Skin or Skim? Inside Investment and Hedge Fund Performance*

Arpit Gupta† **Kunal Sachdeva**‡

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Abstract

We document the role that inside investment plays in managerial compensation and fund performance. Merging against a comprehensive and survivor bias-free dataset of US hedge funds, we find that funds with greater investment by insiders outperform funds with less "skin in the game" on a factor-adjusted basis. We emphasize the role of capacity constraints in explaining this result: insider funds are smaller, are less likely to accept inflows in response to positive returns, and are more likely to be closed to outside investors. These results suggest that managers earn outsize rents by operating trading strategies further from their capacity constraints when managing their own money. Our findings have implications for optimal portfolio allocations of institutional investors and models of delegated asset management.

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†NYU Stern School of Business, Email: arpit.gupta@stern.nyu.edu
‡Columbia Business School, Email: kunal.sachdeva@columbia.edu

Delegated asset managers are commonly seen as being compensated through fees imposed on outside investors. However, access to profitable, but limited, internal investment opportunities can also be a form of compensation for managers. Consider the hedge fund industry, which manages more than $3 trillion in assets, of which $400 billion can be attributed to investments from insiders and related parties.[1] This large allocation of insider capital suggests that an important, and previously overlooked, component of hedge fund compensation is the channel of returns on personally invested capital. This paper examines insiders' decisions to allocate private capital to funds under their control, and the impact of this "skin in the game" on returns received by outside investors.

The role of managerial discretion over internal capital allocation across funds can be seen in the case of Renaissance Technologies.[2] The company's Medallion Fund is one of the most successful funds in history and is predominately a fund for insider investment (as we confirm in Figure I). News accounts of Renaissance Technologies emphasize how the company prioritizes strategies with greater excess returns and lower scalability in the Medallion Fund, while shifting strategies with lower return profiles (for reasons of scalability or staleness in execution) to other funds in the family characterized by greater outside investor participation and lower fees.

The scope of personal capital commitments can be seen in Table I, which lists the top hedge fund manager paychecks in 2016. In aggregate, the top-10 fund managers earned over $6.9 billion, reflecting a combination of not just management and incentive fees, but as well as gains on personally committed capital. Our Figure II examines the distribution of insider capital across the top-10 earner funds (of which James Simon at Renaissance was the top performer), and finds considerable discretion over private capital investment within these fund families. The role of this discretion in GP capital commitment has also been the subject of considerable investor and regulatory interest.[3]

[1] For the size of the industry, see figures provided by the Securities and Exchange Commission: https://www.sec.gov/reportspubs/special-studies/im-private-fund-annual-report-081514.pdf Inside investment is estimated using the inside ownership measure from Form ADV.

[2] See, for instance https://www.bloomberg.com/news/articles/2016-11-21/how-renaissance-s-medallion-fund-became-finance-s-blackest-box

[3] See Mary Jo White, SEC Chair on Oct. 16, 2015: "Examiners observed that some hedge fund advisers may not be adequately disclosing conflicts related to advisers' proprietary funds and the personal accounts of their portfolio managers. Examiners saw, for example, advisers allocating profitable trades and investment

This paper first proceeds by extending the Berk and Green (2004) framework to include several key features that better capture institutional features of compensation structures in hedge funds. In our model, managers face capacity constraints in determining the optimal level of invested capital, can choose to endogenously create new funds with different strategies, and can allocate internal capital across funds. When managing personal capital, managers internalize the fact that raising additional capital is dilutive to their investments in the sense that it causes the strategy to operate further from its optimum, lowering the returns for all existing investors.

This basic framework yields several key predictions about the relationship between inside investment and fund performance. We predict that when firms face a menu of investment strategies with different excess return and scalability: 1) Inside investment will be concentrated in particular funds within a family; 2) Funds with a greater percentage of inside investment are smaller, as they are further from their capacity constraint; and 3) Because they are operated further from their capacity constraint, funds with greater inside capital outperform on a risk-adjusted basis. Taken together, our model predicts that greater inside investment better aligns incentives between managers and investors and induces managers to limit the size of their funds, resulting in higher alpha even in equilibrium.

We examine these predictions on the relationship between inside investment and fund returns through a novel usage of a comprehensive and survivor bias-free dataset, Form ADV, provided by the Securities and Exchange Commission (SEC). This regulatory form requires all hedge funds with assets over $100m to disclose the fraction of fund assets held by insiders yearly at the fund level. We merge Form ADV data with numerous commercially available datasets on hedge fund returns to understand the connection between "skin in the game" and fund returns.[4]

We analyze the relationship between inside investment and hedge fund performance using a panel regression. Using both the Fama and French (1992) and Carhart (1997) factors, as well as the Fung and Hsieh (2004) seven factors, we control for factor exposure of returns

opportunities to proprietary funds rather than client accounts in contravention of existing policies and procedures." Also see BlueCrest: https://www.ft.com/content/4eb275f2-a4dd-11e5-a91e-162b86790c58.

[4]Including HFR, CISDM, eVestment, BarclaysHedge, and EurekaHedge.

at the fund level. We find that inside investment—as measured either by percentage or gross investment—remains an important predictor of excess returns even when comparing different funds *within* firms. An investor who changes their allocation from a fund with the mean inside investment to one with a standard deviation increase in inside investment will see a rise in excess returns of 1.26% annualized. This significant and economically large magnitude indicates that inside investment is an important, and previously neglected, cross-sectional predictor of hedge fund returns.

Having established the superior performance of insider investment funds, we investigate the main drivers of this result by examining standard return predictability and fund flow-performance specifications. We find strong evidence that funds with greater inside capital accept lower inflows, consistent with the hypothesis that managers limit fund inflows into funds with greater amounts of their own managerial capital in order to operate the fund closer to their optimum. Though our results on return predictability are less precise, we find suggestive evidence that insider funds also exhibit greater return predictability (particularly among funds with higher returns); also consistent with the idea that managerial discretion over fund inflows enables superior performance. The joint behavior of fund flows, performance, and inside investment suggests that capacity constraints are an important driver of hedge fund performance; and that managers of hedge funds choose to deploy less capital (and so gain greater alpha) when their own personal capital is involved.

Additional evidence for the role of active discretion over fund flows comes from the subset of funds which are closed to outside investors. The presence of these funds is a challenge for conventional models of delegated asset management, as managers are leaving money on the table by forgoing the management fees earned on additional capital. We find that such funds strongly outperform—delivering 2–4% additional excess returns yearly. Such strong performance suggests that outside investors are in fact rationed from fund participation. Notably, such funds closed to outside investors are disproportionately funded by inside capital. The presence of such high-skin, closed-to-outsider funds provides strong evidence for the operation of our proposed mechanism: that fund managers will allocate private capital in vehicles in which fund inflows are more tightly managed in order to operate strategies closer to their optimum, resulting in greater excess returns.

Next, we examine the heterogeneity across funds. Consistent with the role of managerial discretion over capacity constraints, our results are driven by funds engaged in specialist roles, arbitrage strategies, and equity funds that might be expected to deploy trading strategies subject to diminishing returns to scale.

We also investigate alternate explanations for our results, such as superior information on the part of fund managers and agency conflicts. Our tests suggest that these alternate factors are unlikely to fully explain our results. While we cannot fully rule out the relationship between inside investment and other fund attributes, understanding inside investment through the lens of fund capacity constraints appears to best explain our results.

Finally, we investigate whether insiders are able to "cream skim" outside investors through fund formation and strategic capital allocation. Specifically, we use an event study framework to analyze firms that begin as a single-fund firm and create a new fund. This transition is illustrated in Figure III. The generation of a second fund provides a test case to analyze the effects of inside investment on fund performance, because insiders have a discretionary choice of private capital allocation: 1) Keep their money in the old fund, and invite outsiders to invest in the new fund; or 2) Move internal capital into the new fund. The two cases present differing predictions on the performance level of the initial fund: when inside capital remains in the original fund, we expect the original fund to outperform relative to when insiders move their capital out of the newly formed fund. We find evidence consistent with this hypothesis, suggesting the possibility of "skimming" motives on the part of fund managers.

Our results come with several caveats which we emphasize here. Though we establish inside ownership as an important predictor of excess returns and highlight the role for capacity constraints in understanding this result from a theoretical and empirical perspective, it is possible that other mechanisms operate in addition to the ones we emphasize. We discuss in section I.C possible mechanisms behind our result. It is possible that inside investors are better informed about the skill of various fund managers and deploy capital accordingly; alternatively, high-skin-in-the-game funds may be less subject to agency conflicts and engage in superior research analysis (see Berk and van Binsbergen (2017)). Inside

investment may also serve as a signal to outside investors by providing costly evidence of managerial commitment. Finally, it is possible that higher returns from high skin-in-the-game funds are a proxy for some risk factors (unrelated to either the Fama-French, Carhart, or Fung-Hsieh factors, such as tail risk as mentioned in Agarwal et al. (2017)). While more research is needed to establish the precise reasons for the outperformance of high inside-investment firms, we emphasize that our work provides novel evidence that managerial ownership is an important predictor of cross-sectional fund performance in ways consistent with a basic model including capacity constraints and inside investment.

Our work is related to literature assessing the role of inside investment as a predictor of cross-sectional returns among mutual funds. The papers closest to ours are Khorana et al. (2007), Evans (2008), Chen et al. (2008), Cremers et al. (2009), and Ibert (2017), which find evidence that greater insider investments improve mutual fund performance. By contrast, we explore inside investment in the context of hedge funds, which feature substantially greater amounts of internal investments in a less regulated industry. Unlike mutual funds, hedge funds invest in a broader variety of strategies with potentially higher—and less scalable—rates of return. While the literature on mutual funds has emphasized the role of inside investment as a signaling device; our results on the hedge fund industry point instead to a role for moral hazard in explaining the relationship between inside investment and returns.

Other papers investigating skin in the game in hedge funds include Ackermann et al. (1999), which documents substantial managerial investment in hedge funds and Qiu et al. (2016), which finds no relationship between inside investment and hedge fund failure rates. Papers examining hedge fund personal stakes and outcomes include Brown et al. (2008), which uses a single cross-section of hedge fund inside investment and finds that high-skin-funds exhibit worse returns and are more likely to exhibit conflicts of interest. Ozik and Sadka (2015) analyzes the role of managerial investment on fund flows. Our paper differs by providing a much more comprehensive series of managerial investments drawn from regulatory filings, and investigating the role of inside investment in a complete dynamic panel of hedge funds. We find substantial evidence that high-skin-funds outperform low-

skin-funds, and explore the mechanisms of this result within a Berk and Green (2004) style context.

Other research in mutual funds has investigated the role of skill and ability of delegated asset managers. Recent papers such as Kosowski et al. (2006), Koijen (2014), Berk and van Binsbergen (2015) find evidence of mutual fund managerial skill in portfolio selection, with Berk and van Binsbergen (2015) emphasizing a value-added measure of managerial skill and Koijen (2014) adopting a structural approach. French (2008) suggests delegated asset managers add little value, while Fama and French (2010) suggests instead that few managers outperform on a factor-corrected basis. This paper instead focuses on the managerial skills of hedge fund managers, and find suggestive evidence that high-skin-funds systematically outperform on a risk-adjusted basis.

This paper also relates to the literature examining the role of fund families. Related papers include Massa (2003), which documents strategy differentiation across funds in a family; Berk et al. (2017), which examines the allocation of talent across funds within a family; while Sialm and Tham (2017) analyzes the relationships between the performance of funds and their overall management companies. Our research expands on this literature by highlighting the differential allocation of internal capital within a family of funds and the link to within-family performance.

Our work is also related to the literature on financial compensation and incentives. Previous papers have explored the compensation contract structure of investment advisors (such as Das and Sundaram (2002)), or investigated empirically the relationship between manager pay and performance (such as Ma et al. (2016), and Ibert et al. (2017)). The closest papers to ours examine the role of managerial contract structure on hedge fund performance, such as Agarwal et al. (2009) and Burasachi et al. (2014), and the connection between managerial compensation and fund size (such as Yin (2016)). Relative to this literature, we emphasize that managers have another option for personal compensation—investing their own private capital—and examine both the theoretical and empirical implications.

Underpinning the motivation of this paper, our model and analysis of managerial skill is also related to the equilibrium modeling approach of Berk and Green (2004), and Berk

and van Binsbergen (2017), evidence on capacity constraints, as in Ramadorai (2013), and funding constraints as in Homberta and Thesmar (2014). We build on this literature by decomposing capital contributions into insider and outsider sources and including the returns on internally invested capital as a part of the overall compensation of the fund manager. Our work is also related to the information spillover model in Glode and Green (2011), which also focuses on hedge funds and examines return persistence in a theoretical context.

In the context of the literature on financial intermediation compensation, we emphasize that access to superior investable opportunities helps explain why financial intermediaries—particularly hedge funds—appear to be so highly compensated even in the face of stiff competition. Our findings are relevant in understanding the recent rise in inequality among the top 1%, who are disproportionately financial managers of capital (See Kaplan and Rauh (2013), Philippon and Reshef (2012), and Alvaredo et al. (2013)).

Finally, our work also contributes to the broader literature on ownership, firm performance, and agency conflicts. Berle and Means (1932), Jensen and Meckling (1976), Fama and Jensen (1983), and Holmstrom (1985) have analyzed the consequences of firm capital structure and internal ownership on governance and agency conflicts as well as firm performance. Demsetz and Lehn (1985) and Himmelberg et al. (1999) find little evidence that managerial ownership affects firm performance, while Randall et al. (1988) emphasize the non-monotonicity of the relationship between board of directors' ownership and firm performance. Porta et al. (2002) find that corporate ownership is more concentrated in climates of weaker investor protection. Our work extends this literature, which has largely analyzed non-financial companies, by focusing on delegated asset managers and emphasizing the conflict between managers and investors regarding the internal capital structure and fund formation decisions of hedge fund managers in the presence of capacity constraints. Decisions of funds to open up additional funding to outside capital (in order to earn management fees) have material consequences on the returns of existing investors. We find, both in our model and in the data, that firms extract considerable surplus through the allocation of internal capital to funds which do not hit their capacity constraint, representing a potential conflict of interest between hedge fund managers and investors.

The remainder of the paper is organized as follows. Section 1 outlines our data and empirical strategy, and also comments briefly on the nature of corporate governance in hedge funds as well as mechanisms. Section 2 presents our main results, while Section 3 concludes. The Appendix contains further details on our model and auxiliary results.

I Data and Empirical Strategy

I.A Data

Our dataset combines regulatory Form ADV filings with commercial hedge fund return series from HFR, eVestment, BarclaysHedge, Eurekahedge, and CISDM. Form ADV is a required regulatory disclosure form used to register with both the Securities and Exchange Commission (SEC) and state securities authorities. Reporting under Form ADV is governed by the US Investment Advisers Act of 1940, as amended by Dodd-Frank. Disclosure requirements under this form have changed over the years. In the period from 1996–2011, funds with assets under management below $25 million, or fewer than 15 clients, were generally exempt from registration. Hedge funds in this period frequently used complex fund structures to evade disclosure even when assets were above this threshold.

Private fund reporting increased in 2005, when the SEC went to court to force funds to count all investors as clients. Though courts ultimately struck down the SEC's interpretation, disclosure through Form ADV increased throughout this period. Our primary sample is formed after 2011, after changes in required disclosure imposed by Dodd-Frank. Under prevailing regulations, all investment advisors—including hedge funds—are now required to file a Form ADV with the SEC if they (1) reach a $100 million threshold for assets under management for a typical fund, (2) reach a $150 million threshold if the firm has only private clients, (3) have over $25 million in assets and are not subject to examination in their home states (states that do not require examination currently include New York and Wyoming). Subsequent to their initial filing, firms must refile once a year (as long as their assets under management exceed $25 million), or if there have been changes in material information since the last filing.

We obtain Form ADV from the SEC over the period 2011–2016. We link Form ADV information together with information on hedge fund returns obtained from a combination of five datasets: HFR, eVestment, BarclaysHedge, Eureka Hedge, and CISDM. We begin the merge with HFR, eVestment and BarclaysHedge, which contain for many firms an SEC identifier common to both the commercial hedge fund datasets and Form ADV. If we do not have an SEC identifier, we next look for close matches (selecting only perfect matches) among firm and fund names in both datasets, after eliminating extraneous stop words (such as LLC, LP, etc.).

In 2012, Form ADV was updated to include questions about the internal investment of their funds. Figure IV shows a sample Form ADV for Renaissance Technologies.[5] Panel A captures firm-level information for the filing firm, Renaissance Technologies LLC. Panel B identifies a specific fund as listed in Section 7.B.(1), in this case Medallion Fund, L.P. Panel C of IV displays the precise question we draw on from Section 7.B.(1), question 14 of Form ADV: "What is the approximate percentage of the *private fund* beneficially owned by you and your *related persons*." This question asks funds to disclose the percentage of investment stakes in the fund which can be attributed in ultimate ownership to "related persons."

Summary Table II shows basic summary information about both our core Form ADV dataset taken from 2016, while Table III reports information on our merged sample. The broad ADV sample is able to establish key statistics about the overall size and scope of the entire hedge fund industry beyond prior work. Figure V demonstrates our merge rate across the range of firm ownership. We find that funds with complete inside investment (100 percent) and no inside investment (0 percent) exhibit worse merge rates into our ADV dataset. These funds also pose additional identification questions—either outsiders cannot invest, or insiders have chosen not to invest in these funds. For these reasons, we focus the remainder of our analysis on funds in the interior of the internal investment distribution: between 1 and 99 percent inside investment, inclusive.

A breakdown of "related parties" is provided in Table IV, which illustrates all possible responses for which parties constitute related parties. The most common response is

[5]Form ADV is publicly available through the SEC's website, https://www.adviserinfo.sec.gov/.

"Sponsor of GP,"[6] suggesting that the definition of related party most often corresponds to a vehicle used by the actual managers or general partners of the fund. Alternately, related parties can include other closely-related entities, such as asset investment by a broker/dealer. A separate set of questions asks the legal name of all related parties: these entities are typically closely related to the management company, share a supervised person three quarters of the time, and over half of the time share a common physical office. Despite the limitations of this measure in exactly calculating managerial stakes, we document that related parties are typically vehicles for fund investment by the general partners, and typically represent asset management on behalf of closely-related entities that can be considered "inside capital."

Panel B of Figure I illustrates the density of fund responses across different fund vehicles for our example of Renaissance Technologies, and demonstrates a clear dispersion of fractional inside investment across different funds within the firm family. Figure II illustrates other sample inside investment distributions across funds for selected well-known hedge funds. The common pattern is one in which hedge funds operate a variety of vehicles with varying degrees of inside investment. The dispersion of inside investment is consistent with our model (see Appendix A), which predicts that insiders do not deploy capital evenly across funds within their family, but instead preferentially allocate inside capital in certain funds as a function of the excess return and scalability of investment strategies.

