performance alone, will be significantly tempered by the other factor. For example, if fund past performance were used to predict fund future performance alone, a high past performance can imply both high manager skill and investor overreaction to a piece of positive information. A similar argument can also be applied to the scenario of predicting fund future performance with fund past dollar flow alone.

A.2 Morningstar Ratings and Benchmark Returns

A recent study shows that mutual fund investors are naïve and do not use sophisticated models to adjust fund performance (Ben-David, et. al., 2022). The study finds that investment decisions made by mutual fund investors are more susceptible to the sway of simple guidelines such as Morningstar Ratings, as opposed to the performance metrics used in academia. Given our study's examination of mutual fund investor behavior, it is important to address the potential impact of Morningstar ratings and disparities in benchmarks on our findings. As a result, we further include the Morningstar ratings as a control in our main tests. However, due to data constraints, the inclusion of Morningstar ratings leads to a notable reduction in the number of observations. Nevertheless, the main results in Table 3 and Table 5 remain consistent.

Also, we address the effect of the benchmark difference between the one that real mutual fund investors use and the one that is used by academia in the model. We model a case where mutual fund investors use a different benchmark compared to the benchmark used by our study. The results show that fund future performance can still be jointly predicted by unit value-added and scaled fee growth as long as we control for the return difference between the benchmarks.

Therefore, we assume that investors are naïve to the point that they do not use any model to adjust fund return, which is supported empirically by Ben-David et, al. (2022). In this way, we can calculate the benchmark return differences and include them as controls in our main test in Table 3 and Table 5. The main results still hold.

A.4 Investment Style and Aggregate Mutual Fund Industry

In the model, we assume that investors are overconfident about their private information. Instead of private information about individual funds, it could also be private information about different investment styles or the active mutual fund industry as a whole. Therefore, we aggregate funds and examine the predicting power of unit value-add and scaled fee growth at the investment style level and at the mutual fund industry level, respectively. The results are reported in Table 4. Column (1) reports the results for aggregate investment style and Column(2) reports the results for aggregate mutual fund industry. We can see that the predictive powers of unit fee-valued and scaled fee growth are largely eliminated when funds are aggregated by investment style or by the entire industry. This suggests that investors do not over-extrapolate the return of a certain style or the return of the actively managed mutual fund industry. In addition, investors are not overconfident about the information about investment style and the actively managed mutual fund industry. Or investors simply do not have private information about investment style or actively managed mutual fund industry.

B. Predicting Fund Future Performance

Next, we examine the predictability of the SC measure constructed based on our model. We first estimate the coefficients for fund unit value-added and fund scaled fee growth using the past 24 months observations of all mutual funds and then construct $SC_{i,t}$ measure with estimated coefficients and realized unit value-added and scaled fee growth this month. Finally, we construct decile portfolios based on SC measure at each month end and examine equal-weighted and value-weighted portfolio performance in the next month. The results are reported in Table 5. We report the results for portfolios constructed using peer-adjusted net returns as the performance measure in Panel A and the results for portfolios constructed using Carhart alphas as the performance measure in Panel B.

The results in Table 5 show that the fund performance increases with the increase of the SC measure. The top decile portfolio constructed based on the SC measure using trailing 12-month peer-adjusted net return as the performance measure can generate a significant 0.14% peer-adjusted net return in the next month. In addition, the equal-weighted long-short portfolio earns a significant 0.22% monthly peer-adjusted net return. We also repeat the portfolio test using Carhart alphas as the performance measure. The results are consistent with the results using peer-adjusted net return as the performance measure. The equal-weighted long-short portfolio constructed using trailing 12-month Carhart alpha as the performance measure can earn 0.3% monthly Carhart alpha. The value-weighted results are weaker but also economically significant.

We also examine the cumulative 3-month, 6-month, 12-month, 24-month, and 60-month performance of the long-short portfolios based on the SC measure. The results are plotted in Figure 1. We can see that the cumulative portfolio performance of the long-short strategy based on the SC measure increases over time, suggesting the slow correction of the 'mispricing' on fund manager skills.

Next, we conduct panel regression (32), which tests the predictive ability of the SC measure controlling for other fund characteristics. The results are reported in Table 6. The SC measure is constructed using the trailing 12-month unit value-added and scaled fee growth. The results in Table 6 show that SC measure can significantly positively predict fund future performance. A one percent increase in SC measure constructed using trailing 12-month unit value-added and scaled fee growth can increase fund future peer-adjusted net return by 0.18% every month.

Overall, the results in Table 5 and Table 6 are consistent with **Proposition 2 - Proposition 4**, which state that SC measure can positively predict fund future performance when investors are not fully rational.

