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Do Private Equity Funds Manipulate Reported Returns?☆

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Abstract

Private equity funds hold assets that are hard to value. Managers may have an incentive to distort reported valuations if these are used by investors to decide on commitments to subsequent funds managed by the same firm. Using a large dataset of buyout and venture funds, we test for the presence of reported return manipulation. We find evidence that some underperforming managers inflate reported returns during times when fundraising takes place. However, those managers are less likely to raise a next fund, suggesting that investors can see through the manipulation on average. In contrast, we find that top-performing funds likely understate their valuations. A simple theoretical framework rationalizes our empirical results as well as those of related papers.

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Do Private Equity Funds Manipulate Reported Returns?

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Private equity funds hold assets that are hard to value. Managers may have an incentive to distort reported valuations if these are used by investors to decide on commitments to subsequent funds managed by the same firm. Using a large dataset of buyout and venture funds, we test for the presence of reported return manipulation. We find evidence that some underperforming managers inflate reported returns during times when fundraising takes place. However, those managers are less likely to raise a next fund, suggesting that investors can see through the manipulation on average. In contrast, we find that top-performing funds likely understate their valuations. A simple theoretical framework rationalizes our empirical results as well as those of related papers.

1. Introduction

Recent SEC inquiries have examined the possibility of private equity general partners (GPs) overstating portfolio net asset values (NAVs) in an attempt to attract investors to future funds.[1] Because there is no liquid market for most assets held by private equity funds, investors (the fund limited partners we will refer to as LPs) rely on estimates of NAVs in quarterly reports provided by private equity general partners (GPs). Increasingly, NAVs are determined by outside valuation consultants and auditors, but the process is nonetheless subjective and is based on data produced by the portfolio companies that are directly owned by the funds.

In this paper, we examine the evidence regarding potential NAV manipulation using a simple theoretical framework and a large dataset of buyout and venture capital funds. Our empirical findings suggest that little manipulation of NAVs goes unnoticed by institutional investors. Some GPs of poorly performing funds appear to overstate NAVs around the time they are raising a follow-on fund. However, these embellishments appear unsuccessful at influencing investment decisions in so far as those firms are on average significantly less likely to raise a next fund. We also find evidence of conservatism in valuations among the best performing funds.

The theoretical framework that we propose is close to Chung, Sensoy, Stern, and Weisbach (2012) who analyze effects from the managerial compensation embedded in future funds and find it to comprise a substantial portion of the typical GPs' wealth. In our framework, GPs trade-off the short-term profits (i.e., fees from the next fund) with long-term consequences (i.e., success in subsequent fundraisings). Conservatism by top-performing GPs and efforts to overstate by underperforming GPs arise jointly under realistic assumptions: (i) the information asymmetry about the valuation bias persists even after a fund is resolved, (ii) the precision at which investors can infer a fund's valuation bias decreases in the magnitude of the valuation bias. The framework guides our empirical tests while explaining findings in related studies: Jenkinson, Sousa and Stucke (2013), Barber and Yasuda (2016), Chakraborty and Ewens (2016), Huther (2016).

We utilize data provided by Burgiss which includes daily cash flows and quarterly NAV reports from a sample of 2,071 funds. These data are sourced from over 200 institutional investors and represent ap-

[1] For example, see "Private Equity Industry Attracts S.E.C. Scrutiny" by Peter Lattman, New York Times, February 12, 2012.

proximately $750 billion in committed capital. We supplement these data with an independent database of private equity firms provided by StepStone. The StepStone database contains a nearly exhaustive record of institutional private equity fundraising between 1971 and 2016. This combination of data sources allows us to examine the relation between private equity performance reporting and fundraising success while ruling out any meaningful selection bias.[2]

We examine whether reported abnormal returns are related to fundraising for a subsequent fund. First, we consider returns around the first capital call for a firm's next fund. If there is no next fund, we assume fundraising attempts occur near the end of the fund's life (i.e., this is when a firm would have to be making a final push to raise a new fund). The data reveal a decline in abnormal performance around these events for both the average buyout and venture fund. We examine the source of the change in performance by separating funds into three groups that raise a next fund quickly, slowly, or not at all. While average excess returns tend to moderate for successful fundraisers, we observe return-reversals only for funds unable to raise a next fund.

Next, we estimate a probability model of fundraising success as a function of reported abnormal returns and distributions to investors while controlling for the variation in fundraising environment and fund characteristics. We find evidence that exaggerated NAVs are associated with lower probability of raising a follow-on fund. Furthermore, we show that credible signalling (via distributing capital back to investors) is more important than the current performance rank. The results are similar for both buyout and venture funds.

We then examine how reported returns depend on the performance of peer funds (i.e., those of similar vintage and strategy) and evolve over a fund life. We find evidence consistent with "peer-chasing" where top-performing funds report lower interim returns subsequently and bottom performing funds report higher returns. Finally, we estimate the expected valuation biases conditional on plausibly exogenous variation in the time elapsed without a follow-on fund and peers' performance and examine whether the adoption of new mark-to-market accounting standards in 2006-08 (FAS 157) has affected the quality of NAV reporting by private equity funds. We find some evidence that regulation has improved accuracy of reported NAVs, however this analysis is confounded by the 2008-09 financial crisis.

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[2] Our sample is at least 40% larger by number of funds than those in other related studies such as Jenkinson, Souse and Stucke, 2013, (761 funds), Chakraborty and Ewens, 2016, (1,453 funds), Barber and Yasuda, 2016, (975 funds), and Huther, 2016 (138 funds). Also, our sample exhibits a representative universe of private equity investors.

Our conclusions add to the private equity literature and are distinct from several contemporaneous studies of private equity interim reporting and subsequent fundraising. Similar to Jenkinson, Souse and Stucke (2013) and Barber and Yasuda (2016), we find abnormal returns for a typical fund are lower after subsequent fundraisings conclude. However, we show that the abnormal returns remain positive, on average, for successful fundraisers. Unlike these studies, we *do not* assume that (i) a constant excess return (conditional on fund age) is an appropriate null hypothesis to study reporting biases; and (ii) empirical proxies of changes in NAV-bias are free of measurement errors that correlate with the explanatory variables of interest. Instead, we show why a particular measurement error arises with those data and is likely to generate spurious regression coefficients because patterns in fund cash flows and market returns strongly relate to fundraising events. Consequently, we exert appropriate caution in constructing our variables and verify the validity of the null hypothesis via falsification tests.

While confirming that performance rank relative to peers tends to peak during fundraising (as do Barber and Yasuda, 2016), we go one step further in examining investor response. Our estimates suggest that "signal-jamming", as proposed in Chakraborty and Ewens (2016) and Barber and Yasuda (2016), is not a sufficient characterization of the private equity fundraising market. Rather, this equilibrium has salient features of costly signaling and conflicts of interests between the current fund's investors and the next fund's investors (with respect to resources for monitoring and nurturing of the investments portfolios). Our findings provide an alternative explanation for the elevated write-off rates (also documented in Huther, 2016) that both studies interpret as evidence of previously overstated NAVs. We argue that the write-offs may increase as a result of the effort-rationing between the newly-raised fund and the old fund by the GP. Importantly, the characteristics that predict less residual effort for the old fund also predict stronger incentives to inflate NAV. Thus, even when tests utilize the portfolio company transactions and valuation data (so that other sources of spurious correlations are plausibly absent), the resulting estimates can be misleading because unwinding the bias and rationing effort are jointly determined. However, the sign of the excess returns provides for a robust identifying assumption.

We also show that (i) performance rank during fundraising predicts final performance rank for both venture and buyout funds and (ii) rookie managers do not report NAVs more aggressively. These findings are different from the evidence in Jenkinson et al. (2013) and Cumming and Walz (2010). The differences arise because we do not condition on the information unknown at fundraising, and because we more clearly separate current performance from experience. This also supplements the analysis of GP reputations in Barber and Yasuda (2016) and relates to the power of LPs to hold-up information as studied in Hochberg, Ljungqvist, and Vissing-Jorgensen (2014).

Overall, our results suggest that the behavior of GPs and investors is influenced by the acknowledgment of asymmetric information and the potential for gaming of reported performance. It appears that sophisticated investors are unlikely to systematically misallocate capital based on false signals from GPs and may therefore prefer the current equilibrium to one with more regulation and (potentially) less gaming. Our findings corroborate the evidence in Robinson and Sensoy (2013) that private equity fundraising outcomes are largely determined by sophisticated counterparties.

The paper proceeds as follows. Section 2 presents the theoretical framework with testable predictions and reviews the related literature. Section 3 describes the data. Section 4 provides our main result. Sections 5 and 6 report additional tests and attempt to quantify the valuation bias. Section 7 concludes.

2. Reporting NAVs with incomplete and asymmetric information

To motivate our analysis of fundraising strategies by PE firms (GPs), we consider a rational learning framework in the spirit of Stein (1989) and Chung et al. (2012). The typical private equity fund has an investment period of five or six years and a fund life of at least ten years. As the investment period (or capital) elapses, the typical GP will seek to raise a new fund so that it can continue to invest while its previous investments mature. As a result, when prospective fund investors (LPs) evaluate the performance of a GP's recent funds, they must rely on net asset values (NAVs) reported by GPs.[3] GPs therefore have incentives to maximize their value by choosing how aggressive (or conservative) these valuations are.

A bias could enter NAVs in several ways. First, valuing companies using comparable firms requires judgment in selecting the set of appropriate firms for comparison. Second, valuing companies using cash flow models requires a set of subjective modeling assumptions about growth rates, discount rates, etc. Finally, a bias in NAVs can derive from timing the change to fair value versus historical cost accounting (or timing of write-downs of less successful investments), particularly for venture funds. Historically, fund

[3] Several studies, e.g., Harris, Jenkinson, Kaplan and Stucke (2013), find persistence in the performance of private equity funds but decaying predictability in fund sequence. That is, the second previous fund is less informative about the most current fund performance. In a survey of over 200 LPs, DaRin and Phalippou (2016) confirm that LPs focus on the recent past performance.

managers have had some flexibility on when to switch valuation methods. While funds now use external valuation firms, the process remains at least partially subjective.[4]

Let $f_j(\hat{r_0}, \gamma_0, F_0)$ denote a present value of the stream of fees to the GP from the yet-to-be-raised fund $j = 1, 2, 3, ...$ conditional on a consistent estimate of the risk-adjusted performance of the current fund $\hat{r_0}$, the valuation bias γ_0 in NAV of the current fund, reported as of fund $j = 1$ fundraising attempt, and the information set F_0 that includes performance of competing funds, investor capital availability, etc. We assume that $\partial f_j / \partial r_0 > 0$ and $\partial^2 f_j / \partial r_0^2 < 0$ for $j \geq 1$ so fund size and fees increase in the previous fund's performance but at a diminishing rate.

Similarly, let $p_j(\gamma_0; \hat{r_0}) := Pr\{f_j \geq \underline{f} | \gamma_0, \hat{r_0}, F_0\}$ denote the probability of raising fund j conditional on the information about fund $j = 0$. As in Chung et al. (2012), we interpret this as the probability of securing the minimal amount of committed capital to operate a fund, $\underline{f}$. In Appendix A.1.1 we generalize the framework to allow multiple attempts.

We will write $p_j(\hat{r_0} + \gamma_0; F_0)$ and $f_j(\hat{r_0} + \gamma_0; F_0)$ to highlight that LPs observe the reported performance of fund $j = 0$ when asked to commit to fund $j = 1$ (while $j = 0$ remains unresolved). Hence, LPs might not distinguish $\hat{r_0}$ from γ_0. However, for funds $j = 2, 3, ...$, the LPs can observe the fully realized performance of fund $j = 0$ and may deduce the previously reported valuation bias, γ_0.

Suppressing the subscript for the next ($j = 1$) fund and the reference to the information set F_0, we can write the GP's value maximization problem as

$$\gamma_0^* = \arg\max_{\gamma_0} f_0(\hat{r_0}, \gamma_0) + p(\hat{r_0} + \gamma_0) \cdot f(\hat{r_0} + \gamma_0) + p(\hat{r_0} + \gamma_0) \cdot V(\gamma_0; \hat{r_0}) \tag{1}$$

$$\text{s.t. } \gamma_0^* \leq \gamma^R$$

where $V(\gamma_0; \hat{r_0})$ is a continuation value,

$$V(\gamma_0; \hat{r_0}) = Pr\{f_2 \geq \underline{f} | r_0, \gamma_0, F_0\} \cdot f_2(r_0, \gamma_0, F_0) \tag{2}$$

$$+ Pr\{f_2 \geq \underline{f} | r_0, \gamma_0, F_0\} \cdot Pr\{f_3 \geq \underline{f} | r_0, \gamma_0, F_0\} \cdot f_3(r_0, \gamma_0, F_0) + \ldots \ ,$$

and γ^R is the maximal bias given the regulatory environment.

The GP wealth is comprised of three parts: (i) the fees from the current fund, (ii) the fees from the next fund if raised, and (iii) the fees from subsequent future funds (also, if raised). Chung at al. (2012) and

[4] Before 2009, GPs had a large amount of discretion in valuing their portfolios. Since 2009, Financial Accounting Standards Board (FASB) Accounting Standard Codification Topic 820 (also known as FAS 159) requires private equity firms to value their assets at fair value every quarter.

Metric and Yasuda (2005) show that a substantial amount of GP wealth derives from the third component, the continuation value $V(\cdot)$. Depending on how easy it is to objectively value the fund assets, γ^R may differ across time and fund type.

Assuming that $V(\cdot)$ is differentiable and the claw-back provisions preclude the bias from altering the value of fees from the current fund (i.e. $f_0' = 0$), the following first-order condition characterizes a solution to the GP's problem in equation (1):

$$p' \cdot \big(f(\hat{r}_0 + \gamma_0) + V(\gamma_0; \hat{r}_0)\big) = -p(\hat{r}_0 + \gamma_0) \cdot \big(f' + V'\big) \quad (3)$$

where we denote partial derivatives with respect to the reported performance of fund $j = 0$ with apostrophes.

2.1. Equilibrium with "naïve" investors

Based on condition (3), if investors cannot deduce the appraisal bias from reported interim returns (i.e. $p' \geq 0, f' \geq 0$), the necessary condition for γ_0^* to not equal the largest feasible bias γ^R is:

$$f' + V' < 0 \quad (4)$$

which implies that the sensitivity of the continuation value to the valuation bias must be negative and exceed in magnitude the (positive) sensitivity of the fees from the next fund ($-V' > f'$). In other words, LPs need to be able to deduce the bias *ex post* and punish GPs by investing less in subsequent funds.

If condition (4) does not hold, there may exist a *Naïve Investors* equilibrium where all GPs overstate interim returns as much as the auditors and litigation risks permit. Consequentially, we would observe that:

NI-1: Abnormal returns are on average negative after fundraising: $r_0 - \hat{r}_0 - \gamma_0 < 0$.

NI-2: Past reputation and performance do not affect the over-valuation bias.

NI-3: While high interim performance increases the probability of successful fundraising, the performance rank at fundraising is uninformative about the final rank when γ^R is large and heterogeneous.

2.2. Signal Jamming

From equation (3), it follows that with $-V' > f'$, adverse shocks to the probability of securing the minimal commitment for next fund increase the valuation bias. To see this, consider a change in the information set F_0 from good (g) to bad (b) such that $p_b(\hat{r}_0 + \gamma_0^g) < p_g(\hat{r}_0 + \gamma_0^g)$ while the expected fees from the next fund (conditional on raising it) and the continuation value remain unchanged. In a new equilibrium, the GP will increase the valuation bias in the reported NAVs provided that

$$p_b'(\hat{r}_0+\gamma_0^g)/p_g'(\hat{r}_0+\gamma_0^g) > p_b(\hat{r}_0+\gamma_0^g)/p_g(\hat{r}_0+\gamma_0^g) \quad (5)$$

$$f_b'(\hat{r}_0+\gamma_0^g) \geq f_g'(\hat{r}_0+\gamma_0^g) \quad (6)$$

This derives from the fact that $V(\cdot)$ and $V'(\cdot)$ need to counter-balance the increase in the left-hand side of equation (3) due to condition (5). The latter is guaranteed if p' is a Gaussian density function.[5] Meanwhile, in the more competitive fundraising environment b, the performance signal should be at least as important in determining the fund size and the fee schedule, as per inequality (6). Since $V' < 0$, the new equilibrium bias, γ_0^b, will be greater than γ_0^g. It is important to note that GPs cannot benefit from a negative valuation bias here unless $|V'| > |\partial V/\partial \hat{r}_0|$. However, if upon fund resolution investors can see the past bias perfectly, γ_0 and r_0 should be "interchangeable" information for LPs.