Panel A of Figure VI illustrates the density of responses on inside investment across our full merged dataset. Panel B of Figure VI shows the distribution of assets under management attributable to inside investment, shown on a log-dollar scale.

I.B Conflicts and Disclosure

In this section we comment briefly on the legal obligation of managers regarding their internal investments. Hedge fund operating agreements demand few fiduciary obligations of managers to prioritize one fund over another, or to prioritize funds with their own

[6] We verify that results hold when we subset on firms for which this is true.

internal capital on the same basis as funds with a greater preponderance of outside capital. As noted in Nowak (2009) and quoted in Morley (2014), the manager:

> is required to devote to the [fund] only that amount of time and attention that the [manager] in its sole discretion deems reasonably necessary to achieve the [fund's] objectives.

Discretion is typically left in the hands of the manager to handle any conflicts of interest across classes of investors, different funds in a family, or in accepting additional outside capital. Corporate governance within hedge funds is deliberately minimal due to strong exit rights among investors, and restrictions on investment to classes of accredited or well-informed investors.

I.C Mechanisms

In this section, we outline the key possible mechanisms underlying the relationship between inside investment and fund performance from our model (see Appendix A), as well as other complementary explanations.

1. *Size Performance Tradeoff:* Our model's explanation for the role of inside investment as a predictor of cross-sectional fund performance relies on the tradeoff between managerial compensation through fee income on delegated asset management and returns on privately invested capital. With limited commitment, managers cannot credibly commit to not increasing the size of their fund in the future to the point that the excess returns to investment strategies are driven down to zero. Personal capital commitments better align the incentives of managers and outsiders, and provide greater incentives for managers to scale their funds less aggressively in a manner which results in greater returns for all investors.

2. *Moral Hazard:* Another possible mechanism driving the relationship between fund performance and inside investment is the possibility for managers to allocate additional attention or trade differently on funds which have greater amounts of privately

invested capital. While our main proposed explanation highlights one aspect of this—the ability for managers to preferentially manage fund size on funds managing private capital—managers can potentially change other attributes of funds managing private capital. These include allocating additional attention or superior managerial quality to these funds, or executing superior trading strategies. Potentially, funds can take different risks on funds managing private capital than on funds managing the capital of outside investors.

3. *Superior Information:* An alternate, and complementary, explanation for the relationship between inside investments and fund performance is that inside investors are simply better informed about managerial ability within the fund family, and allocate their capital to the better fund managers.

4. *Signaling:* One potentially offsetting role for managerial capital allocation to funds relies in the role of public signaling. Fund managers, particularly for less established funds, may need to demonstrate private capital commitments in order to convince outside investors of fund quality. When managers are required to hold costly private stakes in order to demonstrate quality and earn management fees on outside capital; inside investment could potentially be a poor predictor of ultimate fund performance. As Form ADVs are commonly used by outside investors to assess fund quality, managerial stakes in this context are unlikely to be purely "cheap talk" but reflect verifiable and costly personal commitments.

These channels need not be mutually exclusive; for instance, the greater the role of moral hazard or risk-shifting effects in driving managers to exert effort or allocate trades differentially depending on private capital investments; the more private information there will be on the success of different funds within a family.

In subsequent analysis, we will first establish the role of inside investment as a predictor of cross-sectional hedge fund performance, focusing on return variation within the fund family. We find support for our main hypothesis that managerial control over fund sizing appears to help describe the superior performance of insider-managed funds, but cannot exclude the possibility that other mechanisms also play a role.

I.D Empirical Strategy

I.D.1 Main Specification

Our main specification asks whether inside investment results in greater risk-adjusted fund-level returns. To do so, we adopt a two-step approach. In the first step, we estimate a time-series regression of excess returns on factor exposures. In the second step, we consider both a panel regression (which allows us to control for firm and year fixed effects) as well as a standard Fama and MacBeth (1973) cross-sectional regression which relates excess returns from fund specific factors to inside ownership and other variables.

First, we run a return regression, taking as our benchmark the Fung and Hsieh (2004) 7-Factor Model:

$$\begin{aligned} r^e_{it} \equiv r_{it} - r_{ft} &= \beta_{1,i} S\&P_t + \beta_{2,i}(SC - LC)_t + \beta_{3,i} 10Y_t + \beta_{4,i} CredSpr_t \\ &+ \beta_{5,i} BdOpt_t + \beta_{6,i} FXOpt_t + \beta_{7,i} ComOpt + \varepsilon_{it} \quad i = 1, \ldots, N \end{aligned} \tag{1}$$

In this specification, we consider excess returns ($r_{it} - r_{ft}$) to be the net returns after fees minus the risk-free rate, as we take the standpoint of an institutional investor investor interested in allocating across the broad investable universe of fund managers. This monthly time-series analysis is run for each of N funds in order to generate fund-specific factor loadings. The Fung and Hsieh (2004) factors are widely used in hedge fund research, including Fung et al. (2008) and Patton and Ramdorai (2013).[7]

We restrict our sample to funds for which we have at least 24 months of data, and which have at least $20 million in Gross Asset Value. We exclude Fund-of-Funds because their inside investment is relatively limited, and the scope for investment is radically different. Because Fund-of-Funds invest in other investment vehicles, rather than underlying securities, we do not expect the same patterns of diminishing returns to manifest themselves. We

[7]These factors are: 1) an equity market factor — the S&P 500 Index monthly return (S&P), 2) A size-spread factor — the Russell 2000 Index monthly return - S&P 500 (SC-LC), 3) a bond market factor — the monthly change on the 10-year Treasury constant maturity yield (10Y), 4) a credit spread factor — the monthly change in the Moody's Baa yield - 10-year Treasury constant maturity yield (CredSpr), 5) a bond trend-following factor (BdOpt), 6) a currency trend-following factor (FXOpt), and 7) a commodity trend-following factor (ComOpt). Additional details on the factors can be found at: http://faculty.fuqua.duke.edu/~dah7/DataLibrary/TF-FAC.xls.

also expect flow-performance and return persistence to work very differently with these investment advisors. We also exclude funds with either 0 or 100 percent inside ownership. We find that funds with complete inside investment (100 percent) and no inside investment (0 percent) exhibit worse merge rates into our ADV dataset. These funds also pose additional identification questions—either outsiders cannot invest, or insiders have chosen not to invest in these funds. For these reasons, we focus the remainder of our analysis on funds in the interior of the internal investment distribution: between 1 and 99 percent inside investment, inclusive.[8]

We also consider the Fama-French and Carhart 4-Factor model, which is more commonly used in mutual fund research:

$$r_{it} - r_{ft} = \alpha_{it} + \beta_{1,i} RMRF_t + \beta_{2,i} SMB_t + \beta_{3,i} HML_t + \beta_{4,i} MOM_t \varepsilon_{it} \quad i = 1, \ldots, N \tag{2}$$

The factor exposures allow us to compute an average excess return α_{it} for each month and fund, shown here for the Fama-French and Carhart 4-Factor model (comparably, we estimate a Fung and Hsieh (2004) excess return α_{it}^{FH}):

$$\alpha_{it}^{FFC} = r_{it}^{e} - \hat{\beta}_{1,i} RMRF_t + \hat{\beta}_{2,i} SMB_t + \hat{\beta}_{3,i} HML_t + \hat{\beta}_{4,i} MOM_t \quad i = 1, \ldots, N \tag{3}$$

With the monthly estimates of risk-adjusted returns, we next estimate Fama and MacBeth (1973) cross-sectional regressions against fund characteristics, including our measure of ownership:

$$\alpha_{it} = \phi + \gamma Ownership_{i,t-1} + \mathbf{X}'_{\mathbf{i,t}} \Theta + \varepsilon_{it} \tag{4}$$

The key variable of interest is γ, which captures the predictive role of greater inside investment on excess returns. To measure ownership, we use both the percentage of the fund that consists of insider investment (our preferred measure, corresponding to the measure our model suggests is the most relevant) as well as the gross insider exposure. This measure of ownership is drawn from annual ADV forms, and represents the ownership

[8] Our analysis is robust to the exclusion of funds with zero or 100 percent inside ownership, the inclusion of Fund-of-Funds, and the inclusion of smaller funds.

stake from the prior year. Additional controls in $\mathbf{X}$ include controls for fund age, size, and strategy.

Though standard in the mutual fund literature, a key limitation of the Fama and MacBeth (1973) cross-sectional specification is that it does not allow us to control for time and firm fixed effects. To do so, our baseline specification is a panel regression of fund and firm characteristics against excess returns:

$$\alpha_{it} = \phi + \gamma Ownership_{i,t-1} + \mathbf{X'_{i,t-1}}\Theta + Firm_i + Year_t + \varepsilon_{it} \tag{5}$$

The key difference is that in this specification; our key coefficient of interest, γ, captures the impact of an additional dollar of inside investment on excess return *relative* to another fund in the same family (i.e., within the same firm) and year with less inside investment. This allows us to control for all other invariant firm and time characteristics which might otherwise drive excess returns. Standard errors are clustered at the month level.[9]

To test for the relationship between ownership and size, we perform a comparable analysis regressing the assets under management of funds against the fraction of inside investment:

$$AUM_{it} = \psi Ownership_{it-1} + \delta Firm_i + \eta Year_t + \varepsilon_{it} \tag{6}$$

The ψ coefficient here captures the relationship of size and fractional inside investment, within firm and year.

I.D.2 Fund-Flow Sensitivity and Return Predictability

Following prior literature, such as Chevalier and Ellison (1997), we define fund flows using net flows $r_{i,t}$ as:

$$Flow_{it} = \frac{AUM_{it} - (1 + r_{it}) \cdot AUM_{i,t-1}}{AUM_{i,t-1}} \tag{7}$$

[9]See Petersen (2009).

Using this definition, we also test standard fund-flow sensitivities:

$$\begin{aligned} Flow_{it} &= \eta \text{High Insider Ownership}_{it-1} + \beta_1 \alpha_{it-1} \times \text{High Insider Ownership}_{it-1} \\ &+ \beta_2 \alpha_{it-2} \times \text{High Insider Ownership}_{it-1} + \beta_3 \alpha_{it-3} \times \text{High Insider Ownership}_{it-1} \\ &+ \delta_1 \alpha_{it-1} + \delta_2 \alpha_{it-2} + \delta_3 \alpha_{it-3} + \mathbf{X'_{it}}\theta + Firm_i + Year_t + \varepsilon_{it} \end{aligned} \tag{8}$$

In these specifications, time is measured quarterly. Other controls in $\mathbf{X}$ include: leverage, lagged fund size, management fees, performance fees, redemption period, high watermark, lagged flows, and fund formation and strategy fixed effects.[10] The key coefficient of interest is β_1: whether funds with high inside ownership (defined as inside investment above the median) exhibit less flow-performance. Lower flow-performance would indicate that when funds with greater inside investment accept less additional funding in responsive to better prior performance.

Similarly, we also test for return predictability:

$$\begin{aligned} \alpha_{it} &= \eta \text{High Insider Ownership}_{it-1} + \beta_1 \alpha_{it-1} \times \text{High Insider Ownership}_{it-1} \\ &+ \beta_2 \alpha_{it-2} \times \text{High Insider Ownership}_{it-1} + \beta_3 \alpha_{it-3} \times \text{High Insider Ownership}_{it-1} \\ &+ \delta_1 \alpha_{it-1} + \delta_2 \alpha_{it-2} + \delta_3 \alpha_{it-3} + \mathbf{X'_{it}}\theta + Firm_i + Year_t + \varepsilon_{it} \end{aligned} \tag{9}$$

The key prediction is that β_1 would be positive: suggesting that funds with high inside investment exhibit higher persistence in returns.

II Results

II.A Regression Results

We start with regressions that control more closely for fund factor exposure. Our model suggests that, within a firm, funds with a greater proportion of inside capital will outperform because managers internalize the capacity constraints of the investment strategy when

[10] Following Getmansky et al. (2015).

accepting new capital. Funds with greater inside capital retain greater alpha, in equilibrium, because managers maximize profits by not accepting additional outside capital to the capacity limit of the investing strategy.

To analyze the role of inside investment and risk-adjusted returns, we examine in Table V fund-level regressions as outlined in section I.D, above. In Panel A, we focus on a panel specification using as the key regressor the percent of a fund's asset under management that can be attributed to insider investment against excess returns. In columns (1)-(2), we measure excess returns using a 7-factor model in the first stage, and show the results of a second stage regression of inside investment against excess returns. We find that inside investment is statistically associated with excess returns. This relationship persists in our preferred specification in column 2, which controls for year and firm effects. Additional fund level controls include: a size control (log of gross asset value), the fund's inception year, and the fund's strategy. Our estimates in that column suggest that a fund with a 1 percentage point increase in inside investment experiences a 0.48 basis point higher excess return per month; relative to another fund in the same family and year of observation with the same strategy, size, and inception year.

Scaling our result; we find a 1.26% increase in alpha per year for a fund with a standard deviation increase (22%) in the amount of inside investment relative to another fund in the same firm with similar characteristics. These results are quite large quantitatively, and suggest a strong importance for internal investment as a predictor of cross-sectional fund performance. The larger magnitude and significance of results when controlling for firm fixed effects suggests the importance of discretionary fund allocation by insiders: there is high dispersion of fund returns within firms in our sample, and insiders choose which investment strategies to pursue in which funds, and which funds to invest in. Our results suggest that their private capital is more likely deployed in funds that outperform others within the family.

We find similar results in columns 3 and 4, which use the Fama-French and Carhart 4-factor model to adjust for excess returns. Appendix Figures B.1 and B.2 plot estimated factor exposures for both sets of models. We also find comparable results in Panel B, in

which we examine the *gross* amount of inside investment, rather than the fractional amount, while also controlling for size and other fund-level characteristics. These results are equal-weighted and make a series of sample restrictions outlined in the section above. To test for robustness of these restrictions, in Table XIII in the appendix, we include funds with 0 or 100 percent inside investment; as well as a specification which value-weights our main specification by Gross Asset Value (measured reliably for all funds from ADV data). We find comparable results in these samples.

In Panel C of Table V, we also examine a Fama-MacBeth cross-sectional regression. In this specification, as outlined above, we do not control for firm or year fixed effects. However, we also find comparable results in these specifications across both the 7-factor and 4-factor models, illustrating the robustness of our result that greater inside investment is associated with superior performance.

These results are subject to several important caveats. First, while these results suggest that fund-level inside investment predicts superior excess returns, the relationship might not be causal. It may well be that our measure of inside skin in the game is a proxy for other fund-level characteristics. Another important caveat is that we are not able to fully control for whether our results are driven by some element of risk or are instead due to agency conflicts within the firm. Despite our attempts to control for risk using the benchmark fund factors, it is also possible that the outperformance of high skin-in-the-game funds is due to a novel risk factor. To further analyze the mechanisms driving our main result, we examine fund decisions along other dimensions.

II.B Main Mechanism: Capacity Constraints

Having established that investment by insiders predicts fund outperformance, we next consider the possible drivers of this relationship. In order to investigate the source of relative outperformance of high investment funds, we are guided by our model (discussed in Appendix A), which yields key predictions on the mechanisms behind inside investment and fund performance.

First, we consider how lagged excess returns relate to asset flows to funds. Figure VII plots a non-parametric relationship between lagged returns and fund inflows by funds

with a greater or lesser degree of insider investment measured at a quarterly frequency. Insider funds are defined as those with a greater-than sample average amount of fraction of fund assets attributable to insiders. Flows are winsorized at a 1% level.[11]

The figure illustrates that outsider funds exhibit a standard fund flow-performance relationship as documented in prior research on hedge funds and mutual funds. However, insider funds demonstrate a different profile: insider funds that experience positive excess returns do not exhibit as subsequently high inflows, consistent with the idea that high performing funds with greater insider capital manage funds further away from their capacity constraint by restricting inflows after good returns.

The fact that high-skin funds do not attract higher inflows is strong evidence in our setting against signaling-based explanations of the role of inside investment. If personal stakes by managers were necessary to attract additional capital; we would expect that funds with greater inside investment might attract additional funds; particularly when prior returns were high. Instead, we find that high-skin funds do not scale up as much as outsider funds when returns are high. Instead, these results point to a role for moral hazard or information-based explanations for superior performance.

Complementing the results on flow performance, Figure VIII plots a non-parametric relationship between excess returns over time. Though these results are not as statistically precise, and we are unable to reject comparable performance of outsider and insider funds; we nonetheless find suggestive evidence for greater return predictability for insider funds. Greater persistence of high returns for insider funds would indicate that insider funds are able to consistently generate superior performance.

Table VI illustrates the flow performance and return predictability specifications, as outlined in equations 8 and 9. The independent variable in these specifications is the same (lagged excess returns, interacted with an indicator for funds with high insider investment); the dependent variable is either fund flows or subsequent excess returns.

We find in column (1) that greater lagged excess returns predict lower flows among funds with greater inside investment, suggesting that insider funds do not accept as much

[11] For all flow-based analysis, we exclude eVestment from our sample due to unreliable NAV information from this data provider.

flows in response to positive returns. Column (2) of this table suggests that funds with greater inside investment are also much less likely to accept any additional inflows in responsive to past superior performance. Column (3) of this column regresses lagged excess return interacted with high inside investment on current excess return. Though we cannot statistically reject equality, we find suggestive evidence that greater inside investment is associated with greater persistence in excess return among insider funds. This joint relationship between flows, performance, and excess return is suggestive that insider funds differ in their management of outside capital in ways consistent with their operation further from the capacity constraint to generate superior performance.

However, a limitation of this analysis is that it examines fund flows in equilibrium: we do not know whether inflows are low in high performing insider funds because managers are actively restricting inflows, or whether outsiders prefer not to allocate flows to these insider funds—perhaps, because they are less informed.

To explore the role of active capital rationing, we focus in Table VII on a sample of funds for which we are able to establish the role of managerial discretion in accepting capital. In this table, we examine funds which are explicitly closed to outside investors, as reported by commercial databases. In columns (3)-(6) of this table, we find extremely strong evidence that funds that are closed to outside investors strongly outperform. In these specifications, we regress a dummy variable for funds open to investors against excess returns measured using a 4- or 7-factor model, finding that funds closed to outside investors outperform by 0.23-0.45 % each month, corresponding to 2-4% a year in excess returns.

Funds which do not accept additional inflows are able to generate strongly superior performance. This strong performance is strongly suggestive that outsiders would like to enter these funds, and are being actively rationed out of them. However, these funds then pose a challenge for view of delegated asset managers—why do managers leave money on the table by not accepting outside investors into these funds and taking management fees?

A potential resolution to this puzzle is suggested in columns (1)-(2) of this table. In these specifications, we examine the relationship between inside investment and funds which are open to investors. We find that funds which are closed to investors are substantially more likely to have a greater concentration of inside investment.

The presence of these funds closed to investors, which instead invest disproportionately insider money in ways that generate strongly superior performance, provides strong support for our main mechanism of fund size rationing in order to operate further from capacity constraints, and the tradeoff between superior returns earned on personally invested capital and management fees earned on larger amounts of outside capital.