C. Investor Overconfidence vs. Over-extrapolation Bias

Next, we test **Corollary 1** by examining the correlation between the coefficient of unit value-added and investor overconfidence and the correlation between the coefficient of scaled fee growth and investor overconfidence. According to **Corollary 1**, when investors become more overconfident, they will overestimate the precision of their private signal more. In this way, the coefficient for fund unit value-added will become larger (more positive), and the coefficient for fund scaled fee growth will become smaller (more negative) as the overconfidence increases. Therefore, using a proxy for investor overconfidence, we would expect to see a positive coefficient for the interaction between fund unit value-added and investor overconfidence and a negative coefficient for the interaction between fund scaled fee growth and investor overconfidence in regression (34).

The results are reported in Table 7. Fund unit value-added and scaled fee growth are constructed using peer-adjusted net return measured over the past 12 months. The results show that the predictive power of fund unit value-added significantly positively comoves with investor overconfidence, and the predictive power of fund scaled fee growth significantly negatively comove with investor overconfidence. The results are consistent with the predictions in **Corollary 1** and show that the predictive ability of unit value-added and scaled fee growth are stronger as investors become more overconfident.

D. Institutional Investors Vs Retail Investors

Different investors can experience different psychological biases. Among the mutual fund investors, there are both sophisticated institutional investors and naïve individual investors. On the one hand, institutional investors can be more rational than individual investors and suffer from less bias when investing in mutual funds. On the other hand, institutional investors are more likely to obtain private information about the fund managers and become overconfident about their private information. To investigate the bias among different investors, we repeat the test in Table 3 using mutual funds with only one share class. The results are reported in Table 8.

There are 322,322 observations for funds with no specific share class, 53,423 observations for funds with only institutional share class, and 174,802 observations for funds with only retail share class. In Table 8, both funds without a specific share class and funds with only institutional share classes exhibit outcomes that align closely with those depicted in Table 3. Conversely, the results for funds exclusively featuring retail share classes are less robust, with the negative predictive significance of fund scaled fee growth no longer holding. These findings do not imply that retail investors are more rational compared to institutional investors. Instead, they may suggest that institutional investors are more likely to obtain private information about fund managers before committing to mutual funds and could be more susceptible to the influence of overconfidence bias. In contrast, retail investors could be equally influenced by both overconfidence and over-extrapolation biases. Consequently, the outcomes are less pronounced for funds exclusively catering to retail share classes.

E. Index Funds

As part of a robustness check, we replicated the tests conducted in Table 3 and Table 5 using index funds within the same sample period. The results are reported in Table 9. It is evident that the results for index funds in Table 9 significantly differ from those pertaining to actively managed mutual funds. The predictive ability of unit value-added and scaled fee growth for fund future fund performance is no longer present for index funds.

Nevertheless, this does not say that index fund investors are more rational than investors who invest in actively managed mutual funds. Index fund investors could also experience over-extrapolation bias or believe that index fund managers have skills. These psychological biases can also affect their flows and thus lead to preditivability of fund future performance. However, it would be beyond the scope of this study.

IV. Conclusion

In this study, we examine how investor overconfidence and over-extrapolation bias affect mutual fund flow and future performance. We first develop a model in which investors are overconfident about their private information and over-extrapolation fund past performance. The model shows that when investors are irrational, mutual fund flows can no longer eliminate fund outperformance effectively. Instead, fund future performance can be predicted by a variable that combines past fund performance, measured by fund unit value-added and fund flow activities, measured by fund scaled fee growth.

We test the model implications with a sample of U.S. actively managed mutual fund data. We find that controlling for fund flow activities using fund scaled fee growth, fund past performance measured by unit value-added can positively predict fund future performance. In addition, controlling for unit value-added, scaled fee growth can negatively predict fund future performance. The predictive power of fund unit value-added and fund fee-added covary significantly with investor overconfidence. We also construct an SC measure based on fund past performance and fund flow activities and test the predictability of this SC measure. The equal-weighted long-short strategies based on the SC measure can generate a significant peer-adjusted net return of 0.22% or a significant Carhart alpha of 0.3% every month. We also conduct panel regressions of fund future performance on the SC measure to control for other factors that could potentially affect fund performance. The results show that a one percent increase in SC measure over the past 12 month will increase fund peer-adjusted net return in the next month by 0.17%.

Overall, the evidence above is consistent with the hypothesis that investor overconfidence and over-extrapolation bias affect the allocation of capital among managers and equilibrium performance in the mutual fund industry. When investors supply capital inefficiently due to investor irrationality, fund performance is no longer unpredictable as stated in Berk and Green (2004). Moreover, investor overconfidence plays a primary role in investors' investment decisions, and fund future performance can be positively predicted by fund unit value-added and negatively predicted by fund scaled fee growth.