This may give rise to a *signal jamming* equilibrium. In this equilibrium, even top-performing funds have the incentive to inflate their interim returns. They do this to mitigate the negative effects on their current fundraising prospects from the overstated NAV reports by underperforming funds that have low continuation values and $p(\hat{r}_0 + 0) \to 0$. Interestingly, GP behavior under such equilibrium would be observationally similar to the case with the *Naïve Investors* described above, even though NAVs' overstatement (for a given information set F_0) will be correctly deduced by the market and reflected in $f(\cdot)$ accordingly. GPs will continue to overstate NAVs as if they were "myopic". As per Stein (1989),

> In spite of being unable to fool the market, managers are "trapped" into behaving myopically. The situation is analogous to the prisoner's dilemma. ... The Nash approach clearly exposes the fallacy inherent in a statement such as "since managers can't systematically fool the market, they won't bother trying."

Also, if overstating interim performance is costlier for (truly) better performing GPs, i.e. $\frac{\partial^2 V}{\partial \gamma_0 \partial r_0} < 0$, there would exist more separation across reporting by GP types where

SJ-1: good past reputation and performance reduces the over-valuation bias, and

SJ-2: interim performance rank is highly informative of the final rank regardless of γ^R.

2.3. Costly signaling

Now we consider an LP $i \in I$ that, instead of just relying on NAVs provided by GPs, *independently* observes a noisy signal about the fund's valuation bias (according to the survey by DaRin and Phalippou

[5] Hence, $p(x)/p'(x)$ is the Mills Ratio which strictly increases in x for standard normal law. See Baricz (2008) for proof and Baricz (2012) for general conditions. By construction, p_b is the same probability function as p_g but shifted to the left due to changes in the subset of covariates x other than the fund's reported return.

(2016), more than 90% of the LPs calculate their own measure of GP past performance), so that

$$\hat{\gamma}_{i0} \sim N(\gamma_0, (1+\gamma_0^2)/\tau_i). \tag{7}$$

That is, LPs infer the valuation bias correctly on average but make mistakes proportional to how far the bias is from zero (e.g., because the more GPs manipulate NAV the more information they have to obfuscate). However, even with $\gamma = 0$, there is some unresolvable uncertainty that decreases in the precision, τ, which is possibly different across LPs.

Consequently, the LP agrees to commit capital to the next fund with a probability $p(\hat{r}_0+\gamma_0-\gamma_{i0})$, so that the probability of raising the follow-on fund by the GP equals the weighted average of individual commitment probabilities across LPs,

$$\bar{p}(\hat{r}_0, \gamma_0) := \sum_{i \in I} w_i \cdot p(\hat{r}_0+\gamma_0-\gamma_{i0}), \tag{8}$$

while the stream of fees depends on the inference of only those LPs who agreed to commit, $i \in I_C$[6]

$$f(\hat{r}_0 + \bar{e}_C) := f(\hat{r}_0 + \sum_{i \in I_C} w_i \cdot e_i(\gamma_0)). \tag{9}$$

Assuming that (i) LPs continue to have perfect inference about the valuation bias ex-post, $\gamma_{Pi}(\gamma_0) = \gamma_0$ and that (ii) the continuation value depends on the inference by all LPs (not just those who agreed to commit to the next fund), the GP's objective function and first-order condition become:

$$\bar{p}(\gamma_0; \hat{r}_0) \cdot \Big(f(\hat{r}_0+\bar{e}_C) + V(\bar{\gamma}_P(\gamma_0); \hat{r}_0) \Big) \tag{10}$$

$$\bar{p}' \cdot \Big(f(\hat{r}_0+\bar{e}_C) + V(\bar{\gamma}_P(\gamma_0); \hat{r}_0) \Big) = -\bar{p}(\gamma_0; \hat{r}_0) \cdot \Big(f' + V' \Big) \tag{11}$$

where $\bar{\gamma}_P(\gamma_0) = \sum_{i \in I} w_i \cdot \gamma_{Pi}(\gamma_0)$.

First, consider the GPs of a significantly underperforming fund, such that $p(\hat{r}_0^L+0) \ll \text{Mode}\big(p(r_0)\big)$. Although the valuation bias tends to be correctly detected, $E[\gamma_{i0}] = \gamma_0$, it is still optimal for GPs with $\hat{r}_0^L$ to choose $\gamma_0^* > 0$ due to the convexity of the probability distribution function in the vicinity of $\hat{r}_0^L$: $\bar{p}(\gamma_0; \hat{r}_0^L) \approx E[p_i(\hat{r}_0^L+\gamma_0-\gamma_{i0})] > p(\hat{r}_0^L+E[\gamma_0-\gamma_{i0}]) = p(\hat{r}_0^L+0)$. That is, the mistakes by LPs who underestimate the fund's γ_0 have stronger effects on fundraising success than mistakes of similar magnitude by LPs who happen to overestimate γ_0. Thus, equations (10)-(11) imply that for such underperforming GPs, the expected wealth

[6] So that fund size (conditional on having been raised) is larger when GPs overstate the previous fund NAVs at fundraising. Otherwise, $E[\bar{e}] = 0$ so $f' = 0$.

increases in γ_0 until either the continuation value's marginal cost, V', or the regulatory constraints, γ_0^R, bind.

In contrast, GPs of a strongly outperforming fund should expect their fundraising probability to fall in $\gamma_0 > 0$ since $p(\cdot)$ is concave around $p(\hat{r}_0^H + 0) \gg \text{Mode}\big(p(r_0)\big)$ (which appears true for the distribution functions that approximate the histograms of PE fund abnormal returns). Thus, GPs with $\hat{r}_0^H$ would seek to minimize γ_0^2 and therefore choose $\gamma_0^* = 0$. Furthermore, if there is a feasible action that increases the precision of the signal observed by LPs, it may be optimal for GPs with $\hat{r}_0^H$ to undertake such an action, even if it is costly (e.g. reduces the current fund's future returns). An example of such costly actions is cash distributions to LPs from exiting the fund's investments before realizing their full abnormal return potential. As in Spence (1973), these actions get relatively less costly for high quality GPs (i.e., as $\hat{r}_0$ increases). Still, such costly signaling might be undertaken by GPs with average performing funds as a cheaper response to "signal jamming" from GPs with $\hat{r}_0^L$. Note that the effects of distributions on fundraising success probability will be strongest for the top-performing funds but relatively short track records (and, hence, higher $\bar{p}'(\gamma_0;\hat{r}_0)$) which is consistent with the primary finding of Barber and Yasuda (2016).

However, there are two mutually reinforcing conditions under which GPs with $\hat{r}_0^H$ would choose to report *conservative* NAVs (i.e., $\gamma_0^H < 0$) instead of the *unbiased* NAVs ($\gamma_0^H = 0$). These are

$$\gamma_{Pi}(\gamma_0) = \frac{\tau \cdot \gamma_{i0} + s \cdot (1+\gamma_{i0}^2) \cdot (\hat{r}_0 + \gamma_0 - r_0)}{\tau + s \cdot (1+\gamma_{i0}^2)}, \text{ and} \tag{12}$$

$$-E[V' \cdot \bar{\gamma}_P'] > \partial V / \partial \hat{r}_0. \tag{13}$$

That is, either LPs cannot observe γ_0 perfectly *ex post* (but to some extent rely on the difference of realized returns and those reported at fundraising to update their beliefs) as per equation (12)[7], *or* LPs punish evidence consistent with $\gamma_0 > 0$ stronger than they reward higher past returns as per condition (13). The latter appears plausible when LPs admit the informational asymmetry preventing the verification of $\hat{r}_0$ and γ_0 (so the two are not interchangeable).

Inequality (12) alone would cause conservative NAV reports from GPs with r_0^H because of the concavity of $V(\cdot)$ in $\bar{\gamma}_P(\gamma_0)$ which is a function of the true return innovation $e_f = r_0 - \hat{r}_0$, unknown as of the γ_0 choice time. $V(\cdot)$ is concave in past fund performance since the underlying $f_j, j = 2,3,\ldots$ are concave. Consequently, the expected continuation value with respect to realizations of e_f (i.e., $\int V(\bar{\gamma}_P(\gamma_0, e_f);\hat{r}_0)dP(e_f)$),

[7] See DeGroot (1970) for a derivation of the Bayesian updating formula utilized in equation (12). In our case, s is the precision of a signal from the realization $r_0 - \hat{r}_0$.

that replaces $V(\gamma_0; \hat{r}_0)$ in equations (10)-(11) is smaller than $V(\gamma_0, \hat{r}_0)$ leading to a *smaller* left-hand side of equation (11), all else equal. This is exactly opposite to the shocks that induce the pressure from "signal jamming" discussed in Section 2.2. So, in this case with "noisy" *ex post* inference GPs with $\hat{r}_0^H$ choose $\gamma_0^* < 0$ instead of $\gamma_0^* = 0$ in the perfect *ex-post* inference case since $V' < 0$ must get less negative (so that the right-hand side decreases) while $V > 0$ has to increase.

Such asymmetry in the optimal reporting strategies for GPs depending on their current performance relatively to the typical ("modal") fund in their cohort effectively induces a peer chasing behavior until the fundraising concludes. GPs with $\hat{r}_0^H$ would tend to report conservative NAVs (i.e. $\gamma < 0$) while reported valuations by GPs with $\hat{r}_0^L$ will exhibit an upward bias (i.e. $\gamma > 0$) so long as the cost to delay divestments is low enough.

We refer to this as the *costly signaling* equilibrium with sophisticated LPs (the analytical proof of its existence is beyond the scope of this paper). The information asymmetry is never fully resolved and LPs act accordingly. When compared to the *naïve investors* and *signal jamming* equilibria, it has three main distinctive features:

CS-1: Abnormal returns after successful fundraising, $r_0 - \hat{r}_0 - \gamma_0$, are *positive* on average across funds.

CS-2: Overstating NAVs is associated with a lower probability of a successful fundraising but nonetheless is pursued by GPs of underperforming funds.[8] However, distributions to LPs mitigate evidence of possibly inflated interim performance.

CS-3: GPs of a top-performing fund will tend to report conservative NAVs during fundraisings.

It is important to note that under *costly signaling*, distributions affect LPs' prior beliefs about bias which, unlike in *signal jamming*, continue to matter even upon fund resolution since the true valuation bias can never be observed by LPs.

2.4. Related studies

The following table summarizes the predictions of the three equilibria discussed above:

[8] Given that overoptimism and overconfidence may jointly characterize GPs of underperforming funds, some of this overstatement might also be behavioral. It does not change the core intuition but merely makes $p_j(\cdot)$ subjective across GPs.

	Naïve Investors	*Signal Jamming*	*Costly Signaling*
Aggressive valuations (of the current fund) tend to increase the size of the next fund (conditionally on actually raising one)	Yes	Yes	Yes[6]
Reputation and past realized performance affect valuation bias	No	Yes	Yes
Aggressive valuations decrease the probability of raising the next fund	No	No	Yes
Average excess return post-fundraising is negative	Yes	Yes	No
Performance rank at fundraising predicts the final rank	No[NI-3]	Strongly	Some[CS-3]
Distributions increase the probability of raising next fund	No	Some	Strongly

Our subsequent analysis attempts to answer which, if any, of these three equilibria are consistent with the data.

Before reporting our results, we put findings and tests from a number of highly related studies in the context of this theoretical framework. Jenkinson et al. (2013) conclude that while on average GPs report conservative valuations, they tend to inflate NAVs during the fundraising to the extent that interim performance is uninformative of the final results. Although the authors examine a vintage-year fixed-effects model of final returns (e.g. PME) rather than the rank persistence, overall their analysis suggests that the naïve investors equilibrium is the closest approximation of the PE fundraising market. Barber and Yasuda (2016) and Charkoborty and Ewens (2016) suggest that the PE fundraising market has more in common with a signal jamming equilibrium with NAV overstatement having adverse long-term consequences for GP reputation (thus, generating a cross-sectional variation in the degree of the bias).

It is important to note that the evidence of wide-spread overstatement of NAVs (or, equivalently, of strategic delays to write-down) in these studies was derived from tests for whether the returns in the existing funds were lower following the completion of new fundraisings. There are a number of reasons that do not involve pre-existent valuation biases for why post-fundraising returns may get flatter. For example, it could be that the costly signalling of skill and portfolio quality through early exits (which Barber and Yasuda (2016) also document) simply changes the portfolio composition towards less successful investments. More importantly, the redirection of GPs' monitoring resources towards the newly raised fund also predicts that excess returns of the old fund will moderate (perhaps due to an increase in write-offs). According to a recent survey of VCs by Gompers, Gornal, Kaplan and Strebulaev, assisting the existing portfolio companies and sourcing new deals are the two most time-consuming activities for GPs with each taking around 30% of partner time. Thus, adding a new fund plausibly constitutes a shock to resources and causes a reassessment of the previous investments.

To better illustrate this mechanism, in Appendix A.1.2-A.1.3 we provide an extension to our theoretical framework. We continue to assume that LPs cannot perfectly distinguish overstated NAVs during fundraising from bad luck post-fundrasing. We then examine how a GP should allocate resources between two funds while also trying to unwind the NAV bias in the old fund. The ambiguity around write-offs is pervasive because the GP characteristics which positively correlate with greater incentives to divert resources to the new fund coincide with incentives to inflate NAV in the old fund (e.g., not in-the-carry, lack of strong track record, few reinvestments from LPs of the old fund). So, the assumption in Chakraborty and Ewens (2016) that write-offs shortly after the next fund launch reveal an upward valuation bias is debatable if effort is especially important early in a fund's life.

Furthermore, there is no credible strategy for "good" GPs (i.e., those who did not inflate the old fund NAVs but just face effort constraints) to separate from those GPs who attempt to disguise the unwinding of the upward valuation bias. For example, to obfuscate, "bad" GPs might try to write-off assets when variance of the comparable valuations is high. However, it is *not* costlier for them to mimic good GPs and refrain from big-baths or to cluster write-offs around times when their new fund makes new investments (to mimic effort-rationing). Thus, inference about PE funds NAV aggressiveness based on the post-fundraising write-downs in the old funds (or a moderation of a positive excess return trend) is particularly susceptible to the endogeneity problem because effort-rationing and unwinding of NAV bias are jointly determined.

Consequently, GPs of top-performing funds may prefer reporting conservative NAVs to have a valuation buffer which enables more optimal resource allocation between the old fund and the new fund (i.e. without jeopardizing their reputation as a truthful reporter). This would also be highly conducive for the persistence in PE fund performance that has been documented in the literature.

Besides the effort-rationing alternative, there are other factors confounding the empirical analysis of PE fund NAV reporting patterns. The first one concerns the mechanical relationship between the volatility of interim performance metrics and the size of the fund's unrealized investments. For example, Barber and Yasuda (2016) measure write-offs as $min\{NAV_t - (NAV_{t-1} - CashFlow_t), 0\}$. Even though the authors rescale cash flows and NAVs with the fund commitment size and control for the time since fund inception, the coefficient on the post-fundraising dummy constitutes a joint test for whether the (market value of) fund invested capital peaks after a new fund is launched. In other words, while keeping the return generating process fixed and the reporting bias of zero, one would expect to reject the null in this test should the capital distribution intensity be relatively low pre-fundraising. Our analysis in section 4 circumvents this problem while also using a more robust identification assumption amounting to the sign of the post-fundraising returns.

The second confounding factor derives from the fact that PE funds' systematic risk exposures and past valuation biases are measured with error while the typical fund cash flows and fundraising patterns are both correlated with the public market returns. The consequence of this measurement error is a spurious correlation with the indicator variables denoting quarters before and after fundraising. In section 5, we demonstrate the source of this econometric bias analytically and supplement our empirical findings with the falsification tests designed to illuminate it. In Internet Appendix I.1, we provide further detail on variables derivation and also demonstrate the magnitudes of spurious correlations using the econometric model specifications as in Jenkinson et al. (2013).