II.C Robustness

II.C.1 Heterogenous Treatment Effects

Figure IX illustrates the main effect (as in column 2 of Panel A Table V) by fund categories. Panel A of this figure plots the coefficient of inside investment against excess return by categories as measured in our set of commercial hedge fund datasets. The main effects are driven by funds that engage in specialist absolute return strategies, arbitrage strategies, and equity funds. Within equity funds (Panel B), effects are driven by long-short funds. These fund strategies more plausibly feature capacity constraints in their investment strategies. By contrast, effects are insignificant among fund-of-funds and CTAs, which are typically associated with lower capacity constraints.

In Figure X we examine a quantile regression in which we examine the relationship between inside investment and fund performance across the distribution of inside investment. We plot the coefficient for percentage inside investment when regressed against Fama-French and Carhart excess returns (controlling also for size) across the quantiles of the distribution of inside investment. We find that our results are largely being driven by funds with higher levels of inside investment; those funds for which inside capital provides a substantial component of the capital base, for which we expect to see the highest-powered incentives.[12]

In Table VIII we examine our basic regression across different fund size levels. We re-run our specification (2) from Panel A in Table V across the quantiles of the fund size

[12]Our findings are weaker if we exclude high inside-investment funds from our sample. When we impose a $500m cutoff and restrict to funds with inside investment of $< 50\%$, we find similar results as in the analysis in Kruttli et al. (2017) based on a linkage of Form PF-ADV. However, our focus is on the larger universe of hedge funds, including those smaller funds not required to file Form PFs and those funds with substantial inside investment stakes.

distribution. We find significant effects for the top two fund size quantiles (corresponding to fund sizes of at least $126 million).

II.C.2 Fund Size

We also analyze the role of size and inside investment. Again, we hypothesize in our model that a key mechanism driving the superior performance of insider funds is their smaller size, due to decreasing returns to scale in investment technologies. To test this hypothesis, in Table IX, we regress the size of the fund against a measure of proportional inside investment. In column 2 of Panel A, we focus on our matched dataset and find that an additional percent of inside investment is associated with a $4–8 million smaller fund. This relationship persists when we examine a specification where the dependent variable is the log of assets under management in columns 3–4.

We are also able to run this specification on the Form ADV dataset only, in Panel B. These specifications use the field "Gross Asset Value" derived from fund-level information in Form ADV. Gross asset value differs from assets under management in that it does not subtract out the value of short positions from the portfolio, and so overestimates true fund size. Despite the limitations of this measure, using this field as a dependent variable enables us to avoid losing observations on the merge between our Form ADV dataset and the commercial hedge fund datasets. Results are very similar when not restricting on funds that merge into commercial hedge fund datasets: we find in column 2 that within a firm, funds with an additional percent of inside investment are around $20 million smaller in gross asset value. These results provide additional support for the model: inside investment funds are both smaller and outperform, suggesting that managers do not hit the limits of the capacity constraints of their investment strategy when their own private capital is deployed. The reluctance to accept additional outside capital on these funds explains why they continue to outperform and gain excess returns, even in equilibrium.

II.D Superior Manger Information

An alternate and complementary mechanism in explaining our main result that greater insider investment predicts higher excess returns is that managers have superior private

information on the abilities of fund managers than do outside investors, and so deploy personal capital to the superior managers. To test this hypothesis, we estimate the following specification in Table X:

$$\alpha_{it} = \beta InsiderInflow_{i,t-1\to t} + \gamma OutsiderInflow_{i,t-1\to t} + \varepsilon_{it} \tag{10}$$

This specification tests whether *changes* in insider investment predict excess returns. We find that changes in neither inside nor outside flows predict excess returns. While this test is not fully conclusive regarding the channel of superior inside information, this result suggests that insiders do not appear to be able to time their capital allocation decisions in ways that predicts future excess returns. Put differently: levels of inside investment, rather than changes, predict future returns. In conjunction with the results on fund flows and performance, this result is perhaps unsurprising: fund insiders appear to frequently extract funds from their best performing funds, rather than further invest, in order to continue to operate funds further from their capacity constraint and gain excess returns.

II.E Event Study

The results from the previous section provide evidence of a role for insider investment in driving fund returns and suggest that the possibility of insider investment should be seen as a critical component of the compensation of managers in addition to management and incentive fees. They raise the prospect that fund managers may seek to further take advantage of this relationship by further steering clients into lower performing funds.

We explore this possibility in Figure XI, which conducts an event study in the aftermath of the creation of a new fund among firms which previously only had one. The creation of an additional fund presents two possibilities for fund managers: they can either keep their internal capital invested in the original fund (using the new fund to attract new capital); or they can shift their own capital to the new fund (and market the original fund to investors). If the amount of insider capital is an important determinant of fund performance, we expect different fund performance in the *original* fund under the two cases. If managers are shifting their capital outside of the fund, we expect the performance of the original

fund to deteriorate (since managers are no longer as invested in success of the fund). If, on the other hand, managers keep their capital in the original fund, the performance of the original fund should remain strong.

To test this possibility, we focus on all cases in which a hedge fund, which previously only operated one fund, opens a second. We isolate two cases: one in which the new fund has less internal investment than the original (the new fund has "low skin"), and another in which the new fund has more internal investment than the original. We plot cumulative returns of the original fund for the two-year window both before and after the fund creation date. We track the returns on the original fund to avoid the issue of incubation bias (Evans, 2010) which would be posed by analyzing the returns of the newly generated fund.

Our results suggest that fund performance is relatively similar before the event date for the original fund, regardless of whether the firm subsequently creates a new fund with high or low internal investment. Differences grow more pronounced in the aftermath of fund creation. We find that when the new fund has "low skin"—suggesting that managers keep their internal capital in the original fund—fund performance suffers relative to when the newly create fund has "high skin." We expect to see this difference because managers are more invested in the success of the initial fund if their capital remains deployed in the fund. If their own capital has moved to a different fund, performance tends to suffer in the window after fund creation.[13]

Though these results are not fully conclusive, they are suggestive of the possibility of "skimming" motives on the part of fund managers. If managers are able to shift their internal investments across funds within the same family, they seem able to focus their investments on successful funds, while steering outside capital into the lower performing funds. These results therefore provide additional context to our model and previous empirical results, suggesting that active decisions made by fund managers regarding fund creation and where capital is deployed play a role in determining returns for outside investors.

[13] In a Difference-in-difference regression, the interacted term of High Inside×Post has a coefficient of 0.969 and a standard error of 0.214, which is significant at the 1% level.

To be clear, this analysis does not distinguish whether this is due to insiders having better information on which fund managers can outperform relative to outsiders, or because managers devote more effort when greater amounts of personal capital are on the line. Despite the multiple possible explanations, we emphasize that our result provides novel evidence on the role of inside investment in shaping fund performance as new funds are created.

II.F Firm-Level Equity

In addition to the choice of investing personal capital in the fund alongside outside investors, managers also have the option of investing in equity at the firm level. Analysis of the ownership structure of the partnerships that comprise typical hedge funds has been limited due to scarce data. In this section, we use Form ADV data to shed light on the ownership structures of hedge funds.

Figure XII illustrates the imputation process for firm-level equity. We use fractional ownership codes, found on Schedules A and B of Form ADV. These ownership fields track both direct and indirect owners, allowing us to examine the ultimate beneficial owners of hedge fund structures, even when shielded behind shell structures such as LLCs. A limitation of our analysis is that ownership codes are fractionally allocated (i.e., ownership fields will track an owner with a stake between 10%-25% of the firm's equity). We tabulate for this reason a minimum and maximum estimate of the firm's equity, illustrated in Panel A of Figure XII.

Panel B of this figure plots a histogram of the Herfindahl-Hirschman index (HHI) measure of dispersion in firm-level ownership. Many hedge funds feature no dispersion in ownership (are beneficially owned by only one individual or entity); however many firms have fractional ownership.

In order to investigate the implications of dispersion in firm-level ownership and its relation with fund-level inside investments, we regress both measures in conjunction in Table XI. Column 3 of this table suggests that inside investment at the fund level remains a significant predictor of excess returns, even when controlling for measures of firm-level

ownership. In addition to fund-level inside investment, we find that the number of equity owners (as a measure of the dispersion in a hedge fund family's ownership structure) negatively predicts excess returns. While this result would be consistent with the idea that dispersion in a firm's equity structure is a sign of agency frictions and internal firm conflict, other explanations might also potentially explain the relationship between the dispersion in firm-level equity ownership and fund performance. Despite the limitations of our measures of firm-level equity, we emphasize that our paper is the first to our knowledge to examine measures of insider capital allocations for a comprehensive sample of hedge funds at the level of fund allocation, as well as firm-level equity contributions.

II.G Managerial Fees

In our model, we take fees to be fixed. In Table XII, we examine the importance of this assumption by regressing inside investment against measures of fees—both the managerial fee (a percentage of assets under management) as well as the performance fee (typically a proportion of returns in excess of some benchmark). We find that inside investment is generally uncorrelated with fees, especially once we add additional controls. In an alternate analysis, we control for fees in our main specification and find our results are unchanged. These result suggest that differential fees cannot explain the relationship between inside investment and post-fee returns.

III Conclusions

The ability to access and allocate capital to profitable, but highly limited, investment opportunities within the companies they oversee is a substantial element of fund manager compensation. However, this has rarely been explored in empirical and theoretical analysis of delegated asset management. We explore how the possibility of inside investment alters fund performance in the context of an equilibrium model along the lines of Berk and Green (2004). Our model highlights the tradeoff between management fees earned by managing funds close to their capacity constraint, and earning excess returns on private capital invested in strategies further from capacity constraint;, as well as the role of inside

investments in better aligning incentives between managers and investors. Our model yields clear predictions on the role of inside investment and fund performance: we predict that when intermediary firms have access to a variety of different strategies that vary along the dimensions of excess return and scalability, managers will differentially allocate private capital across funds at their disposal to maximize private returns. The model predicts that we should find a dispersion of inside investment across funds, and that greater inside investment should predict excess returns and smaller fund size.

We take these predictions to the data using a comprehensive and survivor bias-free dataset of hedge fund characteristics taken from Form ADV. We document novel patterns of inside investment in hedge funds by related parties, which typically include sponsors of the general partners and closely-related entities, and find confirmation of our hypothesis that firms—including several prominent hedge funds—typically operate a variety of funds with varying degrees of internal investment.

To better understand the relationship between inside investment and returns, we begin with an implementable hedge fund investment strategy that selects high inside-investment funds. We find this strategy outperforms a portfolio invested in funds with low insider allocations. We further analyze the role of inside ownership by regressing excess returns (controlling for the Fama-French factors and the Carhart factor, as well as the Fung-Hsieh seven factors) against measures of ownership. We find that funds with higher internal investment have greater excess returns, even when we control for firm fixed effects. Our results are large in magnitude, that a fund with a one standard deviation increase in inside investment relative to the mean will provide an additional 1.46% of excess returns annually.

We find that high inside-investment funds have both different fund flow-performance and return predictability characteristics compared with funds largely catering to outside investors. In response to very positive excess returns, they do not accept as many inflows of capital as do outsider funds, and in tandem experience greater persistence of high excess returns. The joint relationship between internal investment, fund flows, and performance suggests that funds better manage capacity constraints when managers have personal capital at stake, leading to superior performance. This finding is consistent with our model

explanation that insider funds operate at a smaller scale because managers internalize the costs of fund expansion.

We also find suggestive evidence that fund managers are able to strategically deploy fund creation and private capital allocation to further "skim" investors. We find performance follows inside investments – when internal assets are shifted to newly created funds they tend to outperform; however when managerial commitment remain with the original fund, the returns tend to persist. Overall, we find that funds that rely more on insider money outperform funds that do not "eat their own cooking."

These results, taken as a whole, provide powerful support for our hypothesis that hedge funds face capacity constraints in their operations, and differentially allocate capital across their funds to maximize profits, depending on the mix of inside and outside capital. Unlike in mutual funds, where inside investment is far smaller in scale and acts as a signaling device to attract additional investment, the scope for inside investment for hedge funds appears to have a substantial impact on operating performance through a moral hazard channel. When funds rely on outside capital, managers are compensated primarily from managerial fees and leave little value to outside investors. Greater reliance on internal financing better aligns incentives of managers and outside investors, leading them to leave substantial "slack" in fund size and operate strategies on a lower scale, thereby receiving excess returns, even in a competitive equilibrium.

Our results contribute to ongoing debates regarding the presence of managerial alpha and financial rents. Many observers are puzzled at the apparently outsize rents earned by financial intermediaries such as hedge funds, even in the wake of apparently strong competition and the role of fund inflows on diminishing returns. In turn, these managerial rents have driven top-end wealth and income inequality (see Kaplan and Rauh (2013)). We suggest a possible reconciliation of these facts can be found in examining the option that fund managers have of not only of earning management and performance fees, but also of deploying their own capital in funds they manage.

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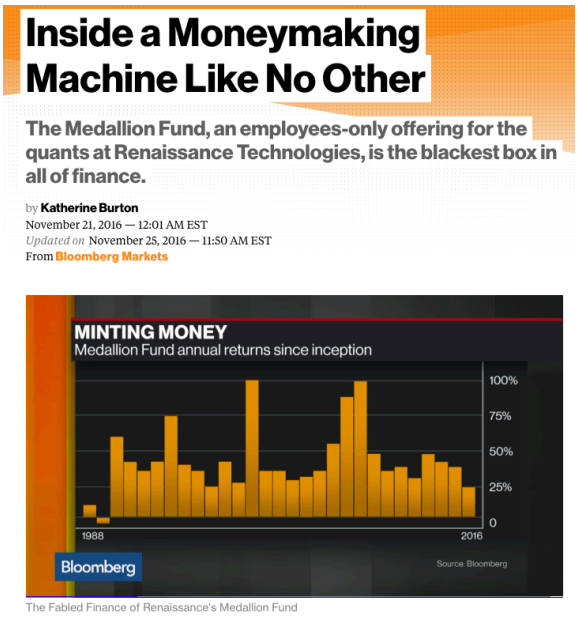
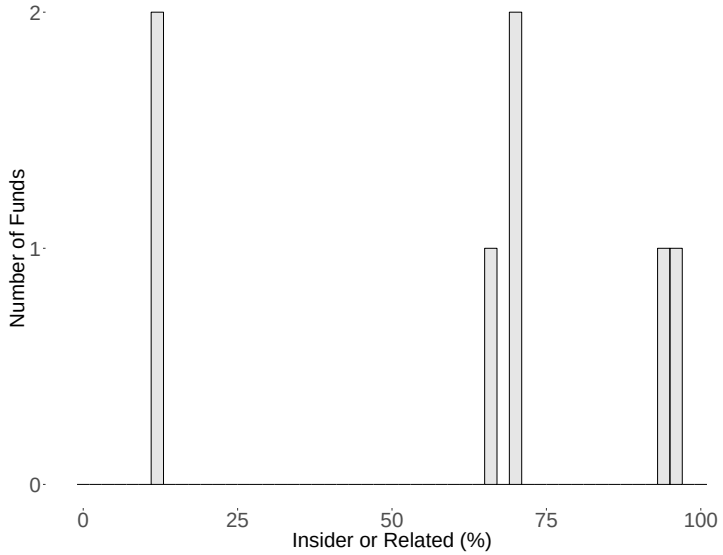


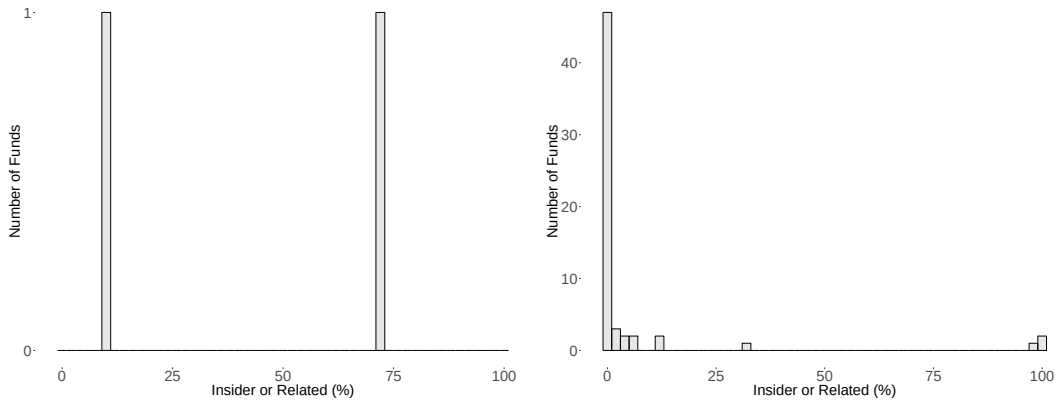
Panel A: Bloomberg Article Highlighting Rentech Returns



Panel B: Within-Fund Investment Distribution

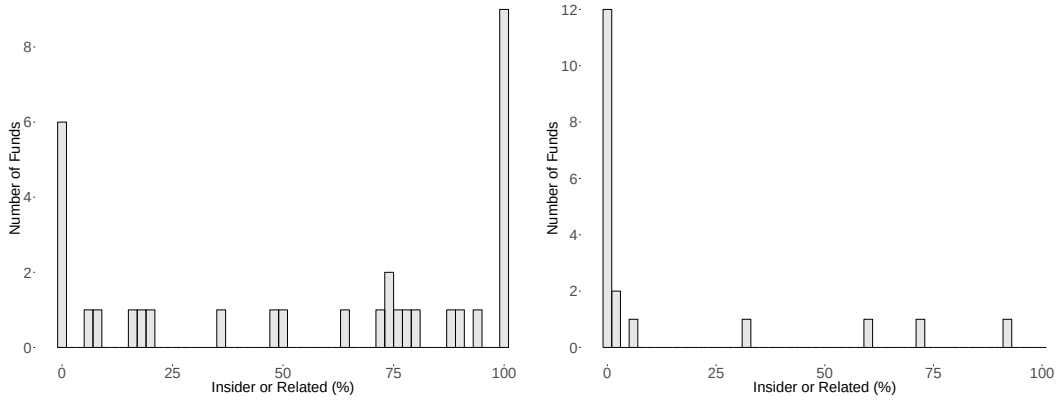
FIGURE I **Anecdotal Evidence, Relating Performance to Insider Investment**

This figure highlights the performance and heterogeneity of insider ownership. Panel A shows a Bloomberg article from November 21, 2016 discussing Renaissance Technologies' highly successful insider fund, the Medallion Fund. Panel B is a histogram of percent insider capital across all funds (> $100m) within Renaissance Technologies from Form ADV showing the heterogeneity of insider investment.