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Panel A: Fund Characteristics	N	Mean	STD	P25	Median	P75
MTNA	1060116	1388.88	6076.70	60.80	218.10	807.70
Total Flow	1060116	0.88%	34.99%	-1.51%	-0.39%	1.17%
Age	1060100	289.26	165.26	182.00	273.00	353.00
Load	1060116	55.82%	49.66%	0.00%	100.00%	100.00%
Expense Ratio	953121	1.21%	0.54%	0.90%	1.17%	1.50%
Number of Stocks	775705	161.76	378.66	43.00	76.00	141.00
Raw Return	1060116	0.87%	5.97%	-1.78%	1.22%	3.81%
Return STD	1060116	4.71%	3.56%	2.94%	4.18%	5.83%
Net Return	1060116	0.78%	5.97%	-1.86%	1.14%	3.73%
PA Net Return	1060116	-0.01%	3.65%	-1.02%	0.00%	0.99%
CAPM Alpha	1060116	0.00%	4.07%	-1.12%	-0.03%	1.06%
Carhart Alpha	1060116	-0.03%	4.26%	-0.90%	-0.04%	0.81%
MKTRF Loading	1060116	0.96	3.31	0.84	0.97	1.08
SMB Loading	1060116	0.16	2.72	-0.10	0.06	0.40
HML Loading	1060116	0.00	3.49	-0.21	0.00	0.22
UMD loading	1060116	0.00	8.39	-0.10	0.00	0.10

Panel B: Performance Correlation	Raw Return	Net Return	Peer-adjusted Net Return	CAPM Alpha	Carhart Alpha
Raw Return	1.00	1.00	0.63	0.56	0.54
Net Return	1.00	1.00	0.63	0.56	0.54
Peer-adjusted Net Return	0.63	0.63	1.00	0.88	0.83
CAPM Alpha	0.56	0.56	0.88	1.00	0.95
Carhart Alpha	0.54	0.54	0.83	0.95	1.00

Table 1: Descriptive statistics for the mutual fund sample obtained from the CRSP Survivor-Bias Free U.S. Mutual Fund Database. Panel A reports the fund characteristics statistics across fund-month observations. The sample includes all U.S. equity mutual funds that existed during January 1990 and December 2020. we exclude sector funds, international funds, specialized funds, bond funds, balanced funds, and index funds. we also remove observations with monthly asset under management less than $5 million. The final sample consists of 5905 fund-entities comprising 807, 709 fund-month observations. MTNA is the monthly total net asset under management in millions. Total Flow is calculated as $\frac{\mathrm{MTNA_t} - MTNA_{t-1}(1+r_t) - MGTNA_t}{MTNA_{t-1}}$, where $MGTNA_t$ is the increase in fund's TNA due to mergers during month t. Age is the number of months the fund exists after the first offering date. Load equals one if any share class of the fund contains a front-end or rear-end load. Expense Ratio is the weighted average annual expense ratio. Number of stocks is obtained from mutual fund's quarterly 13F reports. Peer-adjusted net return is measured as the difference between the net return of each mutual fund by the average net return of all mutual funds that target the same

benchmark index. The benchmark indices are obtained from Prof. Cremer's website (https://activeshare.nd.edu/). Loadings of the CAPM Model and the Carhart Four Factor Model are estimated using previous 24 months observations. we calculate monthly Carhart (CAPM) alpha by subtracting monthly net return by risk-free rate and estimated loadings time realized factor returns each month. Panel B reports the pairwise correlation among different performance measures.

Panel A: Peer-adjusted Net Return

Fund Unit Value-added	Fund Scaled Fee Growth 1	2	3	4	5	5-1
1	-0.55% ***	-0.58% ***	-0.60% ***	-0.44% ***	-0.55%***	-0.01%
	(-6.64)	(-8.99)	(-9.41)	(-6.43)	(-8.68)	(-0.08)
2	-0.34% ***	-0.43% ***	-0.43% ***	-0.43%***	-0.47% ***	-0.13% ***
	(-9.80)	(-9.72)	(-12.3)	(-10.3)	(-12.5)	(-2.98)
3	-0.25% ***	-0.33% ***	-0.34% ***	-0.33% ***	-0.36% ***	-0.10% **
	(-6.46)	(-8.16)	(-9.63)	(-7.62)	(-11.5)	(-1.97)
4	-0.23% ***	-0.26% ***	-0.32% ***	-0.27% ***	-0.22% ***	0.02%
	(-6.52)	(-6.04)	(-8.84)	(-6.73)	(-5.41)	(0.35)
5	-0.09% **	-0.15% ***	-0.13% **	-0.14% **	0.03%	0.10%
	(-2.27)	(-2.96)	(-2.29)	(-2.13)	(0.31)	(1.39)
5-1	0.46% ***	0.41% ***	0.39% ***	0.37% ***	0.58% ***	
	(4.16)	(4.15)	(4.21)	(3.36)	(4.45)	