3. Data

We obtain data on private equity funds from Burgiss and StepStone. The Burgiss dataset is sourced exclusively from LPs and includes the complete transactional and valuation history for fund investments. The Burgiss data we utilize are provided by over 200 institutional investment programs and represent over $750 billion in committed capital. The Burgiss LP customer base consists of approximately 60% pension funds (a mix of public and corporate), 20% endowments and foundations, and 20% other institutional investors such as funds-of-funds and sovereign wealth funds. Data from individual LPs are scaled by Burgiss to be representative of the full fund and supplemented with fund-specific characteristics (e.g., investment strategy).[9]

We supplement the Burgiss data with information obtained from the StepStone SPI database to provide an independent source of information about fund sequences and start dates. The SPI database tracks 12,545

[9] Additional details on the Burgiss data (known as "Burgiss Manager Universe") are available in Brown et al. (2015)

funds by 5,128 PE firms between 1969 and 2016. The SPI database is among the most comprehensive we are aware of in terms of coverage of buyout and venture funds, but unlike Burgiss it does not typically have the complete cash-flow and valuation history. For each of the funds in the Burgiss sample, we identify the same fund and parent firm in the SPI database to verify the dates of new fund formation and the sequence of funds operated by a particular GP. Independent verification of fund sequence is especially important for our analysis of unsuccessful fundraising as described in more detail below.

The Burgiss dataset has been utilized in other academic studies. Harris, Jenkinson, and Kaplan (2014) compare several private equity datasets and conclude that the Burgiss dataset is representative of the buyout and venture funds investable universe. A major advantage of the Burgiss dataset is a complete and audited set of fund cash flows derived from direct recording of the fund accounting information disseminated to LPs. This feature is important for our research question because it insures against breaks in voluntary reporting by GPs and certain selection biases in other datasets (e.g., those relying on disclosures from public records and Freedom of Information Act requests). We limit our sample to buyout (venture) funds with more than $25 ($10) million in capital commitments denominated in U.S. dollars. Our sample with performance data includes 997 buyout funds and 1,074 venture funds. Of these, 641 buyout and 910 venture funds focus on North America. In our sample, 488 of the buyout and 323 of the venture funds remain active (i.e., are unresolved) as of March 2012.[10] We are able to categorize each fund by: (1) industry sector according to Global Industry Classification Standard; (2) amount of capital committed; (3) strategy description; (4) firm affiliation; (5) dated (to the day) cash inflows and outflows as well as quarterly reported NAVs.

Table 1 reports summary statistics for the funds in our sample with complete performance data (i.e. Burgiss) separately for buyout and venture funds. We define a fund as no longer active or "resolved" once it has an NAV less than 2% of the fund's initial commitment amount. Results in Panel A indicate the well-known heterogeneity and positive skew in performance among both resolved and active funds as well as the typically larger commitment amounts for buyout funds. The median buyout (venture) fund makes a distribution or capital call in 66% (46%) of active quarters.

Our data allow us to track each fund's affiliation with a private equity fund-management firm (henceforth, PE firm) so that we are able to generate fund sequences. Panel A of Table 1 also shows that for

[10] In unreported results, we verify that the main findings hold in just the funds focusing on North America. Because of the smaller sample size, the power of tests using samples of funds focusing outside North America are necessarily weaker, but we do not find any results contrary to those reported for the full sample.

firms with at least two funds, the (interquartile) time between a particular fund's inception and a follow-on fund's first capital call varies from two to five years. Panel B of Table 1 presents further detail on successive fundraising patterns by breaking out each fund type into groups based on the number of years between a fund's inception and the next fund offering by the same firm (as measured by the date of the follow-on fund's first capital call). In addition, we tabulate the number of funds (i) by firm experience as measured by the number of previous funds raised and (ii) fundraising conditions as measured by public equity market performance through the third year of fund operations. If public market total returns in the three years around a fund's inception were in the bottom (top) tercile in comparison to other fund-vintages of the same type, we classify the fund as starting operations in a low (high) market environment.

Combining the Burgiss data on cash flows and NAVs with the SPI data on fund starts enables an analysis of the relationship between fund interim performance and fundraising success. For all tests in this paper, we define a follow-on fund as the first fund by the same GP raised after 3 years from the current fund's first capital call. We define "same GP" for follow-on funds as those: (i) operated by the same PE firm; (ii) with the same geographic focus (if any) and currency denomination; (iii) with a similar investment strategy (e.g. buyout or venture). According to the above criteria, the follow-on success rate for buyout (venture) funds is 86.5% (83.2%). These values are about 10% higher than the follow-on rates inferred from the Burgiss data alone which are 77.2% (72.7%).

4. Primary results

4.1. Do excess returns become negative after fundraising?

If private equity firms inflate existing fund NAVs to boost to-date performance during new fundraisings, fund performance should subsequently deteriorate. The theoretical framework in section 2 calls for a proxy of cross-sectional mean excess returns of PE funds to be examined in an event study framework.

Our analysis in this section relies on Public Market Equivalent (PME), the measure of excess returns proposed by Kaplan and Schoar (2005). For each time t where we observe a fund's net asset value report (NAV_t), we define the PME since inception (i.e. the fund's first capital call, $\tau = 0$) as

$$PME_t = \frac{\sum_{\tau=0}^{t} Dists_\tau R_{\tau:t}^{mkt} + NAV_t}{\sum_{\tau=0}^{t} Call_\tau R_{\tau:t}^{mkt}} \equiv \frac{fv_t(Dists) + NAV_t}{fv_t(Calls)} \ , \tag{14}$$

where $R^{\text{mkt}_{\tau:t}}$ is the public equity index (value-weighted CRSP) gross return between time τ and t, assuming $log(R^{mkt}_{t:t}) = 0$. $Calls_\tau$ and $Dists_\tau$ are non-zero for some τ and denote the fund's capital calls (including management fees) and distribution (net of carry and other fees). Note that equation (14) is invariant to the time increment - if non-zero cash flows happen at a monthly frequency there will be 120 intervals between $\tau = 0$ and t of ten years. In practice, fund cash flows are irregular, so we cumulate their time-t values, $fv_t(Calls)$ and $fv_t(Dists)$, at a daily frequency (according to the date stamps supplied by Burgiss). Since PME_t is observed only quarterly (the overwhelming majority of funds report NAVs as of quarter end), we can measure the change in it from the previous quarter, $t-1q$.

As evident from equation (14), variance of PME across different periods depends of the ratio of NAV to the present value of capital calls. More specifically, the change in PME equals to the product of fund excess return over the public equity benchmark ($R^{NAV}_{t-1q:t} - R^{mkt}_{t-1q:t}$) realized during that quarter and the beginning of quarter value of unrealized investments normalized by $fv_t(Calls)$:[11]

$$\Delta PME_t = E\left[(R^{NAV}_{t-1q:t} - R^{mkt}_{t-1q:t})\frac{NAV_{t-1q}}{fv_t(Calls)}\right] \ , \tag{15}$$

While capturing the importance of NAV changes in the performance numbers that investors get to observe, equation (15) highlights that the magnitudes of changes in PME increase in the unrealized investments value and decrease in the time-t value of cumulative capital calls. Hence, keeping the excess return fixed, the changes in PME will moderate as a fund distributes its assets back to LPs. As discussed in the section 2.4, such moderation in PME can be mistaken for inferior excess return during the later phase of the fund life (while even the sign of change can be misleading with such popular performance metrics as Money multiple or IRR). Therefore, to compute abnormal performance based on NAVs over a time interval (a,b) for a cross-section S of funds, we define the Weighted-PME (WPME) as

$$WPME_{a:b} = 1 + \sum_{t=a}^{t=b}\left[\sum_{i\in S}\Delta PME_{i,t}\Big/\sum_{i\in S}\frac{NAV_{i,t-1q}}{fv_{i,t}(Calls)}\right] \ , \tag{16}$$

where we essentially unwind the above-mentioned downward bias on the magnitude of excess returns while allocating relatively more weight to funds with larger fraction of yet unrealized performance and, thus, greater sensitivity of reported returns to subjective valuations.

[11] This is true exactly when capital calls between $t-1q$ and t are absent. For quarters with positive capital calls, there is additional measurement error that is approximately mean-zero and does not affecting the inference about the path of cross-sectional mean returns. See Internet Appendix, sections I.2-I.2.1, for details.

Figure 1 presents the WPMEs across all buyout and venture funds in our sample since fund inception (Panel A) and +/-12 quarters around the next fundraising event (Panel B). We define the date of the next fundraising event as the quarter of the first capital call by the next fund by the same firm (given at least 11 quarters since the current fund inception). If there is no such follow-on fund according to our data, the event quarter is the 13$^{\text{th}}$ quarter preceding the last NAV report if the fund is resolved or at least 10 years old.

Panel A of Figure 1 shows that average abnormal performance since inception for both buyout and venture funds increases steadily for the first few years of fund life. Around quarters 15-20 average fund returns start to grow more slowly, though excess returns remain mostly positive. The slowing in return growth is slightly more pronounced for venture funds.

Since funds launch a follow-on fund at different times in the existing fund's life, we next examine returns around the subsequent fundraising event. In particular, the 3-year window before a fund's first capital call is the time that a firm is most likely to be active in trying to secure commitments to a new fund. Panel B of Figure 1 plots cumulative abnormal performance starting 3 years before the next fundraising event. The plots show the same pattern suggested by Panel A. The cumulative average excess return for both buyout and venture funds in the 3 years following the fundraising event is less than in 3 years preceding the event.

However, it is important to note that after fundraising ($t > 0$ in Panel B) excess returns remain positive. This is not consistent with the *naïve investors* and *signal jamming* equilibria, as discussed in sections 2.1-2.2. There are multiple explanations consistent with the flattening of excess returns post-fundraising which do not involve biased valuations. The flattening of excess returns post-fundraising is to be expected when GPs tend to exit some of their best investments early to convey a credible signal to LPs. Thus, it is consistent with the *costly signaling* hypothesis (section 2.3). The *effort rationing* hypothesis (section 2.4) also predicts lower, but still positive, returns for the old fund after the new has been launched.

There could be important factors outside our theoretical framework as well. For example, some investors could overreact to particularly strong (yet truthfully reported) returns over the last few quarters. Thus, a reversion to lower levels (that would occur irrespective of the new fund launch) may induce the aforementioned pattern. Finally, it is also possible that broad market conditions relevant to buyout and venture fund returns (e.g., access to exits or new capital) determine the timing of fundraising. Much of our subsequent analysis seeks to differentiate among these explanations.

4.1.1. Post-fundraising returns and market conditions

As a next step, we investigate WPMEs for subsets of buyout and venture funds. First, we categorize funds into groups based on the time it takes to raise a next fund. We create three groups: The "Early (Late) Next Fund" group is defined as those funds that take less (more) than the median time to raise a new fund. The "No Next Fund" group is defined as those funds for which we do not observe a follow-on fund (as discussed in section 3). We also split the sample based on median 5-year rolling public markets returns as of the 13th quarter of the fund's life and call these "High Market Return" and "Low Market Return" funds.

Panel A of Figure 2 shows the cumulative changes in excess returns for buyout and venture funds conditional on the time it takes to raise a follow-on fund. Unsurprisingly, funds with no next fund have much weaker performance than funds successful at fundraising. Otherwise, moderation in performance is only apparent for venture funds with a late next fund. Excess returns in early years are typically as good or better for those funds that take longer than average to raise a next fund though we show subsequently that this is partly related to market conditions.

Recall that we define a hypothetical fundraising event for the No Next Fund group as the 13th quarter before the last NAV report for funds that are resolved or lived for at least 10 years.[12] This approach takes into account the salient features of the contractual and operating environment documented for private equity funds (e.g. see Metrick and Yasuda, 2010). Specifically, GPs are generally free to choose when to exit fund investments, subject to constraints on how long they can charge management fees, and rarely enter (or exit) several deals simultaneously. In such settings, we expect that any existing valuation bias will reveal itself gradually as the fund unwinds its portfolio (rather than in a one-time write-off or liquidation).

Panel B of Figure 2 reveals the most interesting results. For both buyout and venture funds, the excess returns of funds that are unsuccessful at raising a next fund (dotted lines) show patterns consistent with funds gaming returns. In both cases, excess returns increase in the period during which a firm is likely to be making a final effort to raise a next fund only to reverse returns in the final years of the fund (as cash flows are realized).[13] We note that these represent not just lower excess returns, but in fact, *negative* excess

[12] In Appendix.A.1.1, we provide a more formal analysis for why valuation bias would increase towards the late fundraisings.

[13] Figure A.1 shows that this result is not driven by outliers and is reasonably robust to assumptions about the timing of a last-ditch effort to raise a follow-on fund. The top charts in Panel A show that when 2008:Q2-2009:Q2 are excluded, the hump-shaped pattern of WPME in buyout and venture subsamples remains largely unchanged for the No Next Fund groups (while not being evident among the successful fundraisers). In Panel B, we define the event time as 3 years after the median peer fund raised a successor fund. The subsequent underperformance relative to successful fundraisers remains obvious in both subsamples. The bottom charts in both panels demonstrate the advantage of using our preferred metric based on Kaplan-Schoar PMEs. Nonetheless,

returns.

Thus, this evidence is suggestive of attempts at manipulation that are not successful since investors are, on average, not willing to commit to a next fund. In other words, the market for buyout and venture funds may look through attempts at gaming NAVs and determine the actual performance of a fund. These results are therefore consistent with the *costly signaling* equilibrium.

In Figure 3, we further refine the analysis by considering the performance of different fund groups during periods of strong and weak market returns. Both buyout and venture funds have higher excess returns prior to fundraising when market returns are low (regardless of when the fund was raised) suggesting a higher bar for raising funds during a weak market. The evidence for No Next Funds shows that the degree of potential gaming also appears to be more pronounced during weak markets for buyout funds. There is no evidence that the mean excess returns become negative after successful fundraising in either of the subsamples.

4.1.2. Does the performance rank at fundraising predict the final rank?

Next, we examine the predictability of the fully realized performance of PE funds conditional on the interim performance reports. We compute tercile transition probabilities (similar to Kaplan and Schoar (2005) and Phalippou (2010) but over a given fund's life rather than across funds). Table 2 reports transition probabilities between performance terciles based on IRR-to-date within each fund peer group. Panel A shows results for buyout funds and Panel B shows results for venture funds. In both cases we examine only funds that have a follow-on fund. For example, the first row of each panel reports the probability of being in each final performance tercile conditional on being in the bottom tercile at the conclusion of fundraising. The last row of each panel reports the unconditional distribution of funds across final performance terciles, and the last column reports how many funds successfully raised a next fund in each tercile.

First, the far right columns in each panel show that GPs are about twice as likely to raise a follow-on fund when the current fund performance is in the top tercile versus in the bottom tercile: 44.7% versus 18.8% for buyout funds and 42% versus 22.9% venture funds. This finding is consistent with the hazard model analysis in Barber and Yasuda (2016) who find that the most recent fund performance rank is perhaps the strongest predictor of fundraising success (amongst other observables considered) as well as the information holdup hypothesis by current fund LPs as studied in Hochberg et al.(2014).

the increase in the performance gap from the successful fundraisers is evident with money-multiples as well.

For both buyout and venture funds, top and bottom performers during the fundraising period are most likely to remain in the same performance tercile. Thus, the interim performance rank is typically informative about the final performance rank for the current fund. In the appendix, we demonstrate that this result holds if PME is used in place of IRR (Table I.4) and appears to be even stronger with quartiles (Table I.5). Furthermore, the persistence pattern in the buyout sample is very similar to that in the venture sample where accounting and regulatory constraints on the valuation accuracy are plausibly far less binding. This is evidence inconsistent with the case of *naïve investors* (see section 2.1).

Nonetheless, there are quite a few funds that transition between top and bottom terciles. For example, about 10% of top buyout and venture funds at life-end were in the bottom tercile during fundraising. As we discuss subsequently, this suggests substantial heterogeneity in the valuation bias, perhaps greater than under a *signal jamming* equilibrium where an upward bias should be monotonically decreasing in true performance (as discussed in section 2.2).

For both buyout and venture funds, there are more transitions from top to bottom terciles than from bottom to top. Likewise, for both buyout and venture funds, more of the middle-tercile funds at fundraising subsequently transition to the bottom tercile than to the top tercile. This suggests that there may be cases of successful deception of LPs with inflated valuations in the midst of fundraising, but does not prove that the strategy associates with higher fundraising probability.