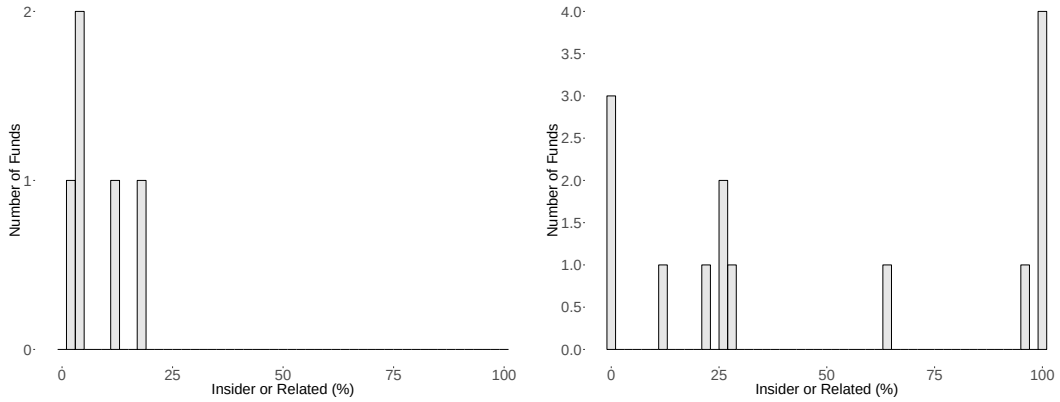
(a) Appaloosa LP

(b) AQR Capital Management



(c) BlueCrest Capital Management

(d) Citadel Advisors LLC

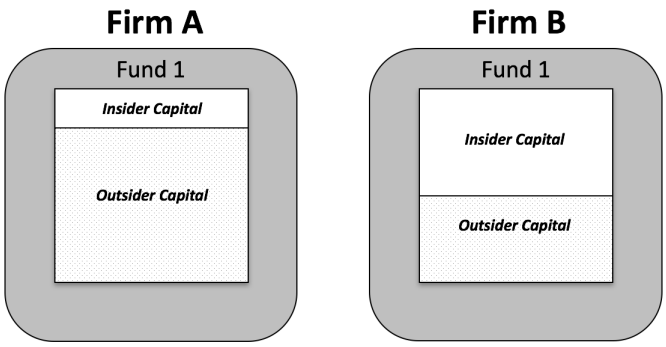


(e) Third Point LLC

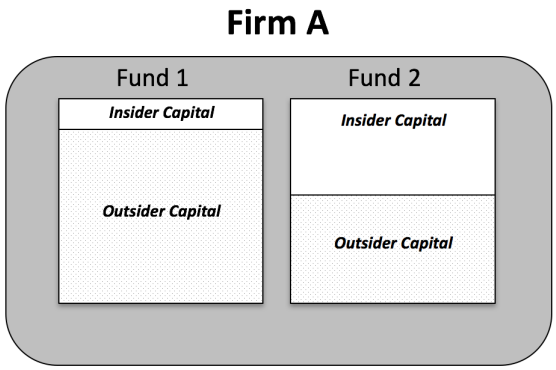
(f) Two Sigma Investments, LP

FIGURE II **Heterogeneity of Insider Investment Across Numerous Funds**

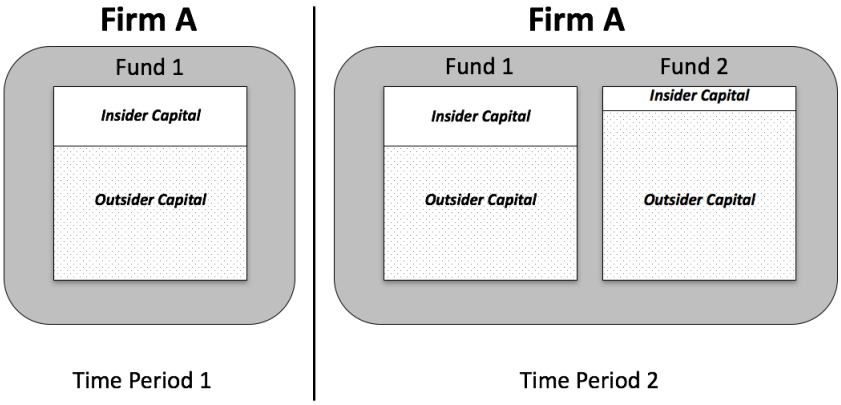
This figure shows the heterogeneity of insider investment for a set of sample firms. The horizontal axis corresponds to the percent of insider investment and the vertical axis corresponds to the count of funds. The histograms correspond to 2016 ADV filings, and excluded any funds smaller than $100 million.



Panel A: One Firm, One Fund (1F1F)



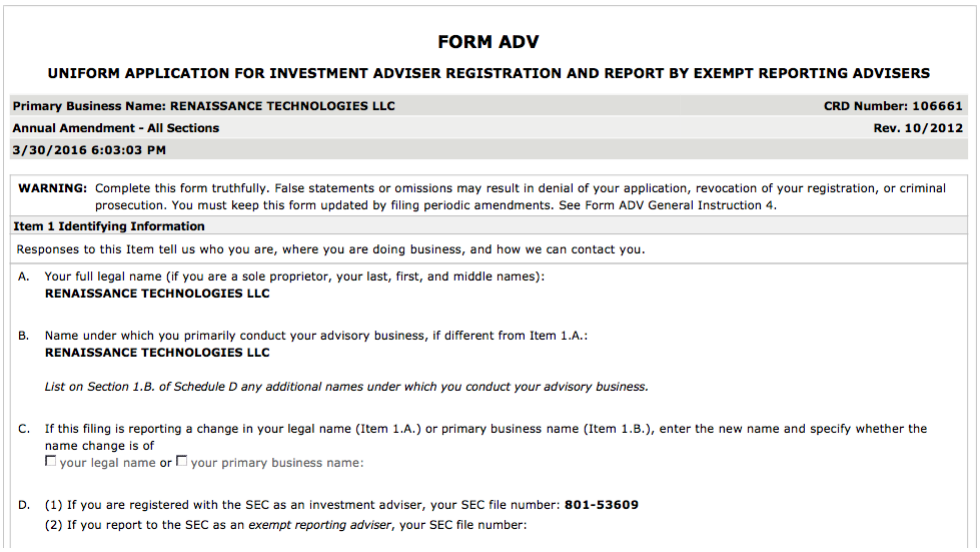
Panel B: Different Insider Investment, Within Firm



Panel C: Event Study Analysis

FIGURE III **Firm and Fund Analysis**

This figure outlines the difference between firm and fund in the context of this paper and emphasizes the different setups we analyze. Panel A describes a one firm one fund (1F1F) structure and the comparison of incentives between two hypothetical firms. Panel B describes a firm with two separate funds with different insider capital. Our within firm analysis compares Fund 1 against Fund 2, within firm. Panel C shows the time evolution of Firm A, transitioning from a one fund to multi-fund firm.



FORM ADV

UNIFORM APPLICATION FOR INVESTMENT ADVISER REGISTRATION AND REPORT BY EXEMPT REPORTING ADVISERS

Primary Business Name: RENAISSANCE TECHNOLOGIES LLC — **CRD Number: 106661**

Annual Amendment - All Sections — **Rev. 10/2012**

3/30/2016 6:03:03 PM

WARNING: Complete this form truthfully. False statements or omissions may result in denial of your application, revocation of your registration, or criminal prosecution. You must keep this form updated by filing periodic amendments. See Form ADV General Instruction 4.

Item 1 Identifying Information

Responses to this Item tell us who you are, where you are doing business, and how we can contact you.

A. Your full legal name (if you are a sole proprietor, your last, first, and middle names):
RENAISSANCE TECHNOLOGIES LLC

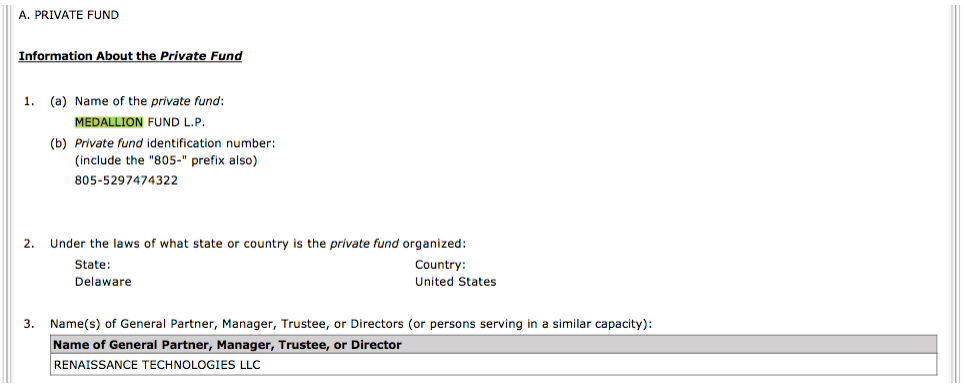
B. Name under which you primarily conduct your advisory business, if different from Item 1.A.:
RENAISSANCE TECHNOLOGIES LLC

List on Section 1.B. of Schedule D any additional names under which you conduct your advisory business.

C. If this filing is reporting a change in your legal name (Item 1.A.) or primary business name (Item 1.B.), enter the new name and specify whether the name change is of
☐ your legal name or ☐ your primary business name:

D. (1) If you are registered with the SEC as an investment adviser, your SEC file number: **801-53609**
(2) If you report to the SEC as an *exempt reporting adviser*, your SEC file number:

Panel A: Section 1, Form ADV



A. PRIVATE FUND

Information About the *Private Fund*

1. (a) Name of the *private fund*:
MEDALLION FUND L.P.
(b) *Private fund* identification number:
(include the "805-" prefix also)
805-5297474322

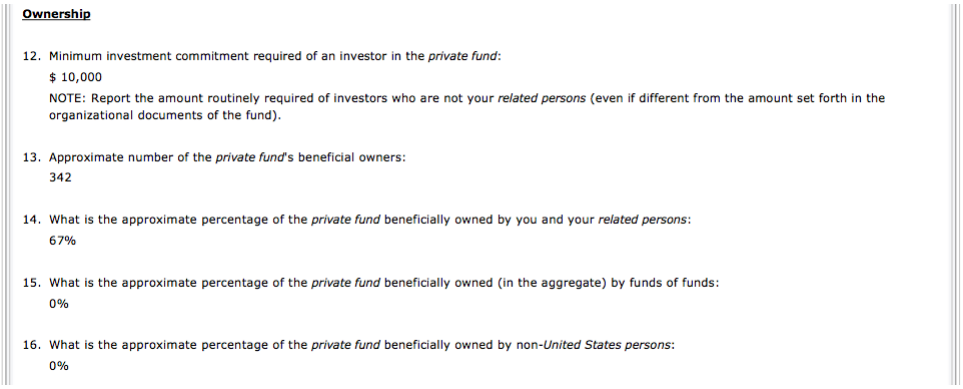
2. Under the laws of what state or country is the *private fund* organized:

State:	Country:
Delaware	United States

3. Name(s) of General Partner, Manager, Trustee, or Directors (or persons serving in a similar capacity):

Name of General Partner, Manager, Trustee, or Director
RENAISSANCE TECHNOLOGIES LLC

Panel B: Section 7.B.(1), Fund Identity, Form ADV



Ownership

12. Minimum investment commitment required of an investor in the *private fund*:
$ 10,000
NOTE: Report the amount routinely required of investors who are not your *related persons* (even if different from the amount set forth in the organizational documents of the fund).

13. Approximate number of the *private fund*'s beneficial owners:
342

14. What is the approximate percentage of the *private fund* beneficially owned by you and your *related persons*:
67%

15. What is the approximate percentage of the *private fund* beneficially owned (in the aggregate) by funds of funds:
0%

16. What is the approximate percentage of the *private fund* beneficially owned by non-*United States persons*:
0%

Panel C: Section 7.B.(1), Ownership Reporting, Form ADV

FIGURE IV **Sample Form ADV — Renaissance Technologies**

This figure shows three excerpts from the SEC's Form ADV for a sample firm, Renaissance Technologies LLC. Panel A shows basic information to identify firms. Panel B shows basic fund information for our sample fund, Medallion Fund L.P., and is found in Section 7.B.(1). Panel C shows ownership data such as minimum investment, number of investors, and basic composition of investors, and is reported at the fund level. We rely primarily on question 14, at the fund level, when studying insider ownership. Form ADVs can be searched at https://www.adviserinfo.sec.gov/.

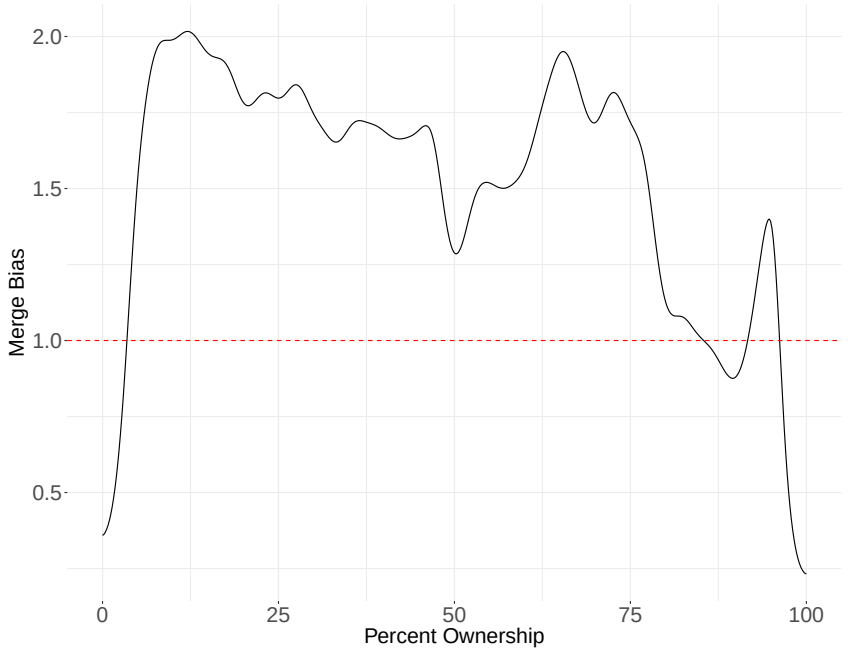
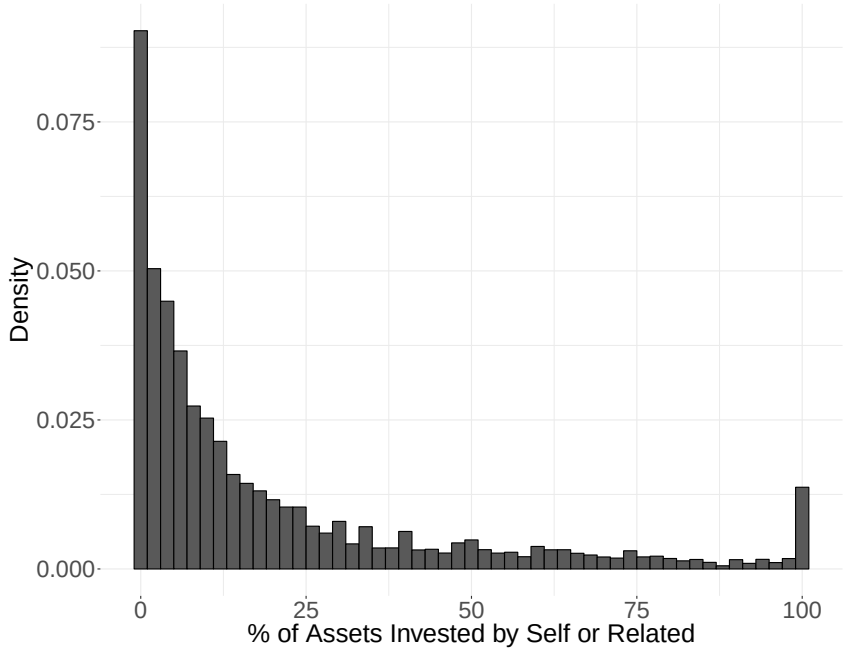
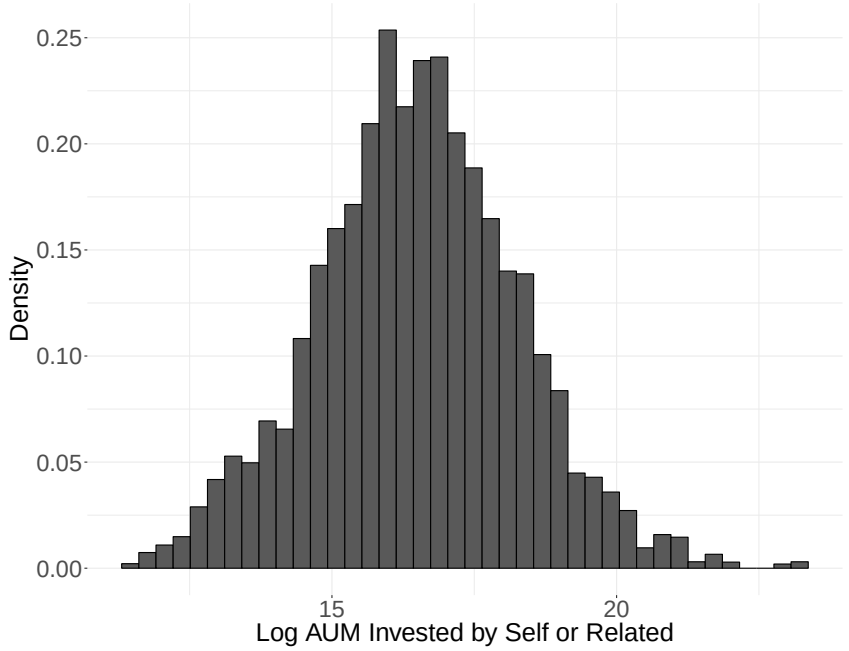


FIGURE V **Bias Analysis of Merged Sample**

This figure plots the merge rate between the insider investment observations from Form ADV and the hedge fund commercial return databases (outlined in the Data section). It is generated by dividing the empirical distribution of the merged sample against the unmerged sample of funds. The red, dotted line, highlights the unbiased boundary. Larger than one indicates a higher match rate relative to the average match rate. Observations for 0% and 100% inside investment have been omitted to be consistent with the analysis. See Appendix for further bias analysis.



Panel A: Distribution of Insider Investment Across Funds, Percentage of Total Assets



Panel B: Distribution of Insider Investment Across Funds, Gross Inside Investment

FIGURE VI **Distribution of Insider Investment from Merged Sample**

This figure plots the insider investment into hedge funds from the merged sample of hedge fund returns and ADV forms. Panel A is a histogram of insider investment, and is in units of percent of total investment. This displays the "dumbbell" insider investment pattern common across fund types. Panel B is a histogram of log(Gross Asset Value) of insider investment across funds for the merged sample between ADV and the commercial hedge fund datasets.