Panel B: Carhart Alpha

Fund Unit Value-added	Fund Scaled Fee Growth 1	2	3	4	5	5-1
1	-0.15%*	-0.11%	-0.12% *	-0.13% *	-0.24%	-0.12%
	(-1.68)	(-1.49)	(-1.73)	(-1.89)	(-2.96)	(-1.39)
2	-0.07%	-0.08%	-0.10% ***	-0.11% **	-0.19% ***	-0.19% ***
	(-1.48)	(-1.48)	(-2.66)	(-2.17)	(-3.90)	(-3.06)
3	-0.02%	-0.08%	-0.06%	-0.06%	-0.09%**	-0.16% **
	(-0.39)	(-1.75)	(-1.76)	(-1.43)	(-2.12)	(-1.99)
4	0.03%	0.04%	-0.04%	0.07%	-0.10% **	-0.15% ***
	(0.54)	(0.85)	(-1.01)	(1.26)	(-2.03)	(-2.39)
5	0.09%	0.13% **	0.10%	0.07%	0.16% *	0.06%
	(1.22)	(2.24)	(1.78)	(0.92)	(1.77)	(0.62)
5-1	0.24% ***	0.12%	0.16%	0.19% **	0.39% ***	
	(2.57)	(0.98)	(1.63)	(2.07)	(3.63)	

Table 2: Monthly performance of portfolios double-sorted on fund unit value-added and fund-scaled fee growth. Funds are double-sorted into 25 portfolios by fund unit value-added and fund-scaled fee growth. The unit value-added in Panel A and B is calculated using the trailing 12-month peer-adjusted net returns, and the trailing 12-month Carhart alphas, respectively. The scaled fee growth in Panel A and B is calculated using the trailing 12-month management fee in dollar amount. The table reports the monthly performance of equal-weighted quintile portfolios, followed by t-statistics in brackets based on White's standard errors. The performance measure in Panel A is the peer-adjusted net returns, and the performance measure in Panel B is the Carhart alphas. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

VARIABLES	(1) PA	(2) PA	(3) PA	(4) PA	(5) PA
$\boldsymbol{Unit\ Value\ Add_{i,t-1}}$	0.0113*	0.0159**	0.0145**	0.0140**	0.0156**
	(1.69)	(2.24)	(2.12)	(2.12)	(2.24)
$\boldsymbol{Scaled\ Fee\ Growth_{i,t-1}}$	-0.586***	-0.580**	-0.541**	-0.344	-0.762***
	(-2.81)	(-2.23)	(-2.03)	(-1.57)	(-2.40)
$\boldsymbol{MS\ Rating_{i,t-1}}$				-0.000138	
				(-1.08)	
$\boldsymbol{Benchmark\ Return_{i,t-1}}$					0.00322
					(0.63)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$			-0.0523*	-0.0755***	-0.0619*
			(-1.92)	(-3.63)	(-1.84)
$\boldsymbol{Load_{i,t-1}}$			-0.000337	3.06e-05	-0.000276
			(-1.37)	(0.29)	(-0.98)
$\boldsymbol{Log(Mtna_{i,t-13})}$			-0.000230***	-0.000118***	-0.000241***
			(-4.05)	(-2.67)	(-3.98)
$\boldsymbol{Return\ STD_{i,t-1}}$			-0.00140	-0.00142	-0.00272
			(-0.27)	(-0.04)	(-0.57)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$			3.68e-07	1.78e-07	2.85e-07
			(1.52)	(0.88)	(0.98)
$\boldsymbol{Log(Age_{i,t-1})}$			0.000979***	0.000687***	0.000914***
			(4.09)	(4.74)	(3.53)
Observations	887,670	434,303	395,520	250,551	393,696
R-squared	0.003	0.003	0.003	0.016	0.003
Time FE	Yes	Yes	Yes	Yes	Yes
Style FE	No	Yes	Yes	Yes	Yes
Measurement Period	12m	12m	12m	12m	12m
Clustered STD	Yes	Yes	Yes	Yes	Yes

Table 3: Panel regression results of fund future performance on fund unit value-added and fund scaled fee growth. This table reports the results of regression (30). The dependent variable is the monthly peer-adjusted net return calculated according to equation (26). $Unit\ Value\ add_{i,t-1}$ is fund value-added over the measurement calculated according to equation (28). $Scales\ Fee\ Growth_{i,t-1}$ is calculated according to equation (29). $MS\ Rating_{i,t-1}$ is the Morningstar Rating for fund *i* last month. $Benchmark\ Return_{i,t-1}$ is the net return of fund *i*'s peer group last month. The expense ratio is the annualized expense ratio. $Number\ of\ stocks_{i,t-1}$ is the number of stocks in the fund's portfolio last quarter. $Return\ STD_{i,t-1}$is the standard deviation of fund's net return over the past one year. Load equals one if any share class of the fund contains a front-end or rear-end load. Fund age is measured in months. $\log(MTNA_{i,t-1})$ is the log of fund size (in millions) at the last month end before the measurement period. we include time fixed effect and cluster the standard error on date and funds. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.