4.1.3. Does it pay to overstate interim performance?

We start our multivariate analysis by estimating a linear probability model where the dependent variable equals one if we observe a follow-on fund and zero otherwise. For now, we limit our sample to the funds that are resolved or operated for at least 10 years. As before, the event time is defined by the quarter in which the follow-on fund made its initial investment or the 13^{th} quarter before the last NAV report (if the fund is resolved or operated for at least 10 years). We consider the following covariates; all are defined as categorical variables to simplify the interpretations:

- *PME drop (after)* – equals 1 if the fund's PME at resolution is lower than at the event time and zero otherwise;
- *PME run-up (before)* – equals 1 if the fund's PME 1 year before the event time is lower than at the event time and zero otherwise;

- *Large Distribution (before)* – equals 1 if the sum of distributions over the year preceding the event time exceeds 20% of NAV and zero otherwise;
- *Top tercile-to-date* – equals 1 if the fund is in the top (best) IRR-tercile across vintage and strategy peers at the event time and zero otherwise, and
- *Bottom tercile-to-date* – equals 1 if the fund is in the bottom (worst) IRR-tercile at the event time and zero otherwise.

Table 3 reports the results of this estimation, separately for buyout funds (Panel A) and venture funds (Panel B). All specifications include the interaction of the fund vintage year and industry fixed effects to absorb the variation in investor demand for certain types of funds over time. The standard errors are clustered by the event year to account for possibly correlated shocks affecting the fund returns. In specifications (3) and (4), we also include the level of PME at the event date as well an indicator whether the market return was positive in the year prior to the event.

Specifications (1) through (3) reveal that negative post-event abnormal returns, as well as lower returns just before the event, correspond to a lower probability of successful fundraising. The magnitudes of the effects are similar to those of being in the top performance tercile (a difference in probability of a successful fundraising of 8-12 percentage points). As discussed above, *PME drop (after)* is a robust indication of overly optimistic NAVs at the event time. The negative coefficient on *PME run-up (before)* suggests that investors also tend to respond negatively to large excess returns reported over the few quarters before the event. Specification (4) examines whether distributions to LPs mitigate evidence of possibly inflated valuations. The significant positive coefficients on *Large Distribution (before)* interacted with *PME run-up (before)* suggests that investors appreciate positive excess returns when accompanied by large distributions from the fund.

These results suggest that it is unlikely that overstating interim returns has been a winning strategy for GPs on average. Although the current fund performance clearly has bearing on the odds of a successful fundraising, overly optimistic NAVs (nefarious or not) associate with a lower probability of raising a follow-on fund. Thus, the evidence is consistent with LPs detecting a valuation bias as discussed in section 2.3 (and with LPs responses to the survey by DaRin and Phalippou, 2016).

4.2. Peer chasing

The theoretical framework in section 2.3 implies that GPs may track their fund's performance relative to their peers and incorporate this knowledge in their NAV reports. As shown, even if the bias tends to be correctly detected by the market, it might still be optimal for underperforming funds to inflate valuations. Under reasonable assumptions about the probability distribution of cross-section of PE fund returns, the mistakes of LPs who underestimate the valuation bias have stronger positive effects on the wealth of those GPs (as compared to similar mistakes from overestimating the bias). In contrast, the GPs of top-performing funds have incentives to report conservatively insofar as the LP uncertainty about the past valuation bias is never fully resolved. Consequently, in this section we directly examine whether past returns of peer funds seem to affect how GPs report NAVs.

Empirically, peer-chasing could appear as mean-reversion in reported performance. To identify peer-chasing, we compare future reported returns conditional on cumulative to-date performance. Specifically, for each fund-quarter we compute the 4-quarter ahead change in PME-to-date. We then rank these changes by funds of similar vintage year (+/- one year) and plot the distribution of the ranks by cumulative performance tercile (as measured by IRR-to-date) for funds of different ages. Specifically, we look at funds of three age groups: young funds with 8-17 quarters since inception (denoted as ˜3yrs), middle-aged funds with 18-27 quarters since inception (denoted as ˜5yrs), and old funds with 28 or more quarters since inception (denoted as >7yrs).

Given the probable relation between fund returns and public market returns, we need to be careful about the null hypothesis for peer-chasing tests. It could be that mean-reversion is naturally present in the unobservable true return-generating process (weighted by fund-quarter population). To address this concern, we also construct placebo return series for each fund in our dataset as a sum of style-matched public equity portfolio returns.[14]

[14] The style-matched public portfolio for each fund is a weighted subset of Fama-French research portfolios that represent U.S. equity sorts into deciles based on mid-year book-to-market ratios and market capitalization. We use only below-median size portfolios. For buyout funds we use the 25 highest book-to-market portfolios and lever their returns by a factor of two to account for leverage in buyout transactions (for example, Axelson, Jenkinson, Strømberg, and Weisbach (2013) report the Debt-to-Enterprise Value ratio of 0.6 for their sample of LBOs against just 0.3 for the public firm matches). For venture funds we take actual returns of the 25 lowest Book-to-Market portfolios. Once the weights are selected, they remain fixed over the fund life-time while the placebo returns correspond to the actual fund operation periods. This placebo comparison can be thought of as deriving from a simulation where we draw factor returns from a sample of actual paths rather than taking a stand on the return-generating process explicitly. An advantage of this approach is that it retains the cross-sectional heterogeneity in the actual time-series of equity returns (including any anomalies).

Results for these tests are reported in Figure 4 for buyout funds (Panel A) and venture funds (Panel B). In each panel, top to-date performers are shown in the top graph and bottom to-date performers are shown in the bottom graph. The results suggest strong peer-chasing patterns for both buyout and venture funds. For example, in Panel A of Figure 4, a buyout fund that is in the top to-date tercile after 3 years is much more likely to report relatively low returns over the next year (as the darkest bar is much higher than the other two). This effect persists but is notably weaker for ˜5yrs since inception. By ˜7yrs since inception, the mean-reversion flips as the top-to-date funds are more likely to report relatively high changes (the darkest bar is the lowest). This is consistent with the undoing of conservatism as portfolio companies are exited. In contrast, before ˜5yrs since inception, buyout and venture funds in the bottom tercile are more likely to report high excess returns over the next 12 months. After ˜7yrs since inception (when performance numbers become increasingly driven by actual cash flows), the 12-month excess returns become notably worse than those of top tercile peers. There is an apparent asymmetry in these results in the early years. Bottom tercile funds appear to overstate performance more than top performing funds understate performance. The placebo returns generated from public portfolios (reported in the appendix, Figure A.2) indicate that comparable public market returns exhibit very weak, if any, return-reversals.

Overall, the evidence in this section reveals strategic patterns in PE funds' interim performance reports. However, the findings are not consistent with the fundraising success being positively related to NAV overstatements. On the contrary, we show that investors punish overoptimistic NAVs by not providing capital to new funds. In addition, LPs appear to put weight on performance signals in the form of cash distributions following successful exits by funds. The data are also consistent with the realized performance bar being higher (and attempts to manipulate NAVs being stronger) in a tough fundraising environment. It appears that LPs are on average well aware of the informational asymmetry embedded in the fundraising process and do not rely on interim performance reports irrationally. Moreover, our tests yield strong support for the *costly signalling* equilibrium (as opposed to the *signal jamming* equilibrium) being a more accurate description of the PE fundraising market. This result is in contrast to other studies previously cited.

5. Comprehensive analysis

In the reminder of the paper we seek to quantify the bias in performance reporting that is robust to measurement errors and certain alternative explanations. We also provide more direct evidence of conservative

NAV reporting by top-performing funds which the *costly signaling* hypothesis predicts.

We define the NAV bias in quarter t as a ratio ($\equiv \Gamma_t$) of reported NAV to V_t, an unbiased assessment of the market price of the fund assets (net of GP fees) in an arms-length transaction.[15] By construction, this ratio will have a value that is always greater than zero and equal to one when the bias is zero (e.g., when NAVs turn into cash).

We next define $R_{m,t} \cdot R_t^{\varepsilon}$ as the fund true gross abnormal return in period t where $R_{m,t}$ denotes the return due to the systematic risk (i.e. market), and write the asset valuation identity as

$$V_t + CF_t = V_{t-1} R_t^{\varepsilon} R_{m,t} \ . \tag{17}$$

That is, the change in fund asset value (up to net distributions to investors, CF_t) is the return on assets from the previous period. Substituting NAV_t/Γ_t for V_t and $\Gamma_{t-1} e^{\Delta bias_t}$ for Γ_t in equation (17), we obtain the following expression for the log change in the valuation bias over a period:

$$\Delta bias_t = \log\left(NAV_t\right) - \log\left(NAV_{t-1} \times R_t^m - K_{t-1} \times CF_t\right) - \log(R_t^{\varepsilon}) \ , \tag{18}$$

where K_{t-1} is a ratio of the valuation bias multiple, Γ, at time $t-1$ to the idiosyncratic gross return, R_t^{ε}.

The intuition behind $\Delta bias_t$ is straightforward. It is a change in log(NAV) that cannot be explained by the asset return or fund cash flows. Conditioning on the previous level of the bias (through multiplication by K_{t-1}) in periods with cash flows is necessary because the cash flows implicitly change the level of the remaining bias. For example, suppose the fund's "true value" of assets did not change from \$10m but had been overstated by 10% last period so that $NAV_{t-1} = 10 \cdot \exp\{0.10\} = 11.05$. Consider what happens when the underlying assets do not change in value, but the fund distributes a quarter of its assets at t (i.e., $CF_t = 1/4 \ \cdot \ 10 = 2.5$). The valuation bias ($\Gamma$) on the remaining assets will have to step-up for the reported returns to be zero. Specifically, $0 = NAV_t + CF_t - NAV_{t-1} = \Gamma_t \cdot 7.5 + 2.5 - 1.105 \cdot 10$ implies that the new bias will be $\Gamma_t = 1.14$. So multiplication by K_{t-1} allows for capturing the innovations in the bias in t (rather than the interaction of the past levels with the cash flows).

However, neither asset returns nor past levels of the valuation bias are observable, so we must replace them with proxies. Next, we discuss the rationale behind our choices.

[15] An unbiased assessment satisfies the GAAP fair value definition as the value "at which that asset could be bought or sold in a current transaction between willing parties, other than in a liquidation." We do not distinguish between cases when GPs (i) pretend that reported NAVs are fair values in the GAAP sense and (ii) report NAVs that are conditional on a successful realization of the business plan (which is a very uncommon practice according to our conversations with LPs).

5.1. Dependent variable

For our dependent variable, we utilize equation (18) assuming K_{it} and R^{ε}_{it} are equal to 1 while R^m_t is the value-weighted CRSP index return (or CRSP index returns levered by market beta estimates from the literature). So for each fund-quarter it, $\widetilde{\Delta bias}$ is defined as:

$$\widetilde{\Delta bias}_{it} = \log(NAV_{it}) - \log(NAV_{i,t-1} \times R^{CRSP}_t - CF_{it}). \tag{19}$$

Thus, $\widetilde{\Delta bias}$ is just the market and cash flow adjusted NAV growth between $t-1$ and t. As outlined above, the measurement error on this feasible proxy for $\Delta bias_{it}$ will be a function of:

1. fund i idiosyncratic returns for period t,
2. the market return for period t, R^{CRSP}_t, and
3. the fund i cash flow for period t, CF_{it}.

Thus, any multivariate analysis with this dependent variable would be susceptible to biased coefficient estimates whenever the regressors (X) correlate with these items. To confirm that our results are not driven by such spurious relations, we also construct a placebo dependent variable that is a function of misspecified systematic risk and the actual fund cash-flows. For each fund, we assign a random combination of publicly traded portfolios (based on Fama-French 100 benchmarks), as discussed in section 4.2. Substituting $(NAV_t + CF_t)/R^{\{FF100\}}_t$ for NAV_{t-1} in equation (18) while keeping K_{t-1}=1, yields the following placebo counterpart:

$$\Delta\widetilde{placebo}^{\{FF100\}}_t = \log(R^{\{FF100\}}_t) - \log(R^{CRSP}_t + (R^{CRSP}_t - R^{\{FF100\}}_t)CF_t/NAV_t). \tag{20}$$

In this placebo experiment, we do not attempt to emulate the PE fund reporting bias and the idiosyncratic return. Instead, assuming that PE funds' true idiosyncratic returns exhibit similar properties to those of public portfolios, we aim to induce correlations with actual fund cash flows and market returns similar to those present in $\widetilde{\Delta bias}$. If the measurement errors due to items 2 and 3 result in spurious correlations of $\widetilde{\Delta bias}$ and X then we should observe similar spurious correlations with $\Delta\widetilde{placebo}^{\{FF100\}}$ and X. In other words, regressions using $\Delta\widetilde{placebo}^{\{FF100\}}$ will indicate the direction and magnitude of the econometric bias in our inference about $\widetilde{\Delta bias}$. Additional details regarding the derivation of $\Delta bias_t$, its feasible proxy ($\widetilde{\Delta bias}_t$), and placebo counterpart $\Delta\widetilde{placebo}^{\{FF100\}}_t$ are provided in the Internet Appendix, section I.3.

5.2. Explanatory variables

Our two primary explanatory variables of interest are called $FundTiming$ and *PeerChasing*. $FundTiming$ is defined as the natural log of the number of years (1 plus years after the second) spent without a follow-on fund. It is a proxy for a growing incentive to boost NAV as the GP goes longer without raising a follow-on fund. By construction, the change in $FundTiming$ will be smaller for each subsequent quarter without a fund.[16]

PeerChasing is defined as the difference between a funds reported IRR-to-date and the median across the fund's peers. We construct fund peer groups as we did for Figure 4. Specifically, peer groups consist of other funds of the same strategy and adjacent vintage years (including already resolved funds) as of the previous quarter. For placebo tests, we also construct a *PeerChasing* series from placebo returns. Under the null of unbiased (independently distributed) NAV changes, risk-adjusted returns should not correlate with their own lags.

An alternative explanation for a relation between NAV growth and $FundTiming$ or *PeerChasing* is that some funds have stale NAVs. That is, some GPs simply lag behind their peers in updating their portfolio valuations. For example, GPs may wait to re-value until a next funding round or follow a convention of holding assets at cost. Such firms may nonetheless have to bring stale NAVs more up to-date when it is time to start marketing a new fund. Thus, managerial style may result in mean-reversion of returns that is stronger when it has been a while since the previous fund's inception. We address this concern via our cross-sectional tests in this section as well as in separate tests in the robustness section.

Because we want to focus on NAV reports that can be plausibly manipulated and also affect the fund performance assessment by investors, we only consider reports between the 6^{th} and 28^{th} quarter of fund life for this analysis. To reduce the impact of outliers and remain realistic about the extent to which a common slope may hold across funds with dramatically different performance, we include only fund-quarter observations where IRR-to-date is within 30 percentage points from the peer-group median. To motivate this censoring, we estimate local polynomial regressions of $\widetilde{\Delta bias}_{it}$ on $PeerChasing_{it-1}$ and $PeerChasing_{it-2}$

[16] It is possible that a reverse causality drives the relationship between upwardly-biased NAVs and follow-on fund launches. Using *FundTiming* should help mitigate concerns about us identifying this as nefarious manipulation. Suppose that, innocuously, GPs become overly optimistic about the investment opportunity set or their skill. These are precisely the times when they would seek to start another fund for a good reason. In other words, GPs may make honest mistakes that induce correlation between reported returns and new fund launches. Unlike dummy variables indicating lead/lags from the fundraising quarter, the variation in *FundTiming* can be considered plausibly exogenous with respect to such "honest optimism" waves in so far as such optimism is unlikely to increase monotonically in the time spent without a new fund.

(Figure A.4 contrasts them against $\widetilde{\Delta bias}^{placebo}$). We find a negative association with reported returns when *PeerChasing* is close to zero. However, when it is more than 30 percent away from zero, the relationship dissipates. These results suggest that *PeerChasing* effect is present only where it might be relevant. Table I.6 reports summary statics for the dependent and explanatory variables used in subsequent tests.