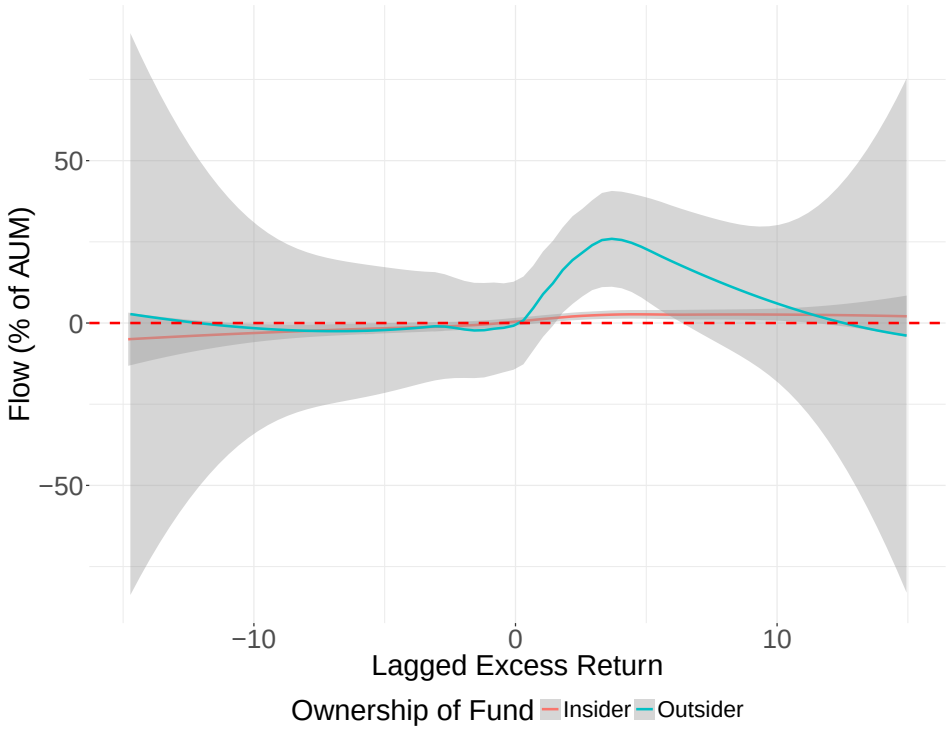


FIGURE VII **Flow Performance of Funds by Insider Status**

This figure plots a kernel density of the relationship between lagged excess return and contemporaneous flow. The flow measure is defined as: $Flow_{it} = \frac{AUM_{it} - (1+r_{it}) \cdot AUM_{i,t-1}}{AUM_{i,t-1}}$. Excess returns are defined using the Fama-French and Carhart 4 factors. Funds are divided by the average level of inside investment into insider funds ($>$ 20.8% Inside Investment) and outsider funds. Grey bars correspond to 95% confidence intervals.

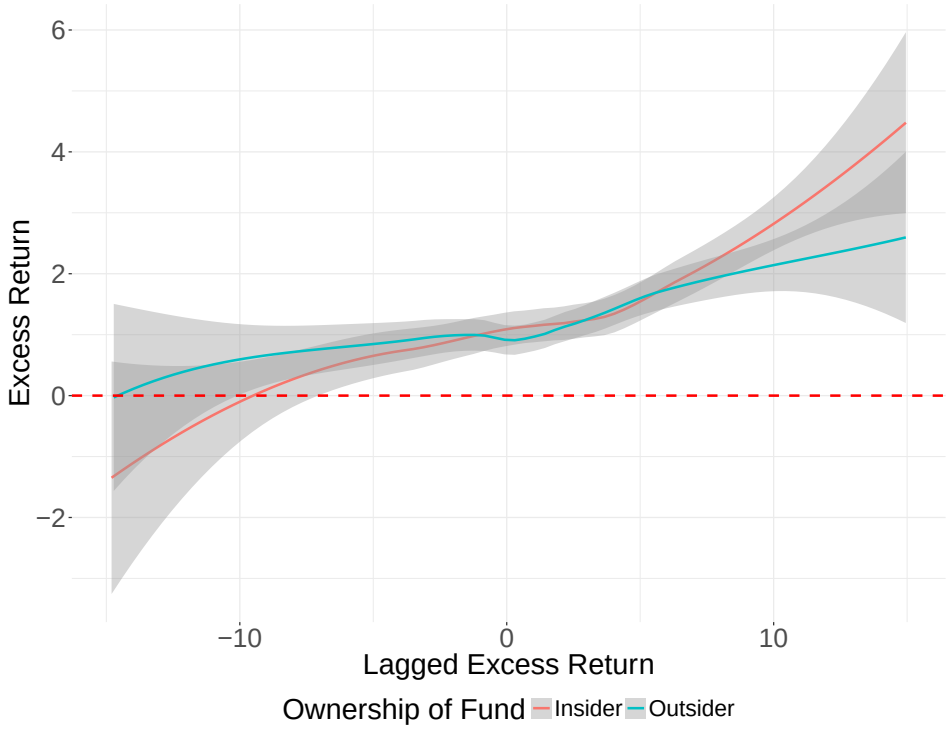
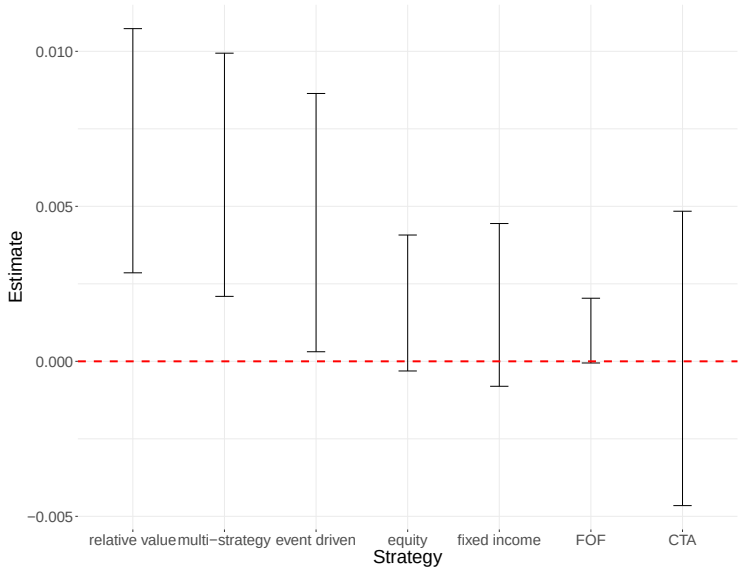
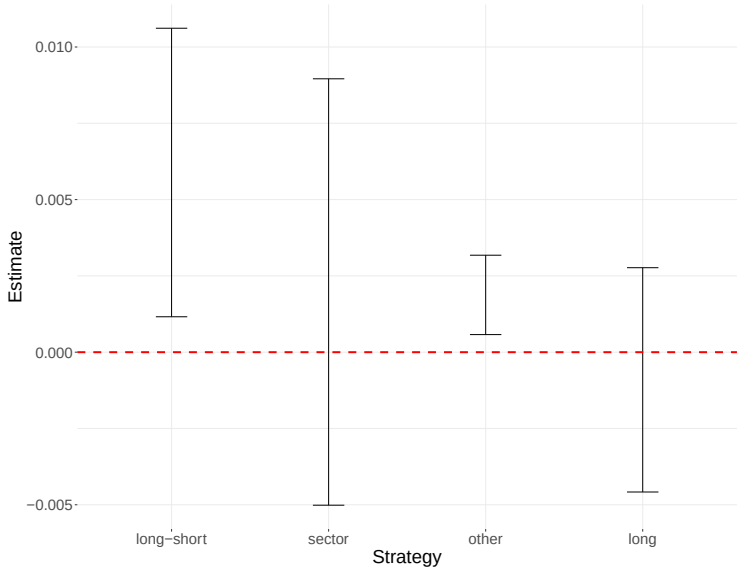


FIGURE VIII **Return Predictability Funds by Insider Status**

This figure plots a kernel density between lagged and contemporaneous excess return. Excess returns are defined using the Fama-French and Carhart 4 factors. Funds are divided by the average level of inside investment into insider funds ($>$ 20.8% Inside Investment) and outsider funds. Grey bars correspond to 95% confidence intervals.



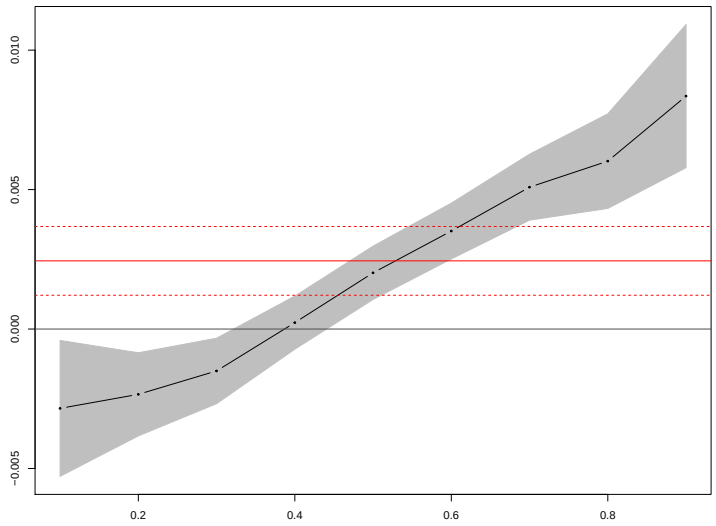
Panel A: Effects by Fund Type



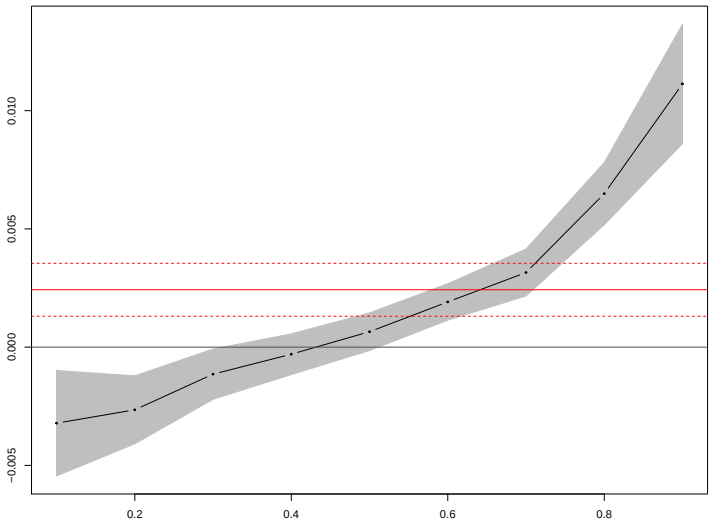
Panel B: Effects by Fund Type among Equity Funds

FIGURE IX **Main Effects by Fund Type**

This figure illustrates the main specification, as shown in column (2) of Panel A Table V, broken out by fund category. Funds are categorized based on descriptions in commercial hedge fund datasets listed in the Data section. The error bars indicate 95% confidence interval for the estimated coefficients.



Panel A: Quantile Regression, 7-Factor



Panel B: Quantile Regression, 4-Factor

FIGURE X **Quantile Regression of Inside Investment on Excess Returns**

This figure plots results from a quantile regression of percentage inside investment against fund-level excess returns, also controlling for fund size. Panel A shows the returns corrected for the Fung and Hsieh (2004) factor, while Panel B shows returns corrected for the Fama-French and Carhart 4 factor model. Across each of the ten deciles of percentage inside investment, we examine the slope of the relationship between inside investment and excess returns. The shaded grey area illustrates the 95% confidence interval. We find that our results are driven by funds at high levels of inside investment.

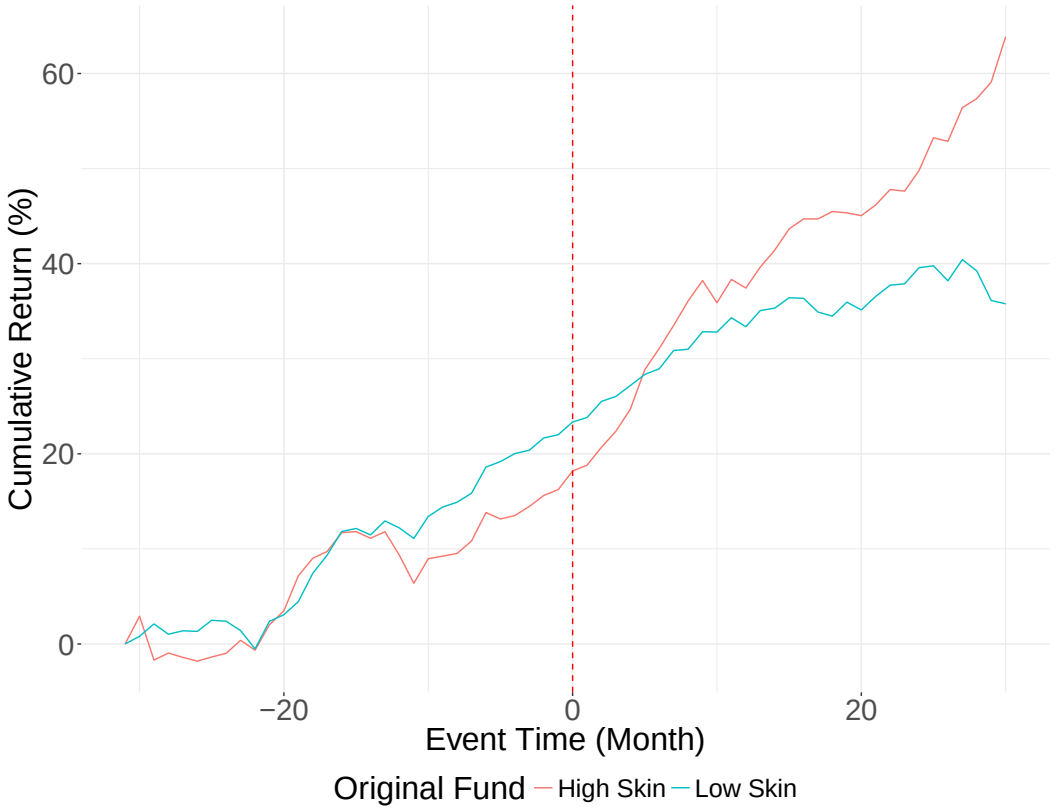
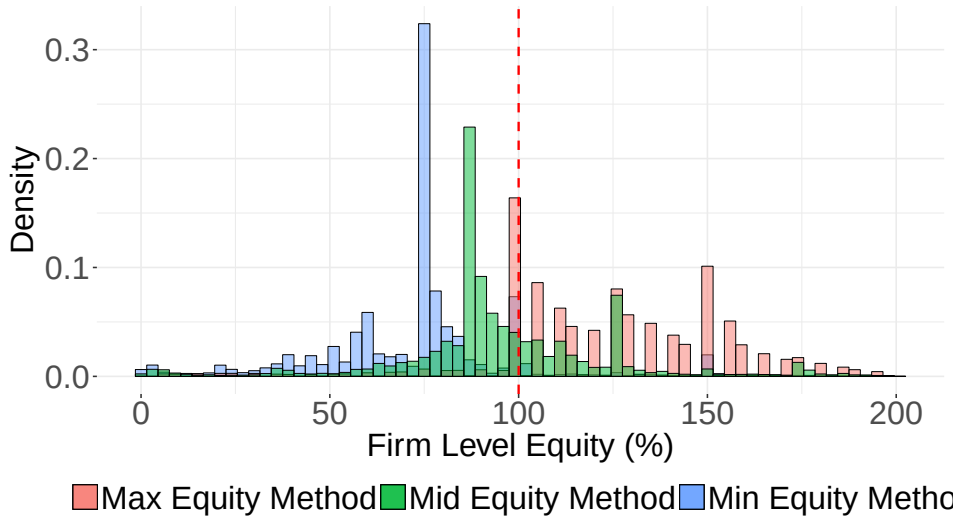
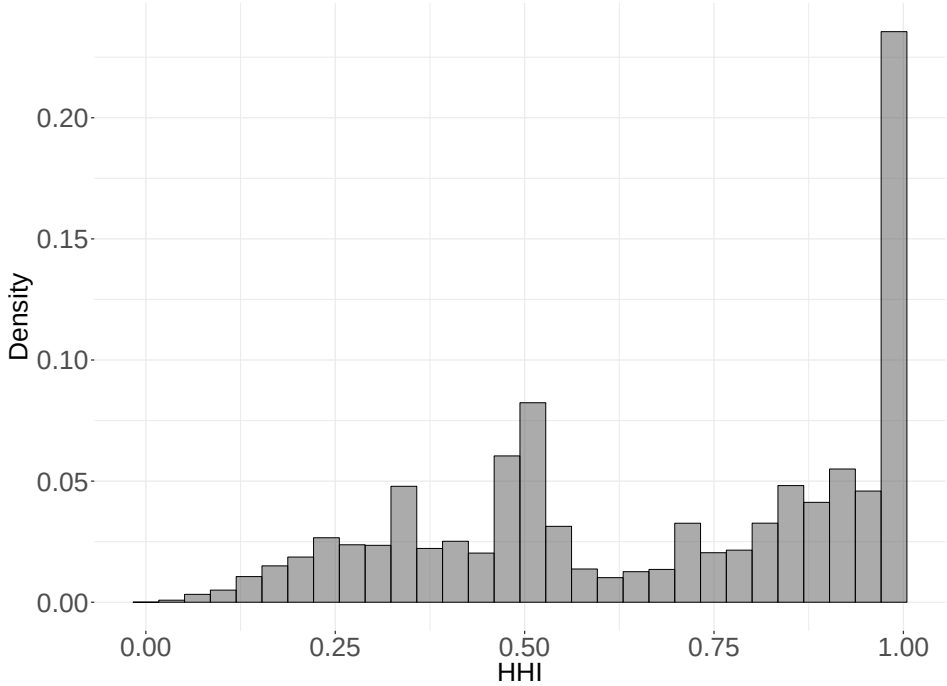


FIGURE XI **Event Study, Transition From One Fund to Multiple Funds**

This figure plots the net cumulative returns of a firm which launches an additional fund after previously only having one. Event times correspond to months from the fund creation date. The lines plot the cumulative performance of the original fund; with the red line tracking a fund in which inside investment increases in the original fund after new fund creation (suggesting that the newly created fund is marketed to outside investors). The blue line tracks the performance of funds in which inside investment the original fund falls after new fund creation (suggesting that the original fund is marketed to outside investors). The post-fund creation rise in returns of the red line indicates that fund performance improves when inside investment is strengthened in the fund. In a difference-in-difference regression, the interacted term of High Inside$\times$Post has a coefficient of 0.969 and a standard error of 0.214, which is significant at the 1% level.



Panel A: Estimates of Firm Level Equity Ownership



Panel B: HHI of Firm-Level Equity Ownership

FIGURE XII **Firm-Level Equity Ownership**

This figure illustrates the firm-level equity ownership estimates of all hedge funds in the Form ADV data. Panel A presents both minimum and maximum estimate of aggregate equity ownership of hedge funds from recursively linking Schedule A B. Panel B presents the concentration of equity ownership at the firm-level and described by the HHI of ownership.