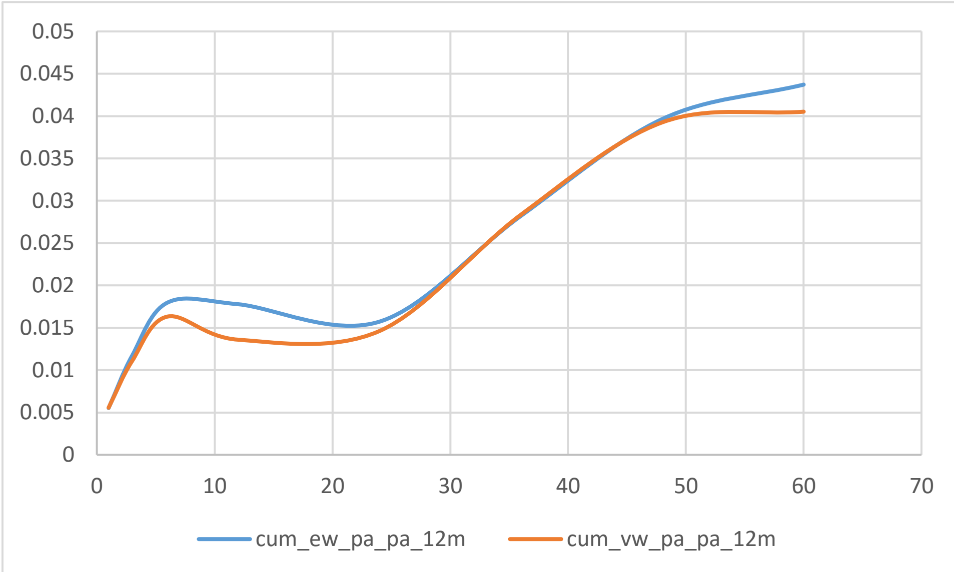
VARIABLES	(1) PA	(2) PA
$\boldsymbol{Unit\ Value\ Add_{i,t-1}}$	0.00134	-0.0142
	(0.64)	(-0.75)
$\boldsymbol{Scaled\ Fee\ Growth_{i,t-1}}$	1.159	-1.504
	(0.70)	(-1.30)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$	-0.461	-0.259
	(-1.81)	(-0.58)
$\boldsymbol{Load_{i,t-1}}$	0.00520*	-0.00130
	(1.80)	(-0.25)
$\boldsymbol{Log(Mtna_{i,t-1})}$	-0.277	-0.332*
	(-0.46)	(-1.78)
$\boldsymbol{Return\ STD_{i,t-1}}$	-0.112**	-0.0134
	(-2.32)	(-1.33)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$	0.000435	0.000968
	(0.72)	(1.29)
$\boldsymbol{Log(Age_{i,t-1})}$	-0.000879	-0.00234
	(-0.79)	(-0.45)
$\boldsymbol{Flow_{i,t-13}}$	-3.74e-05***	-9.61e-05
	(-3.24)	(-1.03)
Observations	4,775	372
R-squared	0.176	0.026
Time FE	Yes	Yes
Style FE	No	No
Measurement Period	12m	24m
Clustered STD	Yes	Yes
Robust STD	No	No

Table 4: Panel regression results for funds aggregated by the investment styles and the mutual fund industry. The dependent variable is the monthly value-weighted peer-adjusted net returns for different investment styles in Column (1). The dependent variable in Column (2) is the monthly value-weighted peer-adjusted net returns for the entire actively managed equity mutual fund industry. The control variables are all aggregate on the investment style level or the fund industry level weighted by fund size except for size, $\log(MTNA_{i,t-1})$. Size is calculated as the natural log of the sum of asset under management of all funds within the investment style for Column (1) and is calculated as the natural log of the sum of assets under management of all funds within the fund industry for Column (2). We include the time-fixed effect for regressions using funds aggregated by investment style and cluster the standard error on dates and investment styles. We report the robust standard error for regressions using funds aggregated by the industry. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.