5.3. Main effects

Table 4 reports estimates for the following two models (for both buyout and venture funds) over the sample period covering 1984 through 2011:

(i) $\widetilde{\Delta bias}_{it} = [FundTiming_{it} \quad PeerChasing_{it}]\gamma + Controls_{it} + v_{it}$

(ii) $\widetilde{\Delta bias}_{it} = [FundTiming_{it} \quad PeerChasing_{it} \quad FundTiming_{it} \cdot PeerChasing_{it}]\gamma + Controls_{it} + u_{it}$

Results from model (i) are reported in specifications (1) and (2) while results from model (ii) are reported in specifications (3) and (4). Controls_{it} include fund fixed effects, year-quarter fixed effects, as well as fund distributions and capital calls over the current quarter scaled by the end-of-quarter NAVs. Specifications (1) and (2) have adjusted NAV growth computed assuming a market beta of one relative to the value-weighted CRSP stock index. In specifications (3) and (4), we use a beta of 1.7 for buyout funds and of 2.4 for venture funds which are provided in Driessen, Lin and Phalippou (2012).[17]

For buyout funds (Panel A), estimation results in specification (1) indicate a positive and significant coefficient on $FundTiming$ and a negative and significant coefficient on *PeerChasing* across all specifications. The corresponding results for the venture sample (Panel B of Table 4) show similar relations with somewhat smaller magnitudes for $FundTiming$. These coefficients constitute a prediction of next period fund reported returns up to a fund-specific trend. Results in specification (3) indicate that the findings are not sensitive to the market beta assumption.

To gauge the economic significance, we can calculate that for a buyout fund, the fourth year spent without a follow-on fund elevates the reported excess returns an average of about 6.5% next quarter (0.08*log(3)). The coefficient on *PeerChasing* indicates how much the average fund excess return increases next quarter if it is above the peer group median IRR-to-date by 1 percentage point. For example, the estimate in the first column of Panel A in Table 4 of -0.205 for buyout funds suggests a reversion of about 20 basis points.

[17] These are the highest values of beta among the papers we reviewed: Cao and Lerner (2007), Kortoweg and Sorensen (2009), Franzoni, Nowak and Phalippou (2012), Driessen, Lin and Phalippou (2012).

Given the standard deviation of 0.13 for *PeerChasing* this suggests a typical reporting distortion of around 2.6 percentage points.

In model (ii), we examine the interaction between fund timing and peer chasing. The coefficients on *FundTiming* remain positive and significant for both buyout and venture funds suggesting that timing effects are robust to accounting for the interaction effects. The coefficient on *PeerChasing* becomes positive and significant in some specifications, suggesting that when the $FundTiming$ variable is zero there is no reversion in returns but rather a persistence (whereas in model (i) the effects are implicitly evaluated at a mean level of other variables). To better assess the economic significance, consider the case where a buyout fund has performance two standard deviations below its peers and five years have elapsed without raising a new fund. In this case, the model suggests that the change in reported performance from the previous quarter will induce a positive bias of nearly 5 percentage points (i.e. 0.053*log(4) +0.117*[2*-0.13] -0.304*[log(4)* 2*-0.13]). Now consider a similar fund that has gone five years without raising a new fund but has performance two standard deviations *above* its peers. In this case the bias will be just about 1 percentage point. These magnitudes are similar to the venture sample.

In short, the negative and significant coefficient on the interaction term reinforces the conclusion that peer-chasing is stronger when the incentive to do so is high (as measured by $FundTiming$). In other words, the longer it takes to raise a next fund, the more strongly the funds reported returns revert to those of its peers. Because the effect is stronger when incentives are large, this finding is consistent with NAV manipulation. To the extent that more time spent without a fund is associated with lower performance, these results are consistent with underperforming funds tending to overstate NAVs.

5.4. Cross-sectional differences

In this section we investigate how cross-sectional differences affect fund timing and peer-chasing behavior. We extend model (i) by including the interactions of $FundTiming$ and *PeerChasing* with the following variables:

- $Rookie_i$, equals 1 if the firm has had two or less previous funds in the sample and zero otherwise;
- $TopTercile_{it}$, equals 1 if fund i to-date-IRR at time t is in the top tercile of peer funds in the same strategy in adjacent vintage-years and zero otherwise;

- $BtmTercile_{it}$, equals 1 if fund i to-date-IRR at time t is in the bottom tercile of peer funds in the same strategy in adjacent vintage-years and zero otherwise.

Table 5 reports four specifications separately for buyout and venture funds. All are estimated with fund fixed effects, year-quarter fixed effects, and fund distributions and capital calls over the current quarter scaled by the end-of-quarter NAVs. Since $TopTercile_{it}$ and $BtmTercile_{it}$ are time-varying characteristics over a fund's life, we can identify the effect on reporting bias in the quarters right after transitions to and from the respective tercile. In contrast, $Rookie_i$ is a fixed characteristic for a given fund so only its interaction terms are present in the model.

Specification (1) examines the *Rookie* effect, (2) examines the $TopTercile$ effect, (3) includes all effects (thus, the base case is middle tercile funds with two or more previous funds from the same firm), and (4) investigates whether our inference is sensitive to the level of market beta we assume. When camparing results across specifications, it is important to note that the baseline group for top tercile funds in specification (2) is both middle and bottom tercile funds, whereas the baseline group in specifications (3) and (4) is only middle tercile funds.

We first consider the results from specification (1) which examines the rookie-effect for buyout and venture funds. The coefficient on the interaction with $FundTiming_{it}$ is negative but insignificant and small. We note that rookie venture funds do not exhibit significantly different fund timing or peer-chasing behavior. However, peer-chasing is more pronounced among rookie buyout funds.

In specification (2), we consider how the effects differ for top-performing funds. The positive and significant coefficient on $TopTercile$ indicates that top-performing funds to-date continue to report abnormally high NAV growth in both subsamples, buyout and venture. This is consistent with these funds carrying conservative valuations or having superior ability. The coefficient on the interaction with $FundTiming$ is negative and significant suggesting that top-tercile buyout and venture funds time less than their underperforming peers. The insignificant coefficient on the interaction between *TopTercile* and *PeerChasing* indicates that the top performing funds appear to peer-chase about the same as other funds. Taking baseline and interaction effects of *FundTiming* and *PeeChasing* together, the point estimates suggest that top-tercile buyout and venture funds tend to report downward-biased returns for the next quarter when current IRR is one or more standard deviations above their peers.[18] This is consistent with the *costly signaling* equilibrium where top-performing funds report conservative NAVs (e.g., to build a cushion against negative idiosyncratic returns in the future).

In specification (3), we examine all effects simultaneously and find similar results for fund-timing overall. Meanwhile, specification (4) suggests that our inference about the cross-sectional effects is unlikely to be affected by heterogeneity in the risk exposure across funds. The estimates with high betas are very similar to those with unit betas. We find evidence that $FundTiming$ among buyout and venture funds is significantly stronger in the bottom-performing funds (as indicated by the large positive coefficient on the *BtmTercile* interactions with $FundTiming$). For *PeerChasing*, the effect appears stronger for bottom tercile buyout funds while it is not significant for the funds in the middle performance tercile. This is somewhat different from the venture sample where the relationship between the next quarter returns and peer-group IRR does not appear to be statistically different across performance terciles.

The evidence presented in Table 5 suggests that GPs that have less experience do not tend to report more aggressive NAVs. Instead, it follows that it is the current fund performance that largely determines the direction and magnitude of the valuation bias. We note that the cross-sectional results are inconsistent with stale NAVs driving these results. If stale NAVs were a significant driver in Table 4, we would expect that funds with the highest true returns had the largest gap to cover which predicts positive coefficients on $Top \times FundTiming$ and a positive total peer-chasing effect for that group (in contrast to our findings in specification (2)).

5.5. Placebo tests

As noted above, to verify the null hypotheses for our tests, we examine a set of specifications similar to those in Table 4 and 5 but use placebo equivalents to determine if our estimation method is capturing something inherent in market conditions or measurement errors. Essentially, we estimate how style-matched public equity returns, conditional on actual fund cash flows, associate with lagged public equity returns since the respective fund inception (via *PeerChasing*). Also, we can identify actual calendar time patterns in subsequent funds starts (via $FundTiming$). The interactions with *Rookie*, $TopTercile$ and $TopTercile$ dummies allow us to check whether these relations (1) are different in time periods when funds with less

[18] Even for IRRs very close to a median peer (i.e. *PeeChasing* near zero), overstating NAVs by top-tercile funds is statistically zero as conveyed by the tabulated F-tests for sum of coefficients on *FundTiming* +*Top* $\times$ *FundTiming*.

than two predecessors were operating, and (2) vary across performance ranks.[19] The results are tabulated in the appendix (Table A.1) and reveal no consistent relationships for either *FundTiming* or *PeerChasing*. Although a few coefficients are statistically different from zero, they have opposite signs from what we find in Tables 4 and 5. This reassures us that the effects we report in Tables 4-5 are unlikely to be spurious.

6. Robustness and other tests

6.1. Alternative estimators

In this section we scrutinize the assumptions about the fund return-generating process in the panel regressions of section 5. Namely, (1) the strict exogeneity of fund fixed effects with regards to other regressors included in the model, (2) the constant trend in fund excess returns between the 6th and 28th quarters of fund life, and (3) the stale NAV explanation for the fund-timing and peer-chasing effects in Table 4.

Assumption (1) is a concern since both key explanatory variables, *FundTiming* and *PeerChasing* values depend on past idiosyncratic returns of the fund which are also components of the measurement error on the dependent variable, $\widetilde{\Delta bias}$. In other words, the underlying model has strong features of a dynamic panel (i.e. $y_{i,t} = \beta y_{i,t-1} + \alpha_i + \varepsilon_{i,t}$) where fixed effects estimators may yield biased estimates of β because $E[y_{i,t-1}(\varepsilon_{i,t} - \bar{\varepsilon}_i)] \neq 0$. The bias of the fixed-effects estimates would be finite and decreasing in panel length but still can be sizeable in the case of highly persistent regressors (Wooldridge, 2002).

Assumption (2) appears vulnerable in light of the discussion in section 4. Absent any valuation biases, the abnormal performance trend may nonetheless deteriorate after a follow-on fund launches because of changes in asset composition, lack of manager attention, etc. Fixed effects models will disregard such changes during a fund's life and may falsely relate them to the variation in the explanatory variables.

A possible fix for these econometric difficulties is to use a first-difference (FD) estimator to remove fund-level unobserved heterogeneity. Furthermore, if we make an assumption that real changes to a fund's return generating process (i.e. due to incentives) do not happen in a short interval (e.g., over few quarters) whereas manipulated changes to NAV do, a FD estimator should yield more power against the "gaming" alternative.

[19] In matching placebo portfolios, we further condition on placebo to-date returns being in the same tercile as the actual fund IRR as of 28th quarter since inception or the last quarter in the sample for younger funds.

Not demeaning the dependent and explanatory variables at the fund level also allows for including explanatory variables that are functions of future idiosyncratic returns. This helps with controlling for the possible effects of stale NAVs. Note that stale NAVs can be formulated as self-correcting valuation errors which should be greater the further the reported performance level is from the final value (i.e., by the time all holdings are converted to cash flows). So if some GPs are simply slow to update values, the difference between the final PME from its level in the next period should absorb all of the suspicious variation in $\widetilde{\Delta bias}$.

With first-differencing, there is still a concern regarding endogenous variables so long as parts of *FundTiming* and *PeerChasing* (henceforth, X_{it}) depend on returns at $t-1$. Therefore, we instrument ΔX_{it} with two lagged levels, X_{it-1} and X_{it-2}. Provided that the process for X is persistent and carries information about unobserved heterogeneity among funds, lagged levels are valid instruments for the difference (Wooldridge, 2002).

Table 6 reports estimates of models (i) and (ii) in first-differences over fund-quarters via a two-step GMM with an optimal weighting matrix, robust to heteroscedasticity and autocorrelation. Results are reported separately for buyout (Panel A) and venture (Panel B) subsamples. All specifications except (3) use the instruments discussed above, namely: $(X_{it-1}\ X_{it-2}\ Controls_{it})$. We seek to further clarify the explanation for the effects we document in specification (3) by using *ExcessFundTiming* and *ResidualPeerChasing* as instruments for X. The tabulated partial F-statistics for the first stages suggest that we do not have a weak-instruments problem.

We define *ExcessFundTiming* as a ratio of the time spent without a follow-on fund to the median time it took to raise a follow-on fund by vintage and strategy peers. In essence, we adjust the temptation to fund-time by the average peer-pressure so that the potentially higher performance bar (see section 4.1) is unlikely to interfere with the biased-NAVs explanation. We define *ResidualPeerChasing* as the residuals from a regression on four lags of median-IRR by peer group, allowing for fund-varying slopes. Hence, this instrument should disregard the variation due to lack of timely updating by some funds.

Specifications (1) and (2) of Table 6 are very consistent with those in Table 4 although the effects are larger in magnitude and stronger statistically (particularly, for venture fund-timing). A comparison of (3) with (1) suggests that some of the peer-chasing effect might be explained by lagged peer returns but the residual effect is still significant.

We only consider funds that are nearly resolved in specification (4) so that the final PME value is known. Although the sample of fund-quarters drops by half, the coefficient estimates on $FundTiming$ and *PeerChasing* are close to those in specification (1) suggesting the model is structurally stable. The coefficient on the proxy of the self-correcting valuation error (the difference from the final PME) is insignificant.

6.2. NAV reporting and SFAS 157

In September of 2006, the U.S. Financial Accounting Standards Board adopted Statement of Financial Accounting Standards 157 (SFAS 157) which effectively changed the NAV reporting standard for PE funds. A part of SFAS 157 referred to as ASC 820 requires fair-value reporting of balance sheet assets. Thus, the implementation of FAS 157 occurred during our sample period. The earliest adopters began complying in the fourth quarter of 2006 with all U.S. funds complying by the end of 2008. As a consequence, our sample may allow us to determine if FAS 157 had a notable effect on reported NAVs.

Unfortunately, the timing of the adoption coincides with the financial crisis of 2007-2008 which confounds the analysis. We undertake several tests and find only weak evidence that the regulation systematically affected reporting for venture funds and no evidence for buyout funds. We discuss these results in the appendix, section A.2.

7. Conclusion

We investigate whether private equity firms manipulate their NAV reports to investors. We find that the data are consistent with an equilibrium where overstatement has different costs and benefits to different GPs. In this equilibrium, LPs do not assume the interim performance reports are unbiased; they punish GPs for the appearance of overstated performance by not providing capital to subsequent funds. Correspondingly, top-performing GPs may try to safeguard their long-term reputation from bad luck by reporting conservative NAVs. They are more likely to do this when it does not jeopardize their high relative performance rank. For underperforming GPs, these long-term reputational concerns appear to be dominated by a short-term concern related to firm survival (and possibly a lack of credible ways to signal that valuations are conservative). Therefore, certain poorly performing funds appear incentivized to boost interim NAVs. We find little support for conclusions presented in previous research that examines performance manipulation.

An assessment of the welfare effects of such a performance-gaming equilibrium hinges on the degree to which relatively unskilled LPs misallocate capital. In light of our results, sophisticated LPs are, on average, unlikely to misallocate capital and may therefore prefer the current stance to one with more regulation and (possibly) less gaming.

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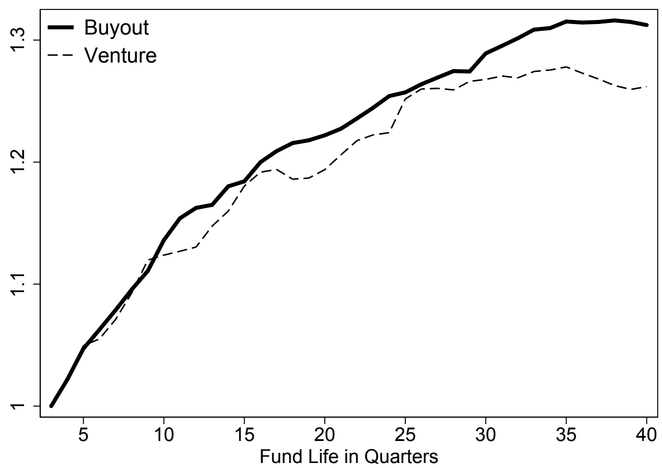
Figure 1: Average Fund Performance

This figure reports cumulative NAV-weighted excess returns of private equity funds over the public market index. Panel A plots values since inception and Panel B plots values twelve quarters before and after the follow-on fund's first capital call. In cases where no follow-on fund exists, the event quarter is the 13th quarter preceding the last NAV report for resolved funds or the 10-year mark for unresolved funds. As described in equations (1) and (2), the change in a given quarter is a mean PME-to-date change from the previous period across a subset of funds multiplied by the average ratio of NAV to market-adjusted paid-in capital (to date).