TABLE I **Top 10 Hedge Fund Manager Paychecks, 2016**

This table reports the top ten hedge fund manager paychecks from 2016, as produced by *Institutional Investor's alpha* magazine in Taub (2017) and reported by the *New York Times*, May 16 2017. Estimates take into consideration individual share of management and performance fees, as well as personal capital commitments. We thank our discussant Clemens Sialm for referring us to the article.

Rank	Name	Fund	2016 Paycheck
1	James Simons	Renaissance Technologies	$1.6 billion
2	Ray Dalio	Bridgewater Associates	$1.4 billion
3	John Overdeck	Two Sigma	$750 million
4	David Siegel	Two Sigma	$750 million
5	David Tepper	Appaloosa Management	$700 million
6	Kenneth Griffin	Citadel	$600 million
7	Paul Singer	Elliot Management Corp.	$590 million
8	Michael Hintze	CQS	$450 million
9	David Shaw	D.E. Shaw Group	$415 million
10	Israel Englander	Millennium Management	$410 million
Total:			$6.9 billion

TABLE II **Summary Statistics: ADV Data**

This summary table describes data on investment advisors taken from Form ADV in 2016. Data is only taken from funds which are registered as hedge funds; firms must have at least one hedge fund and a minimum level of assets of $20 million. Panel A describes firm level information at the level of the management company. Panel B describes information available at the level of individual funds. Note that some assets may be double-counted due to the inclusion of fund of funds. Inside Investment corresponds to ownership by management or related parties, the key variable explored in this paper.

Panel A: **Firm Level Variables**

Names	Total	Median	Mean	Std.Dev
Custodial AUM ($m)	8,525,754.0	775.5	6,458.9	28,332.9
Regulatory AUM ($m)	18,084,715	1,166.7	13,700.5	72,114.3
Discretionary AUM ($m)	17,518,589	1,030.8	13,271.7	71,040.1
Non-Discretionary AUM ($m)	566,126	0	428.9	2,585.1
Number of Employees	139,264	13	57.2	199.0
— Support Staff	81,033	5	33.3	132.9
— Advisors	58,231	7	23.9	75.6
Number of Firms	2,433			

Panel B: **Fund Level Variables**

Names	Total	Median	Mean	Std.Dev
Number of Hedge Funds	9,763			
Gross Asset Value ($m)	6,177,174.0	127.8	632.7	3,060.7
Gross Assets, Inside Investment ($m)	772,663	3.8	79.1	553.2
Gross Assets, Fund of Funds ($m)	1,160,354.0	0	118.9	873
Gross Assets, Non-US Investors ($m)	2,492,344.0	4.7	255.3	1,698.6
Number of Owners		19	66.8	544.3
Minimum Investment ($m)		1	7.5	70.3
Inside Investment (%)		3	16.7	28.6
Investment by Fund of Funds (%)		0	15.9	29.5
Non-US Investors (%)		4	30.7	39.0
Number of Fund of Funds	2,322			

TABLE III **Summary Statistics: Merged Data**

This summary table describes data on the primary dataset based on a merged dataset of Form ADV and commercial hedge fund data providers (Eureka, HFR, BarclaysHedge, eVestment, and CISDM). Data is taken as of 2016. Data is only taken from funds which are registered as hedge funds; firms must have at least one hedge fund and a minimum level of assets of $20 million. Panel A describes firm level information at the level of the management company. Panel B describes information available at the level of individual funds. Note that some assets may be double-counted due to the inclusion of fund of funds. Panel B reports additional variables not included in Table 1. Inside Investment corresponds to ownership by management or related parties, the key variable explored in this paper.

Panel A: **Firm Level Variables**

Names	Total	Median	Mean	Std.Dev
Custodial AUM	1,195,040.0	591	5,218.5	16,444.6
Regulatory AUM	1,759,749.0	1,022	7,684.5	27,716
Discretionary AUM	1,750,849	952.9	7,645.6	27,633.2
Non-Discretionary AUM	8,899.7	0	38.9	195.1
— Number of Employees	16,665	12	38.8	100.4
— Number of Support Staff	9,941	5	23.1	72.4
Advisors	6,724	6	15.6	29.9
Number of Firms	504			

Panel B: **Fund Level Variables**

Names	Total	Median	Mean	Std.Dev
Number of Hedge Funds	720			
Gross Asset Value ($m)	497,625.5	88.3	278.3	708.9
— Equity	219,868.9			
— Relative Value	122,522.7			
— Fund of Funds	53,330.4			
— Multi-Strategy	55,526.5			
— Fixed Income	29,912.7			
— CTA	26,240.1			
— Event Driven	22,403.2			
— Other	20,527.9			
— Options	623.5			
Gross Assets, Inside Investment ($m)	61,380.4	11.9	41.5	108.8
Gross Assets, Fund of Funds ($m)	73,352.2	0	45.8	200.8
Gross Assets, Non-US Investors ($m)	176,673.4	0.2	112.5	400.9
Number of Owners		39	162.3	865.0
Minimum Investment ($m)		1	1.1	3.3
Inside Investment (%)		10	22.8	27.1
Investment by Fund of Funds (%)		0	9.0	16.7
Non-US Investors (%)		1	24.6	36.2
Management Fee		1.5	1.5	0.5
Performance Fee		20	18.2	5.4
Leverage Ratio		1.1	1.5	0.9

TABLE IV **Related Party Information**

This table illustrates the identity of related parties. The rows need not sum to one: firms select as many options that apply to identify all related parties.

Statistic	Mean	SD
Sponsor of GP	0.741	0.438
Other Investment Advisor	0.501	0.500
Commodity Pool	0.401	0.490
Broker/Dealer	0.160	0.367
Insurance	0.065	0.246
Sponsor of LP	0.046	0.210
Bank or Thrift	0.045	0.207
Trust	0.042	0.201
Pension	0.027	0.161
Accountant	0.025	0.156
Real Estate	0.024	0.153
Lawyer	0.019	0.138
Municipal Advisor	0.013	0.113
Futures Merchant	0.009	0.094
Swap Dealer	0.007	0.081
Swap Participant	0.001	0.026
Share Supervised Persons	74%	
Share Office	59%	

TABLE V **Relationship between Inside Investment and Excess Return**

This table shows the panel regression between the excess monthly return of an investment advisor and percent investment from an insider or related party. The first two columns always regress against the Fung and Hsieh (2004) 7-Factors, and the second two columns always regress against the Fama-French and Carhart 4-Factor model. A size control is always included. Panel A shows a panel regression of percentage inside investment against excess returns. Column (1) includes only a size control, while column (2) also adds additional fund controls (a year fixed effect, a firm fixed effect, and controls for age of fund inception and strategy type). Columns (3) and (4) similarly show results with and without controls for the Fama-French and Carhart model. Panel B shows panel results changing the main dependent variable from percentage inside investment to gross inside investment (log of total insider capital committed). Standard errors are clustered monthly for panels A and B. Finally, Panel C illustrates a Fama-MacBeth cross-sectional specification. This specification differs in that year and firm fixed effects are not included, and standard errors are computed using the Fama and MacBeth (1973) approach.

Panel A **Baseline Specification**

	FH Excess Returns		FFC Excess Returns	
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0024***	0.0048***	0.0024***	0.0048***
	(0.0009)	(0.0015)	(0.0009)	(0.0013)
Year FE	No	Yes	No	Yes
Firm FE	No	Yes	No	Yes
Fund Controls	No	Yes	No	Yes
Log(Fund Size)	Yes	Yes	Yes	Yes
Observations	41,097	41,097	41,097	41,097
R^2	0.0003	0.0368	0.0009	0.0404

Panel B: **Gross Inside Investment**

	FH Excess Returns		FFC Excess Returns	
	(1)	(2)	(3)	(4)
Skin (Gross)	0.0397**	0.0710**	0.0297**	0.0856***
	(0.0184)	(0.0284)	(0.0150)	(0.0235)
Year FE	No	Yes	No	Yes
Firm FE	No	Yes	No	Yes
Fund Controls	No	Yes	No	Yes
Log(Fund Size)	Yes	Yes	Yes	Yes
Observations	41,097	41,097	41,097	41,097
R^2	0.0002	0.0367	0.0008	0.0404

Panel C: **Fama MacBeth Approach**

	FH Excess Returns		FFC Excess Returns	
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0024***	0.0020**	0.0020**	0.0021**
	(0.0008)	(0.0008)	(0.0008)	(0.0009)
Year FE	No	No	No	No
Firm FE	No	No	No	No
Fund Controls	No	Yes	No	Yes
Log(Fund Size)	Yes	Yes	Yes	Yes
Observations	41,097	41,097	41,097	41,097
R^2	0.1662	0.2034	0.0469	0.0690

Note: *p<0.1; **p<0.05; ***p<0.01

TABLE VI **Flow Performance and Return Predictability**

This table shows the panel regression of fund flow-performance and return predictability regressions. In both cases, the key dependent variables are lagged excess return (excess of the 7-Factor model). The specifications follow equations 8 and 9. The independent variable in columns 1-2 is Fund Flows, where flows are defined as: $Flow_{it} = \frac{AUM_{it} - (1+r_{it}) \cdot AUM_{i,t-1}}{AUM_{i,t-1}}$, regressed against an indicator of funds with greater than median inside investment interacted against lagged excess returns. Columns 3-4 are return predictability specifications with the same independent variables but instead examining current period excess return as the dependent variable. Time is measured at a quarterly frequency, and flows are winsorized at a 1% level. Standard errors are clustered at the date level.

	Percent Flow	Percent Flow >0	Excess Return$_t$	Excess Return$_t$ >0
	(1)	(2)	(3)	(4)
Excess Return$_{t-1}$ × Insider	−0.1126**	−0.3747***	0.0437	0.3321
	(0.0548)	(0.1309)	(0.0369)	(0.2230)
Excess Return$_{t-2}$ × Insider	−0.0227	−0.0618	0.0116	0.1605
	(0.0817)	(0.2162)	(0.0381)	(0.2633)
Excess Return$_{t-3}$ × Insider	0.0213	−0.0850	−0.0288	−0.1880
	(0.0684)	(0.2178)	(0.0353)	(0.2522)
Excess Return$_{t-1}$	0.2156***	0.8441***	−0.0235	−0.0017
	(0.0361)	(0.1949)	(0.0662)	(0.4447)
Excess Return$_{t-2}$	0.0935	0.4186**	−0.1082**	−0.5273
	(0.0707)	(0.1727)	(0.0441)	(0.3414)
Excess Return$_{t-3}$	0.0642	0.3942***	−0.1519***	−1.1576***
	(0.0485)	(0.1406)	(0.0289)	(0.2550)
Insider	0.0091	0.0298	−0.0004	0.0017
	(0.0059)	(0.0219)	(0.0025)	(0.0221)
Fixed Effects:	Yes	Yes	Yes	Yes
Controls:	Yes	Yes	Yes	Yes
Observations	7,255	7,255	7,255	7,255
R^2	0.2479	0.2465	0.1677	0.1490
Note:				*p<0.1; **p<0.05; ***p<0.01

TABLE VII **Open for New Investments**

This table shows the panel regressions between fund and if they are open for new investments. The analysis is based on the HFR, EurekaHedge and BarclaysHedge dataset. Columns (1) and (2) relates percent of inside investment to the openness of a fund. Columns (3) and (4) relate the openness of the fund to monthly excess returns, as measured by the Fung and Hsieh (2004) 7-Factors model. Columns (5) and (6) similarly show results with and without controls for the Fama-French and Carhart model.

	Open for Investors		Excess Returns (FH)		Excess Returns (FFC)	
	(1)	(2)	(3)	(4)	(5)	(6)
Inside Investment (%)	-0.0013^{***}	-0.0021^{***}				
	(0.0003)	(0.0003)				
Open for Investors			-0.2291^{**}	-0.2186^{***}	-0.4463^{***}	-0.3141^{***}
			(0.0971)	(0.0746)	(0.0660)	(0.0706)
Fixed Effects	No	Yes	No	Yes	No	Yes
Log(Fund Size)	No	Yes	No	Yes	No	Yes
Sample:	Yearly	Yearly	Monthly	Monthly	Monthly	Monthly
Observations	1,977	1,977	12,065	12,065	12,065	12,065
R^2	0.0069	0.1385	0.0007	0.0168	0.0034	0.0130
Note:						*p<0.1; **p<0.05; ***p<0.01

TABLE VIII **Cuts by Fund Size**

This table illustrates our main specification (column (2) of Panel A in Table V) across the fund size distribution. We cut by the quantiles of fund size, which correspond to the buckets: [$20m-$57m), [$57m, $126m), [$126m, $378m), [$379m+). Standard errors are clustered at the date level. Excess returns are computed using the Fung-Hsieh model.

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0009	0.0021	0.0037^{***}	0.0054^{***}
	(0.0015)	(0.0013)	(0.0014)	(0.0017)
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Fund Controls	Yes	Yes	Yes	Yes
Log(Fund Size)	Yes	Yes	Yes	Yes
Observations	10,280	10,281	10,267	10,269
R^2	0.0133	0.0127	0.0141	0.0189
Note:				*p<0.1; **p<0.05; ***p<0.01

TABLE IX **Inside Investment and Fund Size**

This table shows the panel regression between size and inside skin in the game. Panel A conducts analysis on the matched sample connecting Form ADV with commercial hedge fund datasets (where the key dependent variable is assets under management, taken from the commercial hedge fund datasets, reported as the log of AUM or in millions). Panel B performs analysis on the complete ADV dataset, using as the dependent variable Gross Asset Value. All specifications regress the fraction of the fund which consists on insider investment against a measure of size, measured yearly. Columns (1) and (3) across all specifications perform this regression with no additional controls; columns (2) and (4) add firm and year fixed effects. Standard errors are in parenthesis.

Panel A: **Results on Matched Dataset**

	AUM (in $m)		Log(AUM)	
	(1)	(2)	(3)	(4)
Skin (Percent)	-3.82^{***}	-7.86^{***}	-0.01^{***}	-0.02^{***}
	(0.24)	(1.20)	(0.001)	(0.003)
Year FE	No	Yes	No	Yes
Firm FE	No	Yes	No	Yes
Fund Controls	No	Yes	No	Yes
Dataset	Matched	Matched	Matched	Matched
Observations	2,633	2,633	2,633	2,633
R^2	0.01	0.88	0.02	0.86

Panel B: **Results on ADV Dataset**

	Gross Asset Value (in $m)		Log(Gross Asset Value)	
	(1)	(2)	(3)	(4)
Skin (Percent)	-6.34^{***}	-10.14^{***}	-0.01^{***}	-0.02^{***}
	(0.89)	(1.12)	(0.001)	(0.001)
Year FE	No	Yes	No	Yes
Firm FE	No	Yes	No	Yes
Fund Controls	No	Yes	No	Yes
Dataset	ADV	ADV	ADV	ADV
Observations	35,960	35,960	35,960	35,960
R^2	0.002	0.57	0.03	0.57
Note:				*p<0.1; **p<0.05; ***p<0.01

TABLE X **Fund Flows and Performance**

This table shows the panel regression between size and flows by insiders and outsiders. "Insider Flow" corresponds to changes in capital provided by insiders and related parties, while "Outsider Flow" captures changes in capital provision by all other investors. Inside and Outsider flow changes are measured annually with the release of new ADV forms. Column (2) adds year fixed effects, and column (3) adds firm fixed effects. Standard errors clustered at the year level.

	(1)	(2)	(3)
Insider Flow (%)	−0.00034	−0.00025	−0.00029
	(0.00023)	(0.00023)	(0.00039)
Outsider Flow (%)	0.00002	0.00003	0.00003*
	(0.00002)	(0.00002)	(0.00002)
Size	Yes	Yes	Yes
Year FE	No	Yes	Yes
Firm FE	No	No	Yes
Observations	228	228	228
R^2	0.00372	0.05192	0.11300
Note:			*p<0.1; **p<0.05; ***p<0.01

TABLE XI **Firm-Level Equity Ownership and Returns**

This table shows a panel regression with alternate measures of firm ownership. # of Equity Holders captures the total number of beneficial owners listed in Form ADV for the firm's equity. HHI of Firm Equity captures a Herfindahl-Hirschman index measure of concentration of equity ownership. Standard errors are clustered at the fund level and are shown in parenthesis. Excess return is computed using the Fung-Hshieh model.

	Monthly Excess Return (FH)			
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0029^{***}	0.0024^{***}	0.0029^{***}	0.0028^{***}
	(0.0009)	(0.0008)	(0.0009)	(0.0008)
# of Equity Holders	-0.0174^{**}		-0.0197^{***}	-0.0191^{***}
	(0.0071)		(0.0070)	(0.0068)
HHI of Firm Equity		0.0444	−0.0645	−0.0578
		(0.0826)	(0.0794)	(0.0796)
log(Gross Assets)	0.0312	0.0163	0.0317	0.0350
	(0.0243)	(0.0249)	(0.0241)	(0.0218)
Year	Yes	Yes	Yes	Yes
Log(Size)	Yes	Yes	Yes	Yes
Fund Controls	No	No	No	Yes
Observations	41,097	41,097	41,097	41,097
R^2	0.0105	0.0101	0.0105	0.0116
Note:				*p<0.1; **p<0.05; ***p<0.01

TABLE XII **Inside Investment and Hedge Fund Fees**

This table shows a yearly panel regression of inside investment and fees. We focus on the main fee components of hedge funds; the management fee levied on assets under management, as well as a performance fee charged on proportional returns which clear a pre-defined hurdle rate. Columns (1) and (2) present a univariate regression; while columns (3) and (4) add a variety of fund and firm-level controls. Standard errors are clustered at the fund level.

	Management Fee	Performance Fee	Management Fee	Performance Fee
	(1)	(2)	(3)	(4)
Skin (Percent)	−0.0030*	0.0040	−0.0014	0.0056
	(0.0016)	(0.0153)	(0.0014)	(0.0128)
Log(Fund Size)	No	No	Yes	Yes
Year FE	No	No	Yes	Yes
Inception Year FE	No	No	Yes	Yes
Strategy FE	No	No	Yes	Yes
Observations	5,925	5,848	5,925	5,848
R^2	0.0137	0.0002	0.3216	0.5405
Note:				*p<0.1; **p<0.05; ***p<0.01

A Internet Appendix: Model

To fix ideas, we outline a simple, rational, two period partial equilibrium model that highlights how the internal capital allocation decisions of hedge fund managers interact with measured performance. We model active portfolio managers that are maximizing their profits by selectively allocating insider capital between a family of funds under their control. Insiders rationally allocate internal capital across strategies to maximize total profits.

Our simple model has several salient features that differ from previous works. First, we disaggregate capital from insiders and outsiders. This captures the idea that an insider's compensation is tied to both management fees earned on outside capital and returns on insider capital. We also model for endogenous fund generation in the form of multiple investment strategies and managerial discretion to differentially allocate insider capital across these strategies. For clarity, both in notation and results, we focus on a two-period model. Finally, costs in our model are convex in *gross returns*, as this helps match stylized facts we observe in the data.

A.1 Capital: Insider and Outsider

There are two types of investors in this model: insiders and outsiders.