SC_rank	Panel A: Peer-adjusted Net Return (1) EW	(2) VW	Panel B: Carhart Alpha (3) EW	(4) VW
Bottom	-0.10%	-0.14%	-0.16%	-0.19% *
	(-1.04)	(-1.36)	(-1.62)	(-1.86)
2	-0.08% *	-0.07%	-0.17% ***	-0.19% ***
	(-1.70)	(-1.43)	(-3.05)	(-2.34)
3	-0.05% *	-0.02%	-0.09% *	-0.10% *
	(-1.67)	(-0.39)	(-1.85)	(-1.86)
4	-0.02%	-0.01%	-0.09% **	-0.09%**
	(-0.58)	(-0.24)	(-2.32)	(-2.19)
5	0.03%	0.03%	-0.10% ***	-0.09% ***
	(1.06)	(1.07)	(-2.94)	(-2.54)
6	0.05%	0.07% **	-0.02%	-0.02%
	(1.85)	(2.15)	(-0.57)	(-0.59)
7	0.02%	0.06% *	-0.03%	-0.00%
	(0.92)	(1.86)	(-0.85)	(-0.06)
8	0.05%	0.06% *	0.03%	-0.01%
	(1.49)	(1.80)	(0.54)	(-0.11)
9	0.06%	0.07%	0.02%	0.02%
	(1.44)	(1.58)	(0.43)	(0.29)
Top	0.14% *	0.08%	0.13%	0.06%
	(1.85)	(0.98)	(1.63)	(0.71)
Top - Bottom	0.22% **	0.16%	0.30% ***	0.25% **
	(2.09)	(1.33)	(3.44)	(2.24)

Table 5: Equal-weighted and value-weighted decile portfolio performance constructed based on SC measure. SC measures are constructed using trailing 12-month peer-adjusted net returns in Column (1) and Column (2), and using trailing 12-month Carhart alpha in Column (3) and Column (4), respectively. The t-statistics are reported in brackets. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.

Panel A:



Panel B:

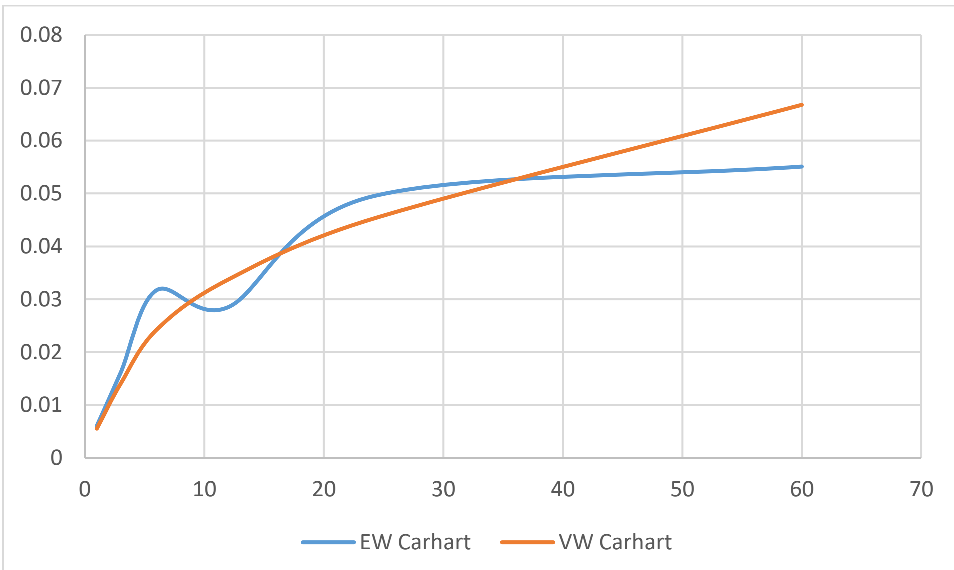


Figure 1: Cumulative performance of the long-short portfolios over time. Panel A and Panel B present the equal-weighted performance and value-weighted performance of a strategy that longs the top decile portfolio and shorts the bottom decile portfolio constructed based on the SC measure. In Panel A, the performance measure used to construct the SC measure and evaluate the portfolio performance is the trailing 12-month peer-adjusted net returns. In Panel B, the performance measure is the trailing 12-month Carhart alpha.

VARIABLES	(1) PA
$\boldsymbol{SC_{i,t-1}}$	0.177***
	(4.87)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$	-0.078***
	(-5.13)
$\boldsymbol{Load_{i,t-1}}$	-0.0002
	(-1.43)
$\boldsymbol{Log(Mtna_{i,t-1})}$	-0.0002***
	(-6.21)
$\boldsymbol{Return\ STD_{i,t-1}}$	0.005*
	(1.71)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$	0.0002***
	(3.73)
$\boldsymbol{Log(Age_{i,t-1})}$	0.0003***
	(2.86)
Constant	-0.0003
	(-0.59)
Observations	655841
R-squared	0.0004
Time FE	Yes
Measurement Period	12m
Clustered STD	Yes

Table 6: Regression results for the Skill-competition measure. $\mathrm{SC}_{i,t-1}$ is the skill-competition measure introduced in equation (31) for fund *i* at time *t-1*. We use the trailing 12-month peer-adjusted net returns as the performance measure when constructing SC measure. The expense ratio is the annualized expense ratio. $Number\ of\ stocks_{i,t-1}$ is the number of stocks in the fund's portfolio in quarter *t-1*. $Return\ STD_{i,t-1}$is the standard deviation of fund's net return over the past one year. Load equals one if any share class of the fund contains a front-end or rear-end load. Fund age is measured in months. $\log(MTNA_{i,t-1})$ is the log of fund size (in millions) at the last month end before the measurement period. we include time fixed effect and cluster the standard error on date and funds. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.