Panel A: Since Inception



Panel B: Around Fundraising

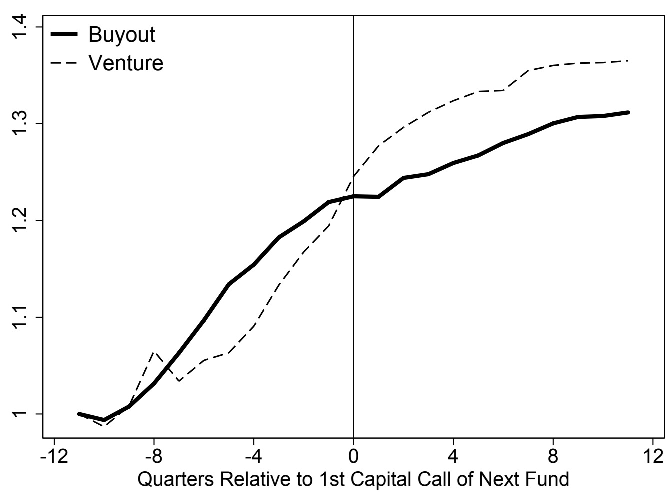
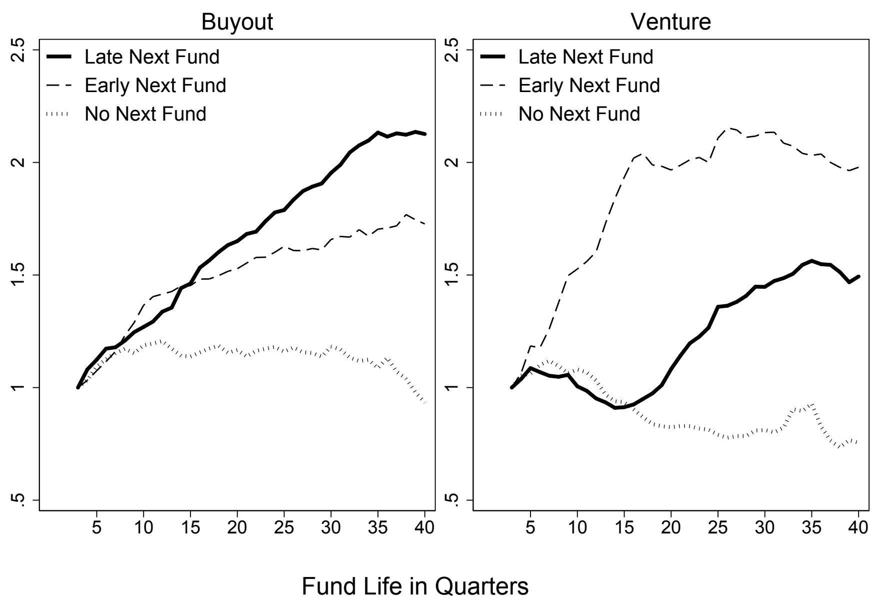


Figure 2: Average Performance Paths by Time Until Next Fund

This figure reports cumulative NAV-weighted excess returns of private equity funds over the public market index. Panel A plots values since inception and Panel B plots values twelve quarters before and after the follow-on funds first capital call. As described in equations (1) and (2), the change in a given quarter is a mean PME-to-date change from the previous period across a subset of funds multiplied by the average ratio of NAV to market-adjusted paid-in capital (to date). We define subsets of funds in the legends of respective subfigures. In cases where no follow-on fund exists (No Next Fund), the event quarter is the 13^{th} quarter preceding the last NAV report for resolved funds or the 10-year mark for unresolved funds. *Late(Early)* denotes whether the follow-on fund was later(earlier) than the sample median across all buyout and venture funds respectively.

Panel A: Since Inception



Panel B: Around Fundraising

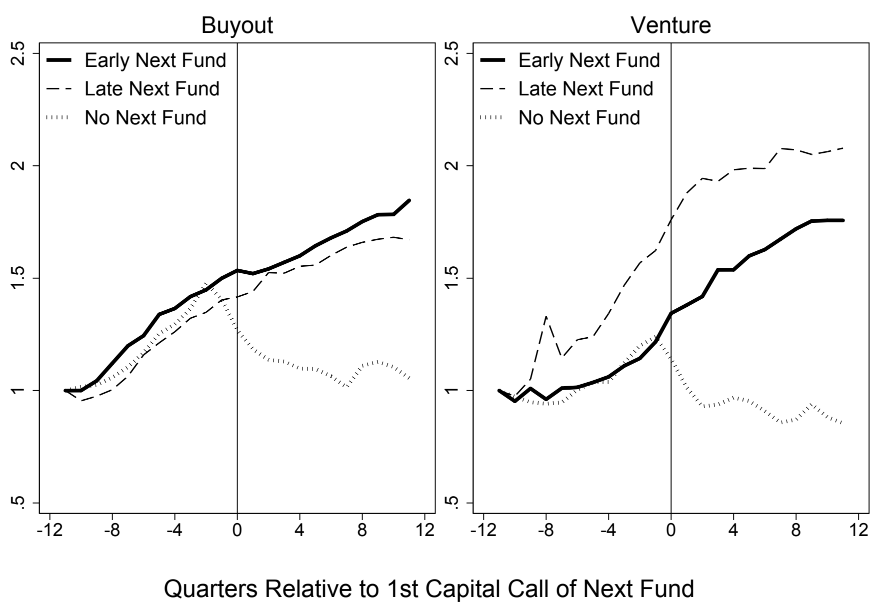
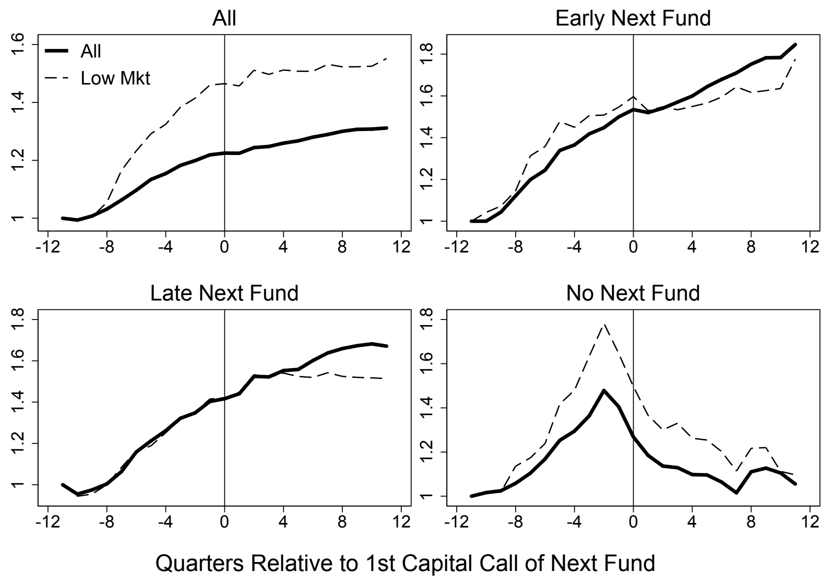


Figure 3: Average Fund Performance Path Around Fundraising

This figure reports cumulative NAV-weighted excess returns of private equity funds over the public market index. Panel A plots values since inception and Panel B plots values values twelve quarters before and after the follow-on funds first capital call. As described in equations (1) and (2), the change in a given quarter is a mean PME-to-date change from the previous period across a subset of funds multiplied by the average ratio of NAV to market-adjusted paid-in capital (to date). We define subsets of funds in the legends of respective subfigures. In cases where no follow-on fund exists (*No Next Fund*), the event quarter is the 13^{th} quarter preceding the last NAV report for resolved funds or the 10-year mark for unresolved funds. *Late(Early) Next* denotes whether the follow-on fund was later(earlier) than the sample median across all buyout and venture funds respectively. *Low Mkt* plots excess returns for funds where the public markets 5-year rolling return was below the sample median as of the 13^{th} quarter of fund life.

Panel A: Buyout



Panel B: Venture

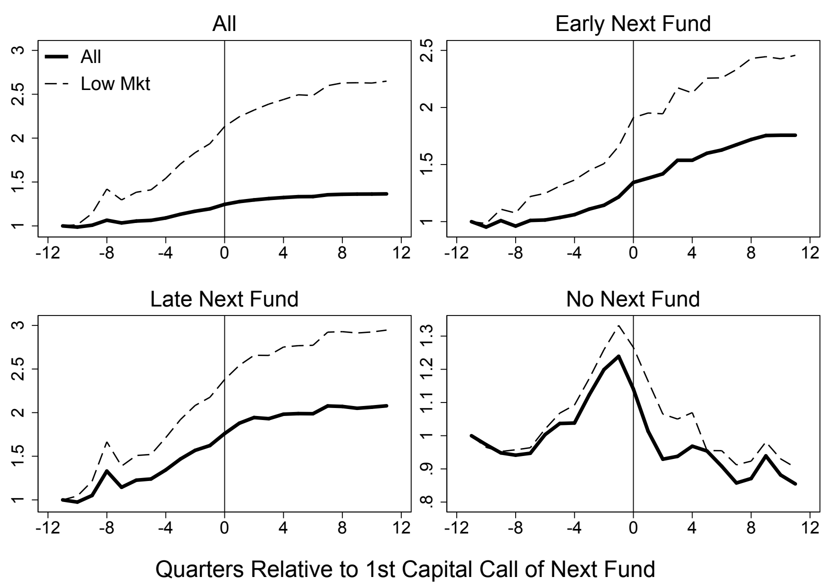
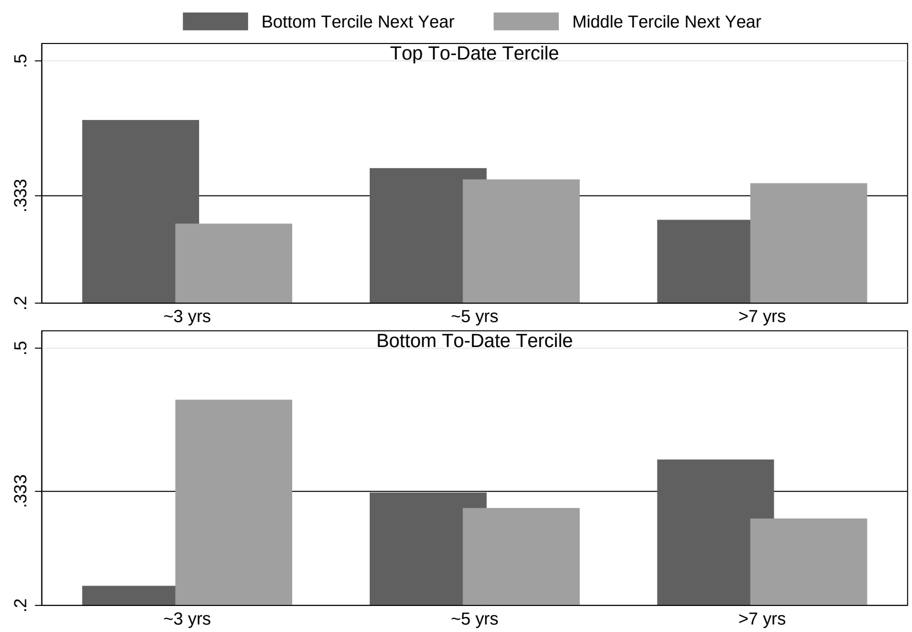


Figure 4: Next Year PME Growth Conditional on To-Date Performance

This figure reports the probabilities of a fund's excess returns over the next 4 quarters being in the top(bottom) tercile conditional on the fund's to-date performance tercile. We plot results separately for Buyout (Panel A) and Venture funds (Panel B). We define the fund peer group for to-date and next year terciles as all funds of the same strategy incepted within one year from the fund vintage year. The top chart of each panel reports results for top to-date tercile funds as of 8 to 17 quarters since inception (∼3yrs), 18 to 27 quarters since inception (∼5yrs), and more than 27 quarters (>7yrs). The bottom chart of each panel reports values for the bottom tercile to-date funds.

Panel A: Buyout funds



Panel B: Venture funds

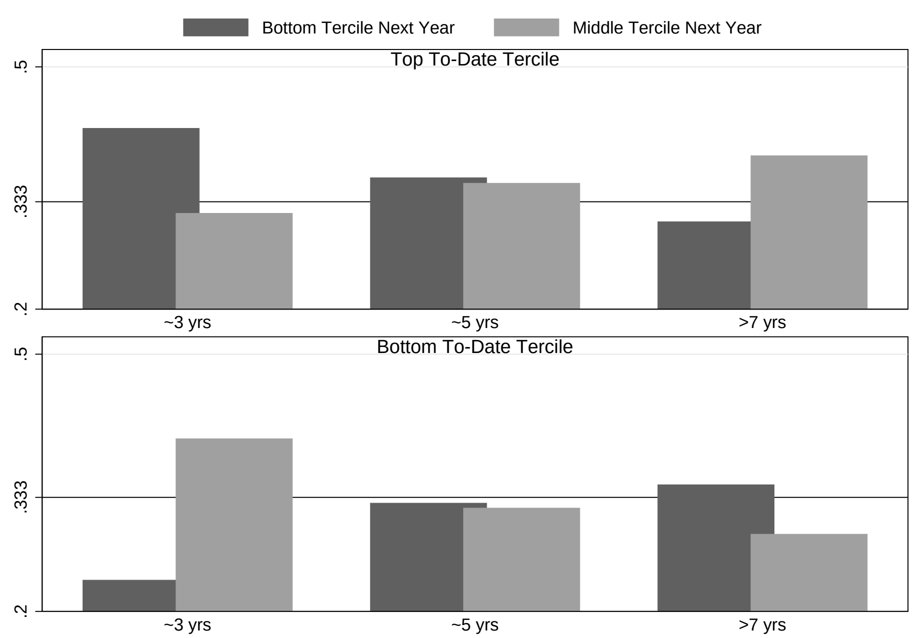


Table 1: Summary Statistics

This table reports summary statistics for the 997 buyout and 1,074 venture funds in our sample. Panel A provides basic statistics for buyout and venture funds separately. We also report common performance statistics conditional on whether or not the fund is resolved (or older than 8 years). Panel B provides detailed statistics on the timing of subsequent funds for buyout and venture funds separately. We provide statistics for subgroups based on number of prior funds and market return terciles (low, mid, high) in the 3 years prior to the fundraising period.