An *insider* is an investor with highly specialized arbitrage skills.[14] This maps into practice to someone who has access to a positive alpha strategy (i.e., portfolio managers, hedge fund employees, and closely related parties). An investor can invest either in their strategy, the appropriate passive benchmark portfolio, or combination of both.

An *outsider* refers to anyone who is not an insider. They can be thought of as limited partners who delegate their capital to a manager through a fund. By definition, outsiders do not possess such specialized skills. As such, outsiders can invest their capital in the appropriate passive benchmark portfolio, delegate their capital to these insiders to access investment strategies, or a combination of both.

[14] We take a similar view to Shleifer and Vishny (1997) that arbitrage is typically carried out by a few, highly specialized investors.

Capital is denoted by q and any superscript notation denotes who supplies the capital. Total capital, insider capital, and outsider capital are denoted by q^T, q^I and q^O, respectively. Total capital is defined as:

$$q^T \equiv q^I + q^O \tag{11}$$

We exclude the possibility of leverage and define total capital (q^T) as the sum of inside (q^I) and outside capital (q^O). Further, we exclude the possibility of short-selling, so $q^I, q^O \geq 0$.[15]

A.2 Investment Technology

An active manager specializes in N strategies indexed by n. Each strategy has limited investible capacity. The more capital invested in a strategy at time t, either from an insider or an outsider, results in a lower gross excess return. Formally, we define the gross return to strategy n at time $t+1$, for an investment of $q_{n,t}$ by:

$$R_{n,t+1} = \alpha_n - C_n\left(q^T_{n,t}\right) \tag{12}$$

The excess return is above an appropriate passive benchmark, which all investors are assumed to have access to. The first term, α_n, captures the maximum alpha to strategy n and is by assumption positive ($\alpha_n > 0$). The second term is a cost function, $C_n\left(q^T_{n,t}\right)$, which depends on the *total* capital invested at period t in strategy n. The cost function is strictly non-negative ($C \geq 0$), increasing and convex ($C' > 0$, and $C'' > 0$). Further, at no investment, $C(0) = 0$, and in the limit, $\lim_{q^T_t \to \infty} C'(q^T_{n,t}) = \infty$.[16] The assumption of decreasing returns to scale is motivated by research suggesting a negative relationship between size and performance, such as Fung et al. (2008).

It is important to emphasize that different strategies have different α_n and cost functions C_n. For simplicity of this model and to make our analysis concrete, we assume a specific functional form for this cost: $C_n\left(q^T_{n,t}\right) = \frac{a_n}{2}\left(q^T_{n,t}\right)^2$. The scale cost is non-negative, $a_n \geq 0$, and captures how well the strategy scales.[17] A smaller scale cost indicates that a strategy

[15] Including leverage subject to a collateral constraint does not affect our model results.

[16] This results in a decreasing returns to scale in the gross excess return and a departure from the Berk and van Binsbergen (2017), where costs are linear in the return equation.

[17] Costs are orthogonal to risk factors and collinear with α_n.

scales better. An example of the tradeoff between strategies with different excess return and scale is shown in Figure A.1.

To simplify notation, we assume that capital is allocated at time t and suppress time subscripts on all capital variables q. All returns are assumed to occur at $t+1$, and time subscripts are omitted for returns as well.

A.3 Baseline Model: One Strategy

We focus first on the case in which firms have only one strategy $N = 1$, and omit the subscript indexing of strategies. We first identify the total dollar payoff to managers. The total dollar payoff, V^I, is defined as the profit from investing in their own strategy in addition to fees collected on managed outsider capital. We assume that the management fee f, is a fraction of outside capital invested, and take these as given. Outsider dollar payoff is similar to the insider dollar payoff, but subtracting the fees:[18]

$$V^I = q^I\left(R\left(q^T\right)\right) + q^O f \tag{13}$$

$$V^O = q^O\left(R\left(q^T\right)\right) - q^O f \tag{14}$$

A.3.1 Case 1: Unconstrained Inside Capital

We first consider the case where insider capital is unconstrained. How much would an insider invest in their own fund? Absent outside investors, the insiders' objective can be written as:

$$\arg\max_{q^I} \quad V^I = q^I\left(\alpha - C\left(q^I\right)\right)$$

With a solution:

$$\bar{q}^{I*} = \sqrt{\frac{2\alpha}{3a}} \tag{15}$$

Notice that if $\bar{q}^{I*} = q^T$, insiders are sufficiently capitalized and refuse outside capital. Substituting back into equation 13, the total dollar payoff to insiders, we get $\frac{2\alpha q^I}{3}$, and corresponds to the maximum achievable benefit from the strategy.

[18] More realistically, hedge fund fees also incorporate a performance fee on returns above a certain hurdle rate, assuming the fund's value exceeds a high water mark, as well as exit fees.

A.3.2 Case 2: Fully Constrained Inside Capital

Next we consider the case where insider capital is fully constrained, and are unable to pledge any of their capital to a strategy. How much outsider capital would they accept? Outsiders will continue to invest until the benefit from investing in the strategy is equal to zero. The maximum q^O is given by:

$$\bar{q}_t^{O*} = \sqrt{\frac{2\left(\alpha - f\right)}{a}} \tag{16}$$

Notice that the total dollar payoff to outsiders is driven to zero and that insiders only earn from management fees. Further, the insider only earns management fees.

A.3.3 Case 3: Constrained Inside Capital

We next consider the interior case where an insider has only one investment strategy but is capital constrained. That is, $q_t^I \in \left[0, \bar{q}_t^{I*}\right)$. How much outside capital should the insider accept? The insiders choose the amount of outside capital to maximize the objective, subject to the outsider capital providers' participation constraint. These conditions are given by:

$$\arg\max_{q^O} \quad q^I\left(\alpha - C\left(q^T\right)\right) + fq^O \tag{17}$$

$$V^O = q^O\left(\alpha - C(q^T)\right) - fq^O \geq 0 \tag{18}$$

When $q^O > 0$, and the insider collects a proportional and fixed management fee, f, for their services. The model is solved by:

$$q^{O^*} = \begin{cases} \sqrt{\frac{2(\alpha-f)}{a}} - q^I & if\ \alpha - f < \frac{f^2}{2a(q^I)^2} \\ \frac{f}{aq^I} - q^I & if\ \left(\frac{f}{aq^I} - q^I\right)\left(\alpha - f - \frac{f^2}{2a(q^I)^2}\right) > 0 \\ 0 & else\ \sqrt{\frac{f}{a}} < q^I \end{cases}$$

The first region is the case where both insiders and outsider allocate to the strategy. Insiders are highly capital constrained, and outsiders can allocate capital up to the point where their participation constraint is binding. As a result, the total dollar payoff to outsiders is equal to zero. In this region, insiders can increase their capital level, which would directly replace the level of outsider capital.

The second region is the case where an insider can maximize their own total dollar payoff by limiting the level of outsider capital. Outsiders would prefer to contribute more capital but this would not maximize the total dollar payoff to insiders. As a result, the remaining outside investors earn a positive total dollar payoff from investing in the strategy.

The final region is the case where the outsider's participation constraint is binding. The insider has reduced the gross return of the strategy to the point where the marginal benefit to an additional dollar from an outsider is less than the marginal cost of fees and the capacity constraint. As a result, no outsider would contribute to this strategy. Notice that there an insider may continue to contribute to this strategy, as they do not pay fees.

Proposition 1 *There exists a positive fee where outsider total dollar payoff equal zero for all levels of investment.*

Proof The optimization problem reduces to:

$$\arg\max_{q^O, f} \quad q^I \left(\alpha - C\left(q^T\right)\right) + f q^O \tag{19}$$

$$s.t.\ V^O \quad = \quad q^O \left(\alpha - C(q^T)\right) - f q^O \geq 0 \tag{20}$$

With the solution corresponding to $f = \frac{2}{3}\alpha$. The insider will choose management fees, f, to capture the entire surplus from investing. As a result, the outsider's participation constraint will be binding.

Proposition 2 *For a non-binding management fee and positive level of outside investment, total capital is weakly decreasing as a portion of insider capital.*

Proof Consider an investment strategy managed by an insider with a non-binding the fee, $0 < f < \frac{2}{3}\alpha$, and a positive level of outside investment, $q^O > 0$. Outsider capital q^T is decreasing in the level of insider investment. This can be seen directly:

$$\frac{dq^{O^*}}{dq^I} = \begin{cases} -1 & if\ \alpha - f < \frac{f^2}{2a(q^I)^2} \\ -\frac{f}{aq^{I2}} - 1 & if\ \left(\frac{f}{aq^I} - q^I\right)\left(\alpha - f - \frac{f^2}{2a(q^I)^2}\right) > 0 \end{cases}$$

Proposition 3 *Total dollar payoff to insiders is weakly increasing as a fraction of insider investment*

Proof Plugging in the optimal level of outsider capital q^{O^*} into the total dollar payoff to insiders, we get:

$$V^I = \begin{cases} f\sqrt{\frac{2(\alpha-f)}{a}} & if\ \alpha - f < \frac{f^2}{2a(q^I)^2} \\ (\alpha - f)\, q^I - \frac{f^2}{2aq^{I2}} + f\sqrt{\frac{2(\alpha-f)}{a}} & if\ \left(\frac{f}{aq^I} - q^I\right)\left(\alpha - f - \frac{f^2}{2a(q^I)^2}\right) > 0 \\ q^I\left(\alpha - \frac{a}{2}q^{I^2}\right) & else\ \sqrt{\frac{f}{a}} < \bar{q}_t^{I*} \end{cases}$$

Taking the derivative of the total dollar payoff to insiders with respect to insider capital, we get:

$$\frac{dV^I}{dq^I} = \begin{cases} 0 & if\ \alpha - f < \frac{f^2}{2a(q^I)^2} \\ (\alpha - f) + \frac{f^2}{aq^{I3}} & if\ \left(\frac{f}{aq^I} - q^I\right)\left(\alpha - f - \frac{f^2}{2a(q^I)^2}\right) > 0 \\ \alpha - \frac{3a}{2}q^{I^2} & else\ \sqrt{\frac{f}{a}} < \bar{q}_t^{I*} \end{cases}$$

Proposition 4 *For a non-binding management fee and positive level of outside investment, gross fees are weakly increasing as a portion of insider capital.*

Proof This is immediate when substituting the optimal level of outsider capital, q^{O^*}, substituting into the gross return equation, and taking the first derivative with respect to q^I.

A.4 Extension: Two Strategies

Up to now we have considered the case of one strategy. We extend the analysis to an insider which has access to two strategies, $N = 2$. Consider the insider with access to the following returns:

$$R_1 = \alpha_1 - C_1\left(q_1^T\right)$$
$$R_2 = \alpha_2 - C_2\left(q_2^T\right)$$

Without loss of generality, assume that $\alpha_1 > \alpha_2$. The interesting case is if, $a_1 < a_2$. This means that strategy one has a higher alpha, and also a lower higher scale cost as compared to strategy two.

Capital between the two strategies and investors is given by $q_n^T = q_n^I + q_n^O$ with $n \in \{1, 2\}$. For insiders $q^I = q_1^I + q_2^I$, for outsiders $q^O = q_1^O + q_2^O$, and in aggregate $q^T = q_1^T + q_2^T$. Shorting an insider's management service is ruled out, so $q_n^I \geq 0$ and $q_n^O \geq 0$.

A.4.1 Case 1: Constrained Inside Capital, One Fund

The insider's total dollar payoff is now the sum from each strategy, $V_1^I + V_2^I$. Given this, how should an insider allocate their capital between strategies? If so, should the insider capital be allocated across strategies? Would an insider ever invest in the low alpha strategy? If so, what rule would govern this?

We first consider the case when an insider capital is in the range of $0 < q^I < \sqrt{\frac{2\alpha_1}{3a_1}}$. Intuitively, an insider would invest in the high alpha strategy up to the point where the marginal total dollar add equals the low alpha strategy. Said differently, the insider would invest in strategy one for the initial range of q^I where:

$$\frac{dV_1^I}{dq_1^I} \geq \frac{dV_2^I}{dq_2^I} \tag{21}$$

While an the above inequality is satisfied, insiders maximize their dollar payoffs by allocating their capital to the high-alpha strategy. That means $q_1^I = q^I$ and $q_2^I = 0$ for the initial insider capital region. The dollar payoff for this partial regions is equal to V_1^I, and is outlined in the previous section.

A.4.2 Case 2: Two Strategies, Sufficient Insider Capital, Two Funds

As an insider allocates capital towards strategy one, the marginal payoff of each additional dollar will decrease towards the marginal value of strategy two. That is at some point, $\frac{dV_1^I}{dq_1^I} = \frac{dV_2^I}{dq_2^I}$ for some $0 < \hat{q}_1^I < \bar{q}_1^{I*}$. Once an insider's capital level reaches the threshold of $\hat{q}_1^I$, they will optimally mix between their two strategies to equate their marginal payoffs to insider capital.

An insider will continue to allocate to *both* strategies, equating the marginal dollar payoff from strategy 1 equal to the marginal payoff from strategy 2. While we do not explicitly solve the optimal mixing scheme in this paper, we can see a sketch of this strategy in Figure A.2. An insider will continue to strategically allocate insider capital to both strategies for insider capital levels of:

$$q_1^I \in \left[\hat{q}_1^I, \sqrt{\frac{2\alpha_1}{3a_1}} + \sqrt{\frac{2\alpha_2}{3a_2}}\right)$$

If funds raise outside capital, they do so to maximize dollar payoff in each fund subject to the fund-specific participation constraint.[19]

[19] We rule out the possibility that outside investors receive negative payoffs in some funds in order to participate in others.

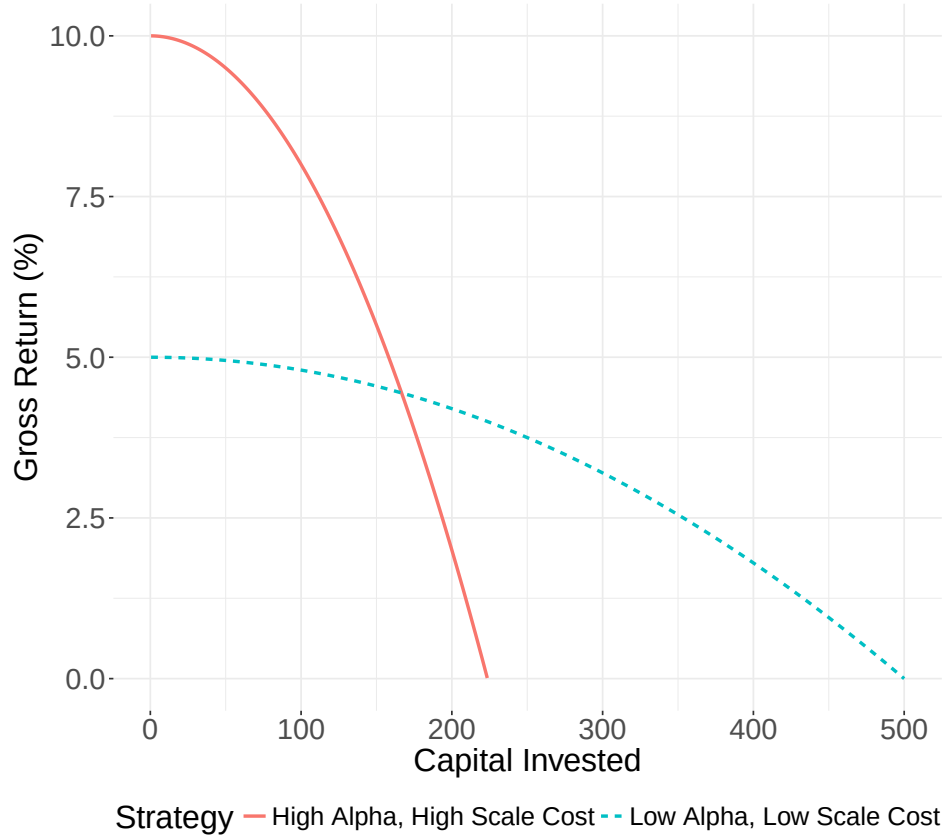
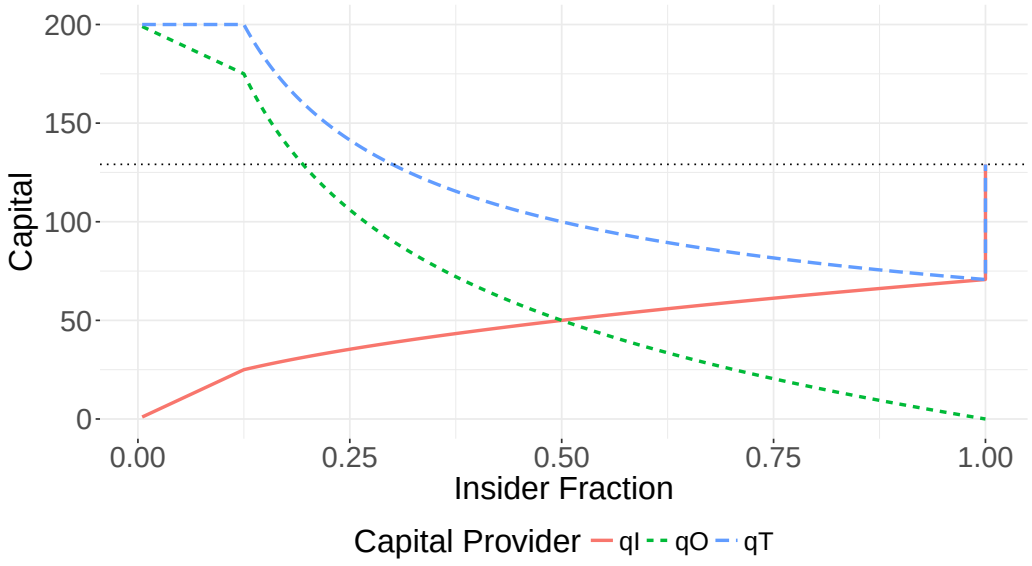
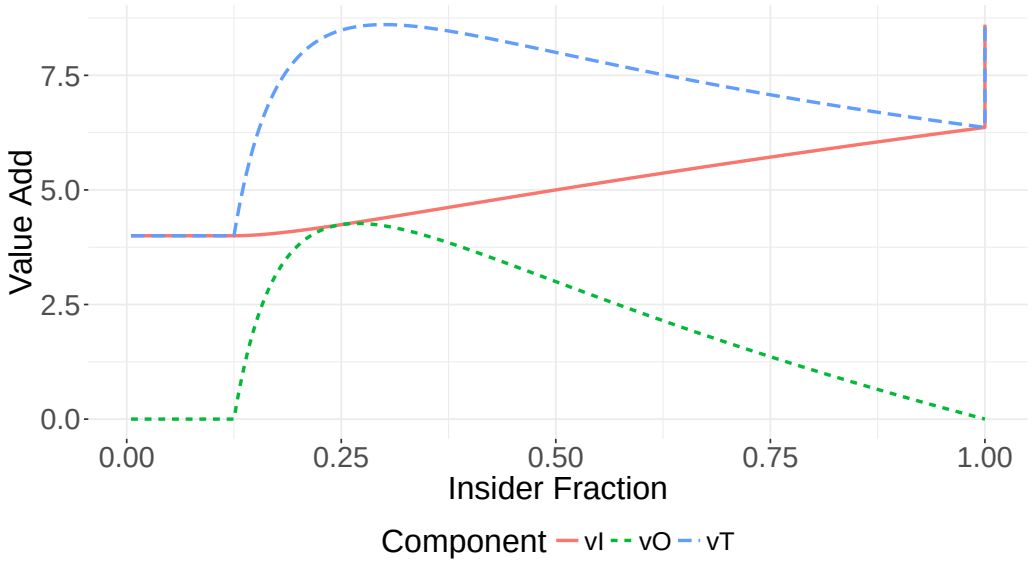


FIGURE A.1 **Gross Return Profiles of Different Strategies**

The above figure shows two strategies. The horizontal axis is the total dollar invested q_t^T in a given strategy, while the vertical axis is $R_{n,t+1}$. The red line refers to a high alpha, high scale costs, while the blue dotted line refers to the low alpha, low scale cost strategy. The first strategy is parameterized by $\alpha = 10\%$, and $a = 4 \times 10^6$, while the second is parameterized by $\alpha = 5\%$, and $a = 4 \times 10^7$. The highest alpha, per strategy, is highest at a zero dollar investment.