VARIABLES	(1) PA	(2) PA
$\boldsymbol{Unit\ Value\ Add_{i,t-1}}$	0.0000	0.0014
	(-0.01)	(0.18)
$\boldsymbol{Scaled\ Fee\ Growth_{i,t-1}}$	0.0929	-0.0893
	(0.44)	(-0.29)
$\boldsymbol{Unit\ Value\ Add_{i,t-1} \times MKT_{t-1}}$	0.0966***	0.0948***
	(3.70)	(3.41)
$\boldsymbol{Scales\ Fee\ Growth_{i,t-1} \times MKT_{t-1}}$	-2.5119***	-2.1268*
	(-2.65)	(-1.85)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$		-0.0536*
		(-1.95)
$\boldsymbol{Load_{i,t-1}}$		-0.0002
		(-1.09)
$\boldsymbol{Log(Mtna_{i,t-1})}$		-0.0003***
		(-4.94)
$\boldsymbol{Return\ STD_{i,t-1}}$		0.0016
		(0.1)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$		0.0000
		(1.03)
$\boldsymbol{Log(Age_{i,t-1})}$		0.0014***
		(5.58)
Observations	659595	659193
R-squared	0.0004	0.0002
Time FE	No	No
Performance Measure	PA	PA
Measurement Period	12m	12m
Clustered STD	Yes	Yes

Table 7: Investor sentiment and the predicting powers of fund unit value-added and scaled fee growth. Unit value-added and scaled fee growth are measured over the past one year. MKT_{t-1} is the aggregate market return over the past one year. The expense ratio is the annualized expense ratio. $Number\ of\ stocks_{i,t-1}$ is the number of stocks in the fund's portfolio in quarter *t-1*. $Return\ STD_{i,t-1}$is the standard deviation of fund's net return over the past one year. Load equals one if any share class of the fund contains a front-end or rear-end load. Fund age is measured in months. $\log(MTNA_{i,t-1})$ is the log of fund size (in billions) at the last month end before the measurement period. we cluster the standard error on date and funds. *, **, and *** denote significance at the 10%, 5%, and 1% level respective.

VARIABLES	(1) PA	(2) PA	(3) PA	(4) PA	(5) PA	(6) PA
$\boldsymbol{Unit\ Value\ Add_{i,t-1}}$	0.0147**	0.0149**	0.0103***	0.0106***	0.0133*	0.0136*
	(2.12)	(2.12)	(2.42)	(2.58)	(1.87)	(1.88)
$\boldsymbol{Scaled\ Fee\ Growth_{i,t-1}}$	-0.643**	-0.804**	-0.942*	-0.874*	-0.281	-0.472
	(-2.07)	(-2.24)	(-1.84)	(-1.77)	(-0.85)	(-1.24)
$\boldsymbol{Benchmark\ Return_{i,t-1}}$		0.00351		-0.00369		0.00469
		(0.70)		(-0.70)		(1.04)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$	-0.0546	-0.0555	0.318	0.321	-0.0828***	-0.0851***
	(-1.47)	(-1.47)	(1.07)	(1.08)	(-2.69)	(-2.72)
$\boldsymbol{Load_{i,t-1}}$	-0.000383	-0.000388	-0.00220	-0.00223	-6.69e-05	-7.72e-05
	(-1.22)	(-1.22)	(-1.38)	(-1.38)	(-0.47)	(-0.54)
$\boldsymbol{Log(Mtna_{i,t-13})}$	-0.000235***	-0.000233***	-0.000270**	-0.000273**	-0.000215***	-0.000216***
	(-3.60)	(-3.54)	(-2.15)	(-2.16)	(-3.13)	(-3.13)
$\boldsymbol{Return\ STD_{i,t-1}}$	-0.00250	-0.00265	-0.00836**	-0.00801***	-0.000575	-0.000920
	(-0.62)	(-0.66)	(-3.11)	(-2.98)	(-0.05)	(-0.08)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$	4.11e-07	3.91e-07	4.64e-07	4.74e-07	1.20e-06***	1.15e-06***
	(1.25)	(1.20)	(0.72)	(0.73)	(2.46)	(2.37)
$\boldsymbol{Log(Age_{i,t-1})}$	0.000908***	0.000904***	0.00279***	0.00280***	0.000760***	0.000758***
	(3.06)	(2.98)	(2.48)	(2.47)	(2.77)	(2.70)
Observations	322,322	320,571	53,423	53,307	174,802	173,877
R-squared	0.003	0.003	0.012	0.012	0.006	0.006
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Style FE	Yes	Yes	Yes	Yes	Yes	Yes
Share Class	No Class	No Class	Institution	Institution	Retail	Retail
Clustered STD	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Institutional Investors Vs. Retail Investors. This table repeats the test in Table 3 using actively managed mutual funds with only one share class. The results for mutual funds with no specific share class information are reported in Column (1) and Column (2). The results for mutual funds with only institutional share class are reported in Column (3) and Column (4). The results for mutual funds with only retail share class are reported in Column (5) and Column (6). The dependent variable is the monthly peer-adjusted net return calculated according to equation (26). $Unit\ Value\ add_{i,t-1}$ is fund value-added over the measurement calculated according to equation (28). $Scales\ Fee\ Growth_{i,t-1}$ is calculated