Panel A: Basic Statistics

		Buyout							Venture						
		Mean	StDev	p5	p25	p50	p75	p95	Mean	StDev	p5	p25	p50	p75	p95
All	Funds per Firm	3.1	2.1	1.0	2.0	3.0	4.0	9.0	4.0	2.7	1.0	2.0	3.0	5.0	10.0
	Fund Size (USD mln)	1265	5529	79	210	440	1020	4060	368	2150	26	73	170	320	720
	Vintage Year	2001	6	1989	1998	2001	2006	2008	1998	7	1984	1994	1999	2003	2008
if >1 Fund	Funds per Firm	3.7	2.0	2.0	2.0	3.0	4.0	9.0	4.5	2.7	2.0	3.0	4.0	5.0	10.0
	Median Interval	4.0	2.2	1.0	2.0	4.0	5.0	8.0	3.6	2.5	1.0	2.0	3.0	5.0	8.0
If Already Resolved	Life (years)	12.2	3.1	7.8	10.0	12.0	14.0	17.3	13.2	3.3	8.3	11.3	12.5	15.0	19.3
	IRR (%)	13.8	18.7	-10.2	4.3	11.4	22.4	38.9	15.0	48.9	-18.8	-5.9	3.8	16.6	88.3
	TVPI	1.27	0.58	0.48	0.89	1.22	1.54	2.17	1.27	1.92	0.21	0.52	0.80	1.23	3.61
	PME	1.74	1.02	0.60	1.18	1.57	2.04	3.39	2.02	3.21	0.29	0.73	1.21	2.03	5.97
If Still Alive	Life (years)	5.3	1.1	3.5	4.3	5.3	6.3	7.3	5.3	1.1	3.5	4.5	5.3	6.3	7.3
	IRR (%)	6.4	12.2	-12.9	0.0	6.9	12.7	23.7	4.4	14.6	-14.8	-4.7	3.8	11.8	30.6
	TVPI	1.04	0.35	0.62	0.85	1.00	1.17	1.59	0.98	0.39	0.55	0.72	0.93	1.13	1.67
	PME	1.21	0.40	0.72	1.00	1.18	1.35	1.78	1.19	0.46	0.67	0.88	1.11	1.35	2.01
If Resolved or Older than 8yrs	# of Distributions	38	30	7	19	31	47	86	20	17	3	10	16	25	49
	# of Capital Calls	36	30	7	17	28	46	92	21	16	4	9	17	30	51
	% Qtrs w/ Flows	65	19	32	52	66	79	97	49	19	22	35	46	61	84

Panel B: Follow-on Fundraising by Current Fund Age (if Resolved or Older than 8 years)

		Years before Next Fund Raised										During	After	None
		1	2	3	4	5	6	7	8	9	10+	Life	Finish	So Far
		Buyout												
Fund Counts	All	24	50	82	66	55	34	18	10	4	10	356	3	110
	No Previous Fund	5	23	50	48	31	18	6	9	3	5	200	0	63
	One Previous	6	12	19	13	12	6	5	0	1	2	77	1	33
	Two or More	13	15	13	5	12	10	7	1	0	3	79	2	14
	Low Market	11	23	47	28	14	5	2	1	0	6	136	1	20
	Med Market	11	19	18	17	19	12	9	3	4	3	119	1	42
	High Market	2	5	16	21	22	16	7	6	0	1	96	1	47
Fund Means	Size (USD mln)	997	976	841	530	866	846	1242	635	290	370	812	767	780
	Last PME	1.37	1.33	1.30	1.38	1.32	1.21	1.32	1.55	1.49	1.05	1.32	0.89	1.13
	Last IRR	16.4	12.0	16.6	17.5	18.5	10.5	13.4	16.1	13.9	11.7	15.6	1.6	10.1
		Venture												
Fund Counts	All	68	131	107	88	60	31	23	8	6	16	549	5	173
	No Previous Fund	29	52	47	45	28	11	8	5	4	11	243	1	90
	One Previous	11	29	21	26	18	11	8	3	0	2	132	1	37
	Two or More	28	50	39	17	14	9	7	0	2	3	174	3	46
	Low Market	14	53	61	34	21	11	5	1	1	7	208	1	27
	Med Market	22	47	26	31	11	8	6	3	2	5	164	1	65
	High Market	31	30	19	23	27	12	12	4	2	3	171	3	75
Fund Means	Size (USD mln)	291	193	174	175	293	169	262	166	108	156	215	93	339
	Last PME	1.54	1.92	1.65	1.06	1.07	0.87	0.92	0.67	1.27	0.92	1.42	0.63	0.79
	Last IRR	28.1	32.7	22.8	12.4	9.8	5.1	6.0	-0.9	12.2	12.4	19.9	0.5	1.2

Table 2: Performance Tercile Transition Probabilities

This table reports transition probabilities between interim and final performance terciles. We define performance based on IRR-to-date within each fund peer group (vintage year and strategy). Panel A reports results for buyout funds and Panel B reports results for venture funds. Only the funds that have raised a follow-on fund within ten years since inception are included. The first row of each panel reports the probability of being in the respective to-date tercile at the end of a funds life (*Final*), conditional on being in the bottom to-date tercile in the quarter preceding the follow-on funds first capital call (*At Fundraising*). Similarly, the second (third) row reports Final performance tercile conditional on being in the middle (top) performance tercile *At Fundraising*. The last row of each panel reports the unconditional distribution of funds across *Final* terciles, while the last column reports how many funds were in each fundraising tercile and the respective fraction in the total number of funds in this analysis. The peer group is all funds of the same strategy incepted within one year from the fund vintage year. Since follow-on fundraising occurs at a different time for each of the funds and fund life varies, neither *At Fundraising* nor *Final* terciles need to have an equal number of funds.

Panel A: Buyout

		Final				
		Btm	Mid	Top	Fund Count	
At Fundraising	Btm	61.2%	26.9%	11.9%	67	(18.8%)
	Mid	36.9%	42.3%	20.8%	130	(36.5%)
	Top	13.2%	25.2%	61.6%	159	(44.7%)
	All	30.9%	31.7%	37.4%	356	(100%)

Panel B: Venture

		Final				
		Btm	Mid	Top	Fund Count	
At Fundraising	Btm	55.6%	36.7%	7.7%	117	(22.9%)
	Mid	31.8%	41.3%	26.8%	179	(35.1%)
	Top	14.5%	25.2%	60.3%	214	(42.0%)
	All	30.0%	33.5%	36.5%	510	(100%)

Table 3: Do LPs Vote With Their Feet?

This table reports the parameter estimates from a linear probability model of a follow-on fund being raised. Results are reported separately for buyout (Panel A) and venture (Panel B) funds. We only include funds that were resolved or operated for at least 10 years. The event time is defined by the quarter in which the follow-on fund made its first capital call or, in the case of unsuccessful fundraising, the 13^{th} quarter preceding the last NAV report if the fund is resolved or 10^{th} year of fund life if the fund is unresolved. The main explanatory variables are defined as: *PME drop (after)* equals 1 if the value of Kaplan-Schoar PME at resolution is lower that at the event time; *PME run-up (before)* equals 1 if the value of Kaplan-Schoar PME 1 year before the event time is lower than at the event time; *Large Distribution (before)* equals 1 if the sum of distributions over the year preceding the event time exceeds 20% of NAV; *Top tercile-to-date* equals 1 if fund is in the top (highest) IRR-tercile across vintage and strategy peers at the event time and zero otherwise, and *Bottom tercile-to-date* equals 1 if the fund is in the bottom (lowest) IRR-tercile at the event time and zero otherwise. All specifications include the interaction of the fund vintage year and industry (GICS sectors) fixed effects. In specifications (3) and (4) we include the level of PME at the event-time as well a dummy indicating where market return was positive in the pre-event year. *t*-statistics reported in parentheses are robust to error clustering at the event year, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Buyout				**Panel B** Venture			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
PME drop after	−0.132**	−0.116**	−0.127**	−0.111**	−0.106**	−0.085*	−0.090*	−0.087*
	(−2.65)	(−2.54)	(−2.74)	(−2.66)	(−2.05)	(−1.84)	(−1.92)	(−1.88)
PME run-up before	−0.076*	−0.064*	−0.088**	−0.170***	−0.122**	−0.129**	−0.131**	−0.183***
	(−1.73)	(−1.74)	(−2.40)	(−3.07)	(−2.29)	(−2.58)	(−2.74)	(−3.37)
Large Distribution				0.007				0.019
				(0.23)				(0.36)
Large Distribution × PME run-up before				0.157**				0.180**
				(2.17)				(2.29)
Top IRR Tercile		0.095***	0.049**	0.048**		0.102***	0.085***	0.075***
		(0.23)	(0.23)	(0.23)		(0.36)	(0.36)	(0.36)
Bottom IRR Tercile		−0.188*	−0.154*	−0.142*		−0.064**	−0.059*	−0.058**
		(−2.04)	(−1.81)	(−1.82)		(−2.07)	(−1.97)	(−2.05)
PME level (event)			0.116**	0.097**			0.018	0.014
			(2.26)	(2.12)			(1.57)	(1.35)
Market run-up before			0.042	0.055			0.049	0.052
			(0.50)	(0.64)			(0.85)	(0.91)
Controls	Vintage Year × Industry FE							
Observations	541	541	541	541	763	763	763	763
R-squared (%)	26.5	33.0	34.4	35.6	26.6	29.3	29.7	31.0

Table 4: Fund Timing and Peer-Chasing

This table reports the parameter estimates from a linear regression model estimated separately for buyout (Panel A) and venture (Panel B) funds. The dependant variable measures risk- and cash flow-adjusted changes in NAV for quarter t that is constructed to be unpredictable under the null of reported NAVs being unbiased estimators of true asset values. The market beta of the fund assets is assumed to be 1.7 (2.4) in specifications (3) and (4) for buyout (venture) subsample and 1 everywhere else. Explanatory variables of interest include *FundTiming* which is the natural log of one plus time spent to-date without a follow-on fund in excess of two years, *PeerChasing* which is the difference between fund i reported Internal Rate of Return to-date for the calendar quarter corresponding to $t-1$ quarter of fund i life and its peers as measured by the median IRR-to-date across all funds of the same strategy incepted within one year from fund i vintage year. Specifications (2) and (4) also include the interaction of *FundTiming* and *PeerChasing* variables. All specifications include fund fixed effects, fund distributions and capital calls over the current quarter scaled by the end of quarter NAVs, and year-quarter fixed effects. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Buyout				**Panel B** Venture			
	$\beta = 1.0$		$\beta = 1.70$		$\beta = 1.0$		$\beta = 2.40$	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
FundTiming	0.080***	0.057***	0.076***	0.053**	0.051***	0.043***	0.054***	0.046***
	(4.22)	(3.00)	(3.63)	(2.57)	(3.62)	(3.08)	(3.78)	(3.26)
PeerChasing	−0.205***	0.131**	−0.202***	0.117**	−0.175***	0.045	−0.180***	0.037
	(−6.51)	(2.55)	(−5.46)	(2.09)	(−9.18)	(1.21)	(−9.21)	(0.99)
FundTiming × PeerChasing		−0.304***		−0.289***		−0.202***		−0.200***
		(−6.61)		(−5.62)		(−6.52)		(−6.29)
Observations	12,150	12,150	12,150	12,150	15,124	15,124	15,124	15,124
R-squared	0.237	0.242	0.420	0.423	0.305	0.309	0.607	0.608
RMSE	0.158	0.158	0.180	0.180	0.120	0.120	0.124	0.124
Controls	Cash Flows, Fund Fixed Effects, and Year-Qtr Fixed Effects							

Table 5: Cross-Section of To-Date Performance

This table reports results of estimating a linear regression model explaining fund abnormal performance. The dependent variable measures risk- and cash flow-adjusted changes in NAV for quarter t that is constructed to be unpredictable under the null of reported NAVs being unbiased estimators of true asset values. The model is estimated separately for buyout (Panel A) and venture (Panel B) funds. Explanatory variables include: *FundTiming* is the natural log of one plus time spent to-date without a follow-on fund in excess of two years; *PeerChasing* is the difference between fund i reported Internal Rate of Return to-date for the calendar quarter corresponding to *t1* quarter of fund *i* life and its peers as measured by the median IRR-to-date across all funds of the same strategy incepted within one year from fund *i* vintage year. *Rookie* is indicator variable denoting if the PE firm had less than two funds before fund *i*, *Top* (*Btm*) is indicator variables denoting if fund i was in the top (bottom) tercile as measured by IRR-to-date as of quarter *t1* across the fund's peers. The market beta of each fund's assets is assumed to be 1.7 (2.4) in specification (4) for buyout (venture) subsample and 1 everywhere else. Control variables in all specifications include fund fixed effects, year-quarter fixed effects as well as fund distributions and capital calls over the current quarter scaled by the end-of-quarter NAVs. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Buyout				**Panel B** Venture			
	$\beta = 1.0$			$\beta = 1.70$	$\beta = 1.0$			$\beta = 2.40$
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
FundTiming	0.088***	0.082***	0.066***	0.063***	0.053***	0.053***	0.040***	0.043***
	(4.67)	(4.31)	(3.47)	(3.07)	(3.74)	(3.81)	(2.86)	(3.03)
PeerChasing	−0.138***	−0.191***	−0.038	−0.025	−0.167***	−0.182***	−0.127***	−0.126***
	(−3.03)	(−4.99)	(−0.64)	(−0.38)	(−7.55)	(−6.81)	(−3.23)	(−3.10)
Rookie × FundTiming	−0.015		−0.017*	−0.019*	−0.007		−0.003	−0.002
	(−1.43)		(−1.70)	(−1.71)	(−0.96)		(−0.54)	(−0.55)
Rookie × PeerChasing	−0.134**		−0.114*	−0.123	−0.022		−0.025	−0.031
	(−2.15)		(−1.77)	(−1.62)	(−0.54)		(−0.46)	(−0.60)
TopTercile-to-date		0.046**	0.023	0.021		0.024**	0.004	0.003
		(1.99)	(0.96)	(0.74)		(2.13)	(0.33)	(0.24)
Top × FundTiming		−0.041***	−0.021	−0.017		−0.025***	−0.019	−0.018
		(−2.92)	(−1.38)	(−0.96)		(−3.49)	(−1.43)	(−1.26)
Top × PeerChasing		−0.026	−0.111	−0.123		0.045	0.005	0.010
		(−0.37)	(−1.39)	(−1.35)		(0.96)	(0.10)	(0.19)
BtmTercile-to-date			−0.073***	−0.070***			−0.053***	−0.050***
			(−3.94)	(−3.50)			(−4.21)	(−3.90)
Btm × FundTiming			0.051***	0.050***			0.041***	0.039***
			(5.03)	(4.74)			(5.23)	(4.90)
Btm × PeerChasing			−0.206**	−0.207*			−0.103	−0.107
			(−2.11)	(−1.89)			(−1.59)	(−1.63)
Controls	Cash Flows, Fund Fixed Effects, and Year-Qtr Fixed Effects							
Observations	12,150	12,150	12,150	12,150	15,124	15,124	15,124	15,124
R-squared	0.238	0.238	0.241	0.423	0.305	0.306	0.323	0.608
Pr(F-stat>F[*FundTiming by Top*])		0.301				0.234		

Table 6: Fund Timing and Peer-Chasing: Dynamic Panel Specifications

This table reports results of estimating a linear regression model explaining fund abnormal performance. The dependent variable measures risk- and cash flow-adjusted changes in NAV for quarter *t* that is constructed to be unpredictable under the null of reported NAVs being unbiased estimators of true asset values. Explanatory variables (X) include: *FundTiming* is the natural log of one plus time spent to-date without a follow-on fund in excess of two years; *PeerChasing* is the difference between fund *i* reported Internal Rate of Return to-date for the calendar quarter corresponding to *t-1* quarter of fund *i* life and its peers as measured by the median IRR-to-date across all funds of the same strategy incepted within one year from fund *i* vintage year. Models are estimated separately for buyout (Panel A) and venture (Panel B) funds. All specifications are estimated in first differences by fund-quarters via two-step GMM with the optimal weighting matrix. Everywhere except in specifications (3), we use two lagged levels of X to instrument for the difference whereas in (3) we use two lagged levels of *ExcessFundTiming* and *ResidualPeerChasing* as the instruments (both defined in Section 6.1). In all specifications, control variables include year and quarter fixed effects as well as fund distributions and capital calls over the current quarter scaled by the end of quarter NAVs. Specifications (4) also includes ($PME_T - PME_{t+1}$), a difference between the next period PME-to-date and the final PME for the funds that were fully resolved by the end of March 2012. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Buyout				**Panel B** Venture			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
FundTiming	0.165***	0.144**	0.143**	0.159**	0.235***	0.213***	0.157***	0.284***
	(2.96)	(2.57)	(2.45)	(2.13)	(5.01)	(4.70)	(3.21)	(4.87)
PeerChasing	−0.315***	0.100	−0.196**	−0.310***	−0.366***	0.286***	−0.117**	−0.403***
	(−5.72)	(0.72)	(−2.50)	(−3.67)	(−7.80)	(2.80)	(−1.97)	(−6.25)
FundTiming × PeerChasing		−0.735***				−1.253***		
		(−3.07)				(−6.60)		
(PME_T-PME_{t+1})				−0.036				0.023
				(−1.27)				(1.00)
Fund Effects	First-Differences							
Controls	Year and Quarter Fixed Effects, Cash-Flows							
Observations	12,003	12,003	12,003	5,875	14,979	14,979	14,979	7,119
R-squared	0.099	0.146	0.08	0.108	0.106	0.211	0.064	0.112
F-stat[*1st stage*]	35.3	33.8	33.2	9.2	16.8	18.5	14.5	7.4

Appendix.

A.1. Extensions to the theoretical framework

A.1.1. Fundraising valuation bias and fund age

Consider the *costly signaling* case setup and notation from section 2.3 but with GPs having multiple attempts to raise a follow-on fund. Specifically, assume that GPs can approach a subset of LPs $\subset I$ either *Early* or *Late*. *Early* is shortly after the terms of the $j = 0$ fund permit raising another fund (usually based on a minimal fraction of capital invested and/or time elapsed). *Late* is when the duration constraint for the current fund ($j = 0$) starts to bind. For now, assume that the subset of LPs invited *Late* ($I^L \subset I$) is similar to other LPs (i.e. $I^E \subset I$) in terms of their preferences and abilities.