Panel A: Capital Sources



Panel B: Components of Payoffs

FIGURE A.2 **Capital and Payoffs**

This figure illustrates the distributions of fund size and returns by fraction of inside investment. Panel A illustrates that the total size of the fund is decreasing in the fraction of inside capital—the fund operates at a smaller capital capacity the more insiders are invested. Panel B shows that net returns to outsiders are higher the greater the proportion of inside investment. Parameters used in this example is $\alpha = 10\%$ and $a = 4 \times 10^6$.

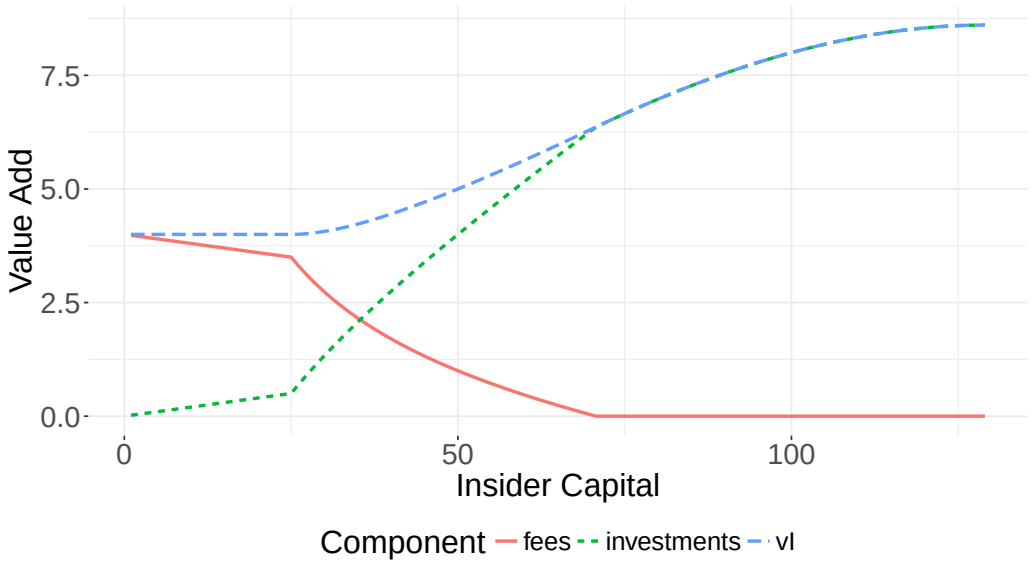
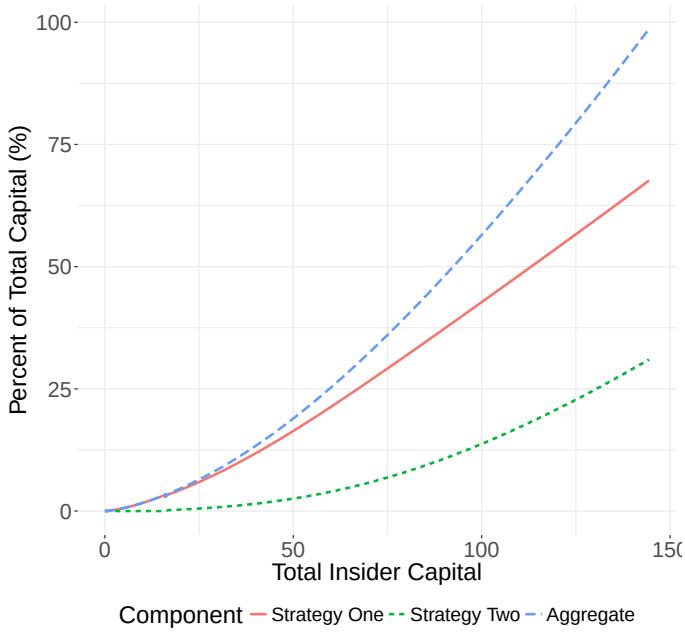
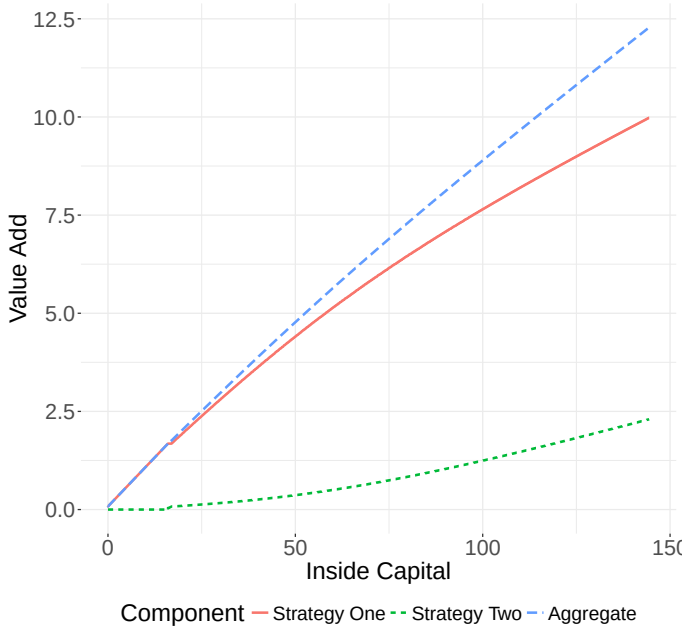


FIGURE A.3 **Payoffs to Insider and Components**

This figure illustrates the payoffs to insiders and outsiders over the range of insider investment. Outsiders have zero value added when insiders have no capital in the fund, or are fully invested. They share in rents when insiders are partially invested in the fund, but also accept outside capital. Parameters used in this example is $\alpha = 10\%$ and $a = 4 \times 10^6$.



Panel A: Percent of Inside Capital Allocated Across Funds



Panel B: Payoffs Between Two Strategies

FIGURE A.4 **Percent Inside Allocation and Payoffs of Two Strategies**

This figure shows the optimal percent insider invested in each strategy across the total insider capital. Parameters for the high alpha strategy is $\alpha = 10\%$ and $a = 4 \times 10^8$. Parameters for the low alpha, is $\alpha = 5\%$ and $a = 4 \times 10^7$

Important Notation

$R_{n,t+1}$	Gross excess return over the relevant benchmark portfolio, after accounting for scale effects of investing in strategy n.
α_n	Gross alpha for the first dollar invested in strategy n. This is the maximum gross excess return over the relevant benchmark. This is taken to be exogenous.
$r_{n,t+1}$	Net return from strategy n.
q_n^T	Total capital invested in strategy n. By definition, $q_n^T \equiv q_n^I + q_n^O$.
q_n^I	Insider capital invested in strategy n. This is taken to be exogenous.
q_n^O	Outsider capital invested in strategy n. This is taken to be exogenous.
$\bar{q}_n^{I*}$	The maximum amount of capital an insider choses to invest in a strategy if unconstrained.
V_n^I	Dollar payoff to insiders from strategy n. This equals the profit from returns and fees.
V^O	Dollar payoff to outsiders from strategy n. This equals the profit from returns minus fees.
$C_n\left(q^T\right)$	Scale factor of investment strategy. For concreteness, we use $C_n\left(q^T\right) = \frac{a_n}{2}\left(q_n^T\right)^2$ in this paper.
a_n	Scale factor of strategy that is associated with strategy n. This is taken to be exogenous.
f	Management fee as a fraction of the assets delegated by the outsider to the insider.
N	Total number of strategies available to an investor.
n	Refers to an individual strategy n. A strategy has a unique α_n, a_n, and thus $C_n\left(q_n^T\right)$.

B Additional Results

TABLE XIII **Alternate Specifications for Inside Investment and Return**

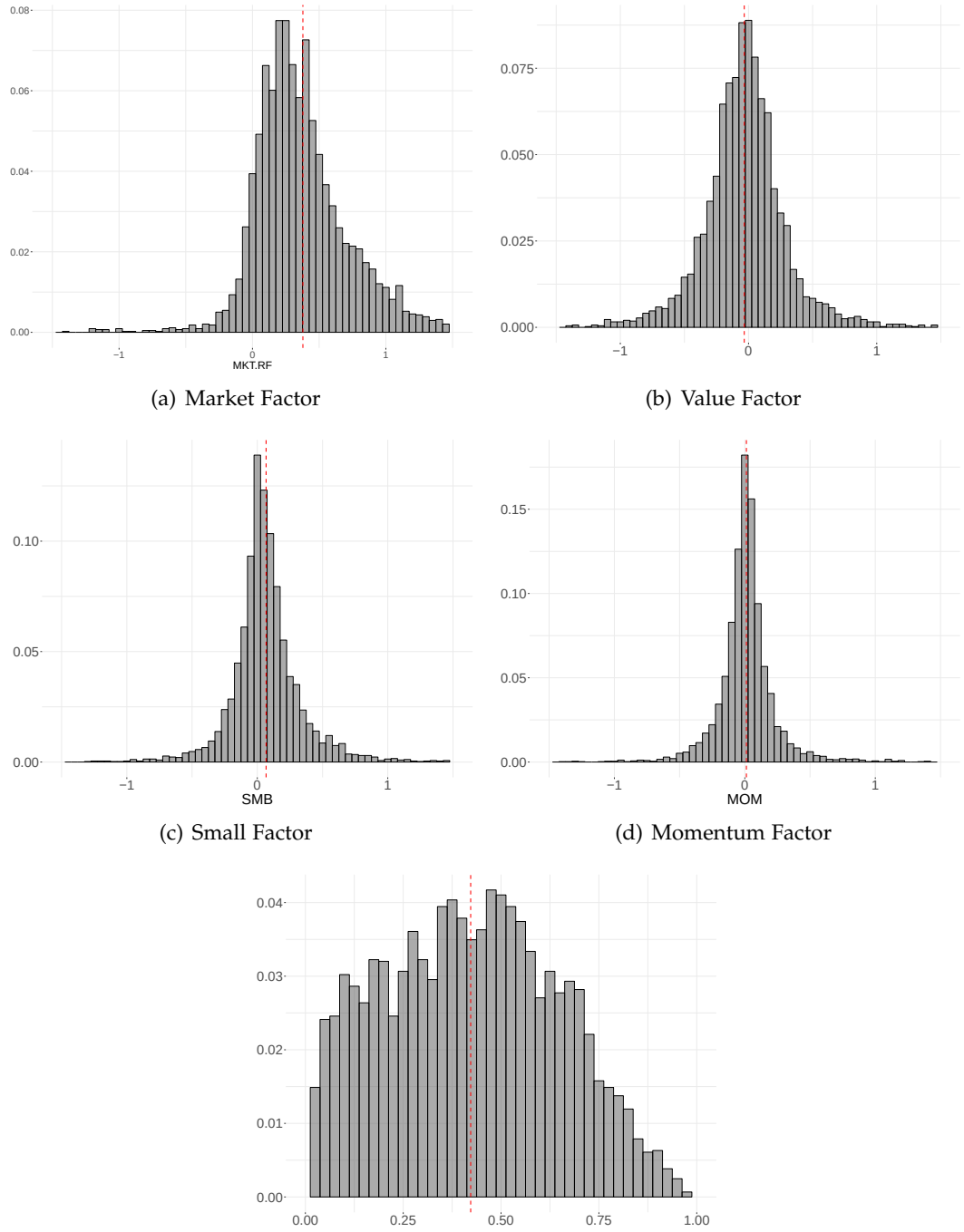
This table illustrates some alternate specifications of our main result. In Panel A, we modify the benchmark specification to include funds with zero or 100 percent inside investment. These funds are excluded from our benchmark results because of difficulty in matching. Panel B illustrates a value-weighted specification using the Gross Asset Value field from form ADV (our primary specification is equal-weighted).

Panel A **Including Full Skin Distribution**

	FH Excess Returns		FFC Excess Returns	
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0017**	0.0035***	0.0026***	0.0044***
	(0.0007)	(0.0012)	(0.0007)	(0.0011)
Log(Fund Size)	Yes	Yes	Yes	Yes
Fixed Effects	No	Yes	No	Yes
Observations	47,589	47,589	47,589	47,589
R^2	0.0002	0.0348	0.0010	0.0393
Adjusted R^2	0.0001	0.0188	0.0010	0.0234

Panel B: **Value-Weighted**

	FH Excess Returns		FFC Excess Returns	
	(1)	(2)	(3)	(4)
Skin (Percent)	0.0060***	0.0048**	0.0047***	0.0073***
	(0.0014)	(0.0022)	(0.0013)	(0.0024)
Log(Fund Size)	Yes	Yes	Yes	Yes
Fixed Effects	No	Yes	No	Yes
Observations	41,097	41,097	41,097	41,097
R^2	0.0015	0.0389	0.0006	0.0352
Adjusted R^2	0.0015	0.0216	0.0006	0.0178
Note:				*p<0.1; **p<0.05; ***p<0.01



(a) Market Factor

(b) Value Factor

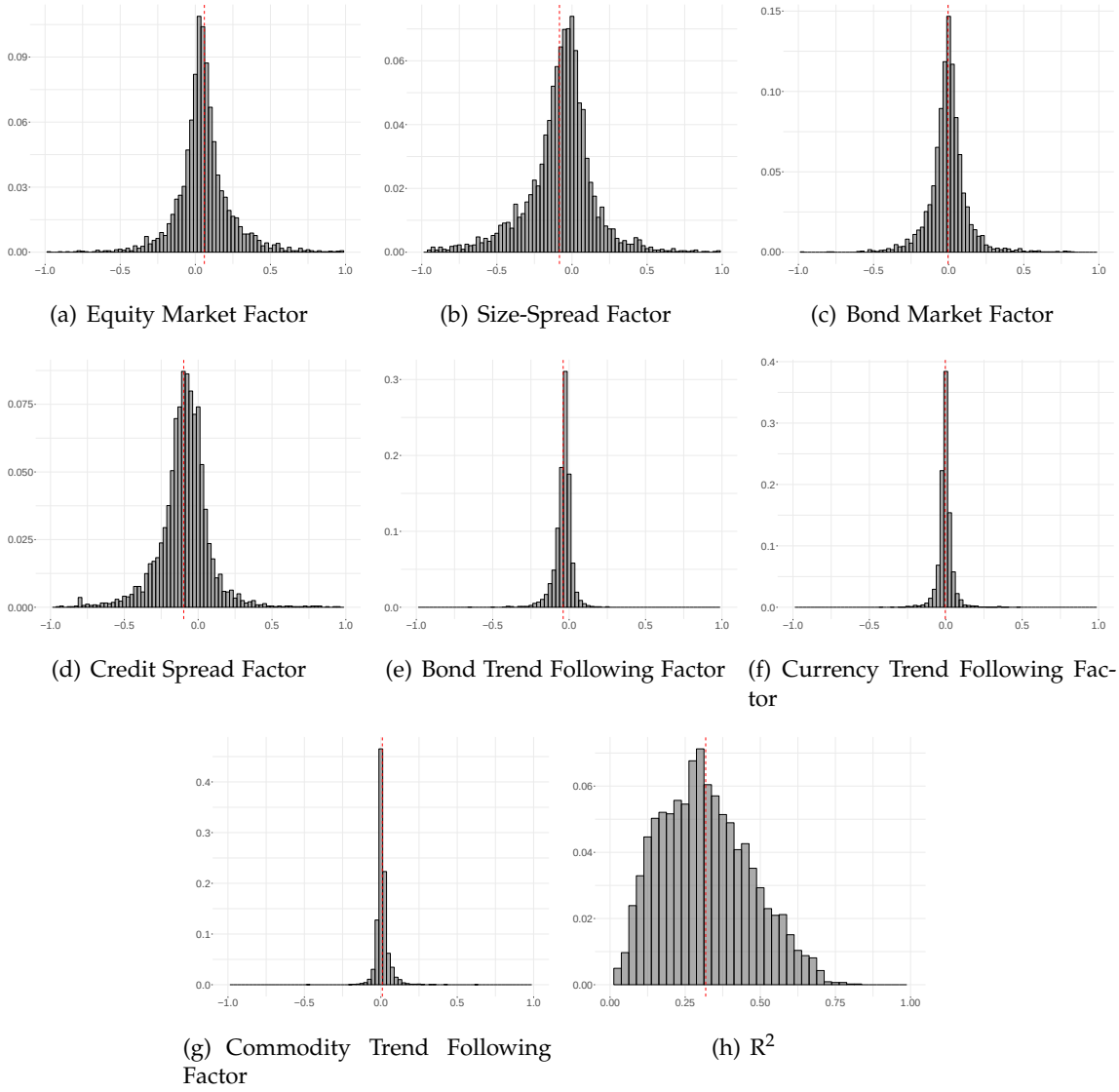
(c) Small Factor

(d) Momentum Factor

(e) R^2

FIGURE B.1 **Factor Distribution in 4-Factor Model**

This figure plots the distribution of factor exposures in the 4-Factor (Fama-French and Carhart) model. The histograms plot the coefficient estimates from a time-series regression of factor exposures against hedge fund returns run for each fund, as well as the R^2 of each model fit.



(a) Equity Market Factor (b) Size-Spread Factor (c) Bond Market Factor

(d) Credit Spread Factor (e) Bond Trend Following Factor (f) Currency Trend Following Factor

(g) Commodity Trend Following Factor (h) R^2

FIGURE B.2 **Factor Distribution in 4-Factor Model**

This figure plots the distribution of factor exposures in the 7-Factor Fung and Hsieh (2004) model. The histograms plot the coefficient estimates from a time-series regression of factor exposures against hedge fund returns run for each fund, as well as the R^2 of each model fit.