according to equation (29). $MS\ Rating_{i,t-1}$ is the Morningstar Rating for fund i last month. $Benchmark\ Return_{i,t-1}$ is the net return of fund i's peer group last month. The expense ratio is the annualized expense ratio. $Number\ of\ stocks_{i,t-1}$ is the number of stocks in the fund's portfolio last quarter. $Return\ STD_{i,t-1}$is the standard deviation of fund's net return over the past one year. Load equals one if any share class of the fund contains a front-end or rear-end load. Fund age is measured in months. $\log(MTNA_{i,t-1})$ is the log of fund size (in millions) at the last month end before the measurement period. we include time fixed effect and cluster the standard error on date and funds. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.

VARIABLES	(1) PA	(2) PA	(3) PA	(4) PA	(5) PA
$\boldsymbol{Unit\ Value\ Add_{i,t-1}}$	0.00623	-0.000154	-0.00211	0.0217	-0.00230
	(0.66)	(-0.01)	(-0.18)	(1.48)	(-0.20)
$\boldsymbol{Scaled\ Fee\ Growth_{i,t-1}}$	-2.127***	-0.741	-0.821	-0.898	-0.727
	(-2.95)	(-1.03)	(-1.18)	(-1.11)	(-1.05)
$\boldsymbol{MS\ Rating_{i,t-1}}$				1.15e-05	
				(0.04)	
$\boldsymbol{Benchmark\ Return_{i,t-1}}$					-0.000277
					(-0.05)
$\boldsymbol{Expense\ Ratio_{i,t-1}}$			-0.199**	-0.251***	-0.202***
			(-2.57)	(-2.95)	(-2.62)
$\boldsymbol{Load_{i,t-1}}$			0.000412	0.000300	0.000429
			(0.86)	(0.62)	(0.89)
$\boldsymbol{Log(Mtna_{i,t-13})}$			-0.000284**	-2.81e-05	-0.000253
			(-2.07)	(-0.18)	(-1.86)
$\boldsymbol{Return\ STD_{i,t-1}}$			0.0126	0.104**	0.0120
			(0.40)	(2.16)	(0.39)
$\boldsymbol{Number\ of\ Stocks_{i,t-1}}$			-1.48e-07	-1.38e-07	-1.45e-07
			(-0.73)	(-0.76)	(-0.72)
$\boldsymbol{Log(Age_{i,t-1})}$			0.000786	-0.000417	0.000707
			(1.46)	(-0.94)	(1.30)
Observations	142,419	86,030	77,879	19,308	141,658
R-squared	0.001	0.007	0.008	0.056	0.001
Time FE	Yes	Yes	Yes	Yes	Yes
Style FE	No	Yes	Yes	Yes	No
Measurement Period	12m	12m	12m	12m	12m
Clustered STD	Yes	Yes	Yes	Yes	Yes

Table 9: Index Fund. This table repeats the test in Table 3 using index funds The results for mutual funds with no specific share class information are reported in Column (1) and Column (2). The results for mutual funds with only institutional share class are reported in Column (3) and Column (4). The results for mutual funds with only retail share class are reported in Column (5) and Column (6). The de

pendent variable is the monthly peer-adjusted net return calculated according to equation (26). $Unit\ Value\ add_{i,t-1}$ is fund value-added over the measurement calculated according to equation (28). $Scales\ Fee\ Growth_{i,t-1}$ is calculated according to equation (29). $MS\ Rating_{i,t-1}$ is the Morningstar Rating for fund *i* last month. $Benchmark\ Return_{i,t-1}$ is the net return of fund *i*'s peer group last month. The expense ratio is the annualized expense ratio. $Number\ of\ stocks_{i,t-1}$ is the number of stocks in the fund's portfolio last quarter. $Return\ STD_{i,t-1}$is the standard deviation of fund's net return over the past one year. Load equals one if any share class of the fund contains a front-end or rear-end load. Fund age is measured in months. $\log(MTNA_{i,t-1})$ is the log of fund size (in millions) at the last month end before the measurement period. we include time fixed effect and cluster the standard error on date and funds. *, **, and *** denote significance at the 10%, 5%, and 1% level respectively.