For brevity, denote $\bar{p}_{E(L)} := \sum_{i \in I^{E(L)}} w_i \cdot p\big(\hat{r}_0 + \gamma_0^{E(L)} - \gamma_{i0}^{E(L)}\big)$ and similarly for f_E, f_L, V_E, and V_L. The GP's (ex-ante) objective function then becomes

$$\gamma_0^* = \underset{\gamma_0^E, \gamma_0^L}{\arg\max}\ \bar{p}_E \cdot (f_E + V_E) + \delta \cdot (1 - \bar{p_E}) \cdot \bar{p_L}(f_L + V_E) \tag{A.1}$$

where $0 < \delta < 1$ is a subjective discount factor to adjust for time-value and utility loss due to failure to raise a fund early.

Thus, the two first-order conditions will be:

$$(\frac{\partial}{\partial \gamma_0^E}):\ p_E' \cdot \Big(f_E + V_E - \delta \cdot p_L \cdot (f_L + V_L)\Big) = -p_E \cdot \Big(f_E' + V_E'\Big) \tag{A.2}$$

$$(\frac{\partial}{\partial \gamma_0^L}):\ p_L' \cdot \Big(f_L + V_L\Big) = -p_L \cdot \Big(f_L' + V_L'\Big) \tag{A.3}$$

revealing that, with the information set F_{0E}, all GPs will report lower valuation bias at their *Early* fundraising attempt. $\gamma_0^{*E} < \gamma_0^{*L}$ because $\delta \cdot p_L \cdot (f_L + V_L)$ is positive, causing the lefthand side of equation (A.2) to be lower than in equation (A.3). Thus, V_E' must be less negative than V_L'.

The intuition behind this result is straightforward. With multiple efforts possible, the long-term gains of conservative reporting (as embedded in V) are more valuable. Also note that, for GPs with $\hat{r}_0^H$, there is a longer period of uncertainty about how realized returns will differ from the current estimate (i.e. $var(e_f^L) > var(e_f^E)$, $e_f = r_0 - \hat{r}_0$) pushing $E[V_E]$ below $E[V_L]$, all else equal.

Next, assume that GPs can observe which LPs have more precise signals about the valuation bias and can chose whom to solicit commitments from. Suppose there are two types of LPs: *Big* ($i \in I^B$) have more resources to scrutinize reported valuations than *Small* ($i \in I^S$). Thus, τ_i in equation (7) is either τ_B

or $\tau_S < \tau_B$. Clearly, in this case GPs with $\hat{r}_0^H$ will approach *Big* LPs during the *Early* fundraising attempt because $\bar{p}(\tau_B) > \bar{p}(\tau_S)$ due to concavity of the probability distribution around $\hat{r}_0^H \gg Mode(r_0)$. In other words, it is less costly to report conservative NAVs to *Big* LPs since the dispersion of their mistakes about γ_{i0} (as per equation 7) is not increasing in γ_0^2 as much as with *Small* LPs.

By this logic, it may appear that GPs with $\hat{r}_0^L$, who are set to benefit from the inference mistakes by LPs (since the probability distribution is convex around $\hat{r}_0^L \ll Mode(r_0)$), would prefer targeting *Small* LPs first and report higher γ_E as compared to the pooled-LP case discussed above. However, if either:

(i) *Big* LPs signal precision improves faster than that of *Small* LPs as the fund continues to operate, i.e., $\delta \bar{p}_L(\tau_B) - \bar{p}_E(\tau_B) < \delta \bar{p}_L(\tau_S) - \bar{p}_E(\tau_S)$;[20] *or*

(ii) a lack of commitments by *Big* LPs reduces the probability of commitments by *Small* LPs,[21]

then GPs with $\hat{r}_0^L$ would choose to pool with GPs with $\hat{r}_0^H$ and cater to *Big* LPs first with whom overstating NAVs is relatively less effective (i.e., $\bar{p}'_B < \bar{p}'_S$) and plausibly more costly (i.e., $V'_B < V'_S$).

This proposition explains why Huther (2016) finds no robust evidence of NAV-inflation by GPs who eventually fail to fundraise using individual company transaction and valuation data on 138 buyout funds obtained from a single large LP. The fundraising attempt is dated according to the fund prospectus with most being 3-4 years after the current fund inception. Thus, most observations are likely to represent *Early* efforts when notable upward bias is suboptimal.[22] Furthermore, given the detail of the records (and the GPs' compliance with such disclosure requests), the LP appears to be a particularly "high-τ"-type which might not be targeted by a representative set of GPs to begin with.

This conclusion also justifies our choice of the event time as the 13$^{\text{th}}$ quarter preceding the last NAV report if the fund is resolved or at least 10 years old. These are *Late* efforts where our theoretical framework predicts the strongest incentives to inflate valuations. In Figure A.1, we also show that results attenuate if we define a failed fundraising event based simply on time elapsed since the fund's inception.

[20] This condition insures that equation (A.1) is maximized when $I^B \subset I^E$ since, for $\hat{r}_0^L$ and, hence, $p_E(\tau_S) > p_E(\tau_B)$, $K/(1 - p_E(\tau_S) > K/(1 - p_E(\tau_B)$, where $K = (f_E + V_E)/(f_L + V_L) > 0$. However, it might not be sufficient if $K_{I^B \not\subset I^E} > K_{I^B \subset I^E}$ which is plausible when continuation value is very small in comparison to the next-most fund fees.

[21] According to Da Rin and Phalippou (2016), 67-70% of LPs admit that "Commitments by top LPs" is at least a "Somewhat Important" criterion to invest in a new fund; with 22-29% calling it "Very Important" or "Crucial". This is also consistent with the information holdup by the current fund LPs (relatively more informed about the fund interim performance) as studied in Hochberg, Ljungqist, and Vissing-Jorgensen (2011).

[22] Lack of power may also arise due to not weighting excess returns by unresolved NAVs which we describe in section 4.1 and later in this appendix (see section I.2).

A.1.2. Write-offs and effort-rationing

We continue with the previous analysis so that $f_0(\cdot)$ and $f(\cdot)$ denote the present values of fees from the current (still unresolved $j = 0$) fund and the new fund ($j = 1$) while $V(\cdot)$ denotes the present value of fees from all future funds adjusted for the probability of raising them. But now consider GPs, endowed with the monitoring effort amount $\theta = 1$, that have *just* successfully raised a new fund, and are choosing how to allocate their effort between the new and the old fund. Assume that the expected excess return from the new fund over its investment period (i.e. 4-6 years) is an affine function of the effort amount so that

$$E[r_1^{I1}] = k \cdot \theta - c, \quad k, c > 0. \tag{A.4}$$

Similarly, while fund $j = 1$ is investing, GPs expect to attain an incremental excess return based on the residual effort, unused to monitor fund $j = 1$, but with possibly different parameters:

$$E[r_0^{I1}] = k_0 \cdot (1 - \theta) - c_0, \quad k_0, c_0 > 0. \tag{A.5}$$

The GPs' wealth maximization problem can be written as:

$$\theta^* = \underset{\theta \in [0,1]}{\arg\max}\, f_0(k_0 \cdot (1 - \theta) - c_0) + f(k \cdot \theta - c) + V(w \cdot k \cdot \theta + w_0 \cdot k_0 \cdot (1 - \theta)) \tag{A.6}$$

where w and w_0 are the weights that the GPs expect LPs to assign to the last and second to last fund's performance when deciding whether to participate in subsequent funds.

Given the overwhelming evidence that LPs should (and do) put more weight on more recent performance, it is reasonable to assume that $w > w_0$.[23] To the extent that the value in private equity is created relatively early in a specific deal's life rather than through exiting (see Kaplan, Gompers and Mukharlyamov, 2015), k will tend to be greater than k_0. This alone can cause a reduction in the excess return trend as the fund matures. Hence, we should expect that $w \cdot k > w_0 \cdot k_0$ for the typical GP. The first-order condition for equation (A.6) therefore implies that the typical GPs have incentives to allocate *all* their effort to the new fund, unless the sensitivity of the previous fund fees' to excess returns is greater than that of the new fund.[24]

[23] Several studies, e.g. Harris, Jenkinson, Kaplan and Stucke (2013), find persistence in the performance of private equity funds but decaying predictability in fund sequence. In a survey of over 200 LPs, DaRin and Phalippou (2016) confirm that LPs focus on the recent past performance. Barber and Yasuda (2016) find that a top-quartile status for the last-most fund is doubles the odds of a successful fundraising relatively to the previous fund top-quartile status. Note also that fund $j = 1$ performance will be fully realized for $j > 2$.

[24] This conflict of interest between the old fund and the new fund is hardly novel or unexpected by LPs. The importance of such tensions has been long recognized as evidenced by the nature of covenants in PE fund term sheets (e.g. see Gompers and Lerner, 1996). However, these covenants barely pertain to the monitoring intensity upon completion of the investment period since it is particularly hard to contract on.

Specifically, for a $\theta^* < 1$ one needs:

$$f_0' = \frac{k}{k_0} \cdot f' + \frac{w \cdot k - w_0 \cdot k_0}{k_0} \cdot V' \tag{A.7}$$

where, unlike in the main text, f' denotes the sensitivity of the new fund fees with respect to the *new* fund return, so $f'' > 0$; while V' denotes the sensitivity of the continuation value with respect to the past two fund returns, so $V'' < 0$ as before.

Consequently, one should expect mostly flat excess returns for the old fund after the new fund is raised unless $f_0' \gg f'$. The latter is plausible when the old fund is "in-the-carry" or has significantly more performance-sensitive compensation than the new fund. Realistically, the GP effort allocation between funds is not continuous and to a large extent irrevocable since each fund represents a portfolio of companies where GPs typically engage as active board members. A decision to disengage with a portfolio company amounts to selling or liquidating that company. To the extent liquidations associate with losses, the write-offs should indicate re-allocation (i.e., *rationing*) of the GP effort towards the new investments.[25]

A.1.3. Write-offs and information asymmetry

The (above-discussed) *effort-rationing* by GPs is certainly not the only reason that write-offs in the old fund may intensify (potentially causing lower excess returns fund-wide) after a successful fundraising. At least three contemporaneous studies (Barber and Yasuda, 2016; Chakraborty and Ewens, 2016; Huther, 2016) utilize the post-fundraising write-off intensity as the identification device for the presence of a valuation bias in NAVs during fundraisings. Indeed, it is very tempting for GPs to disguise the unwinding of the upward valuation bias as write-offs occurring due to the optimal effort re-allocations that maximizes the combined value across two funds. If the asymmetric information about fund investments' valuations never resolves, as discussed in section 2.3, the LPs should be factoring in the possibility for such deceptions.

Consider the Bayesian-normal updating of beliefs about the old fund's valuation bias by LPs as in section 2.3. Here the updating occurs quarterly as LPs observe new reports about the excess return in the old fund:

$$\hat{\gamma}_t = \frac{\tau_0 \cdot \hat{\gamma}_0 + \sum_{n=1}^{t} s_t \cdot e_t^-}{\tau_0 + \sum_{n=1}^{t} s_t} \tag{A.8}$$

where $t = 0$ is the quarter when the new fund ($j = 1$) was raised; $\hat{\gamma}_0 \sim N(\gamma_0, 1/\tau_0)$ is the LPs' prior belief

[25] According to SFAS 157 (ASC 820), the Level III assets must be assigned a value corresponding to "*Highest and Best Use*" as being "*consequently operated with the other assets in its group*". So even changes to the fund portfolio may naturally trigger changes to "*Highest and Best Use*" valuations of the remaining assets without any pre-existent valuation bias.

about the old fund's period $t = 0$ valuation bias; and $e_t^- = -(r_{0,t} - r_{0,t-1})$ is the change in the excess return of fund $j = 0$ over quarter t.

Because the change in excess return of the old fund depends on the effort the GP allocates to the new fund, e_t^- falls in $(1-\theta)$. Correspondingly, $\hat{\gamma}_t$ is an increasing function of θ because LPs rationally consider negative abnormal returns being consistent with previously inflated NAVs (since GPs cannot credibly communicate the private information about portfolio valuations and efforts' rationing to LPs). Thus, in equilibrium, such informational asymmetry should be reducing the extent the old funds get neglected by GPs during post-fundraising quarters (i.e., θ_t, $t > 0$).

This result emerges because the sensitivity of the continuation value to the effort, as modeled in equations (A.6-A.7), now has a second component, $\frac{\partial V}{\partial \hat{\gamma}_t} \cdot \hat{\gamma}_t'$, which has to be negative except in the *naïve investors* equilibrium where all GPs inflate NAVs as regulators permit (section 2.1). The new first order condition is

$$f_0' = \frac{k}{k_0} \cdot f' + \frac{1}{k_0} \cdot \left(\frac{\partial V}{\partial r} \cdot (w \cdot k + w_0 \cdot k_0) + \frac{\partial V}{\partial \hat{\gamma}_t} \cdot \hat{\gamma}_t' \right). \tag{A.9}$$

Note that the precision of the signal e_t^- in equation (A.8), s_t, will be changing with t to reflect the information set of that quarter. Arguably, s_t may increase during the fund's life as the portfolio matures and has fewer unrealized investments left. Thus, GPs who indeed had $\gamma_0 > 0$ should perhaps rush to unwind the bias before the weight on e_t^- becomes large.[26] However, to the extent $1/s_t$ remains positive, there is a value in the option to delay the write-off in hope that good idiosyncratic shocks materialize and offset the upward pressure in e_t^-. Furthermore, it is equally plausible that maximizing efforts in the new fund is especially useful early in its life (so that it has mature enough projects to signal with during the next fundraising). Hence, the pressure to disengage with underperforming old projects is also strongest shortly after the new fund was raised.

The ambiguity with the interpretation of write-offs is pervasive because the fund and GP characteristics that positively correlate with θ (see the discussion in section A.1.2) coincide with incentives to have had inflated valuations in the old fund (e.g., low f_0', lack of strong past track record, few reinvestments from the old fund LPs). More importantly, there appears to be no credible strategy for "good" GPs (i.e., who did not inflate the old fund NAVs but just face effort constraints) to separate from those GPs who attempt to disguise the unwinding of the upward valuation bias. For example, one may argue that, to the extent s_t decreases

[26] This is essentially the identifying assumption in Chakraborty and Ewens (2016) who document that, shortly after the next fund is closed, VCs tend to write-off more (in the old fund).

in the variance of the broad market and/or the comparable valuations, bad-type GPs would try to write-off during those times whereas "good-type" GPs would prefer low-variance quarters. However, it is *not* more costly for "bad" GPs to mimic the "good" GPs and occasionally refrain from accounting for a "big-bath". Similarly, it is *not* more costly for "bad" GPs to cluster write-offs around times when their new fund has made many new investments (that presumably require heightened attention).

We therefore argue that econometric inference about private equity funds' valuation aggressiveness based on the post-fundraising write-off intensity in the old fund (or just a moderation of a positive excess return trend) is particularly susceptible to the endogeneity problem because effort-rationing and unwinding a NAV bias are jointly determined. Thus, even when tests utilize the individual investee company-level transaction and valuation data, so that other sources of spurious correlations (see next section) are plausibly absent, the resulting estimates can be misleading. In contrast, (on average) *negative* excess returns post-fundraising contradict the assumption that $k_0 > 0$, because to avoid paying c_0 in equation (A.5), GPs can simply divest fund $j = 0$ holdings. Thus, negative excess returns post-fundraising should reveal the upward valuation bias in the cross-section of funds under much weaker assumptions (i.e., $Ef_0' \nless 0, Ek_0 > 0$).

Finally, note that *conservative* NAVs in the old funds (i.e. $\gamma_0 < 0$) allow the recently top-performing managers (GPs with r_0^H in the notation of section 2.3) to easier mitigate the possibly bad news from (A.8) since it is less costly for them to understate the old fund performance. In other words, the probability that they successfully raise fund $j = 1$ is less sensitive to some LPs inferring $\hat{\gamma}_0 \gg \gamma_0 < 0$). So, whenever these GPs need to revise valuations down, they can utilize the "reserve" within that fund and, hence, keep e_t^- small (or even negative). Consequently, those GPs with r_0^H can attain a more optimal effort allocation between their funds which is conducive for the persistence in PE fund performance that has been documented in the literature.

A.2. FASB 157 adoption

We undertake two simple tests in an attempt to identify effects that might be attributable to accounting changes related to SFAS 157. First, Figure A.3 plots median fund performance during this period based on changes in PME indexed to 2003:Q4 value of 1.0. The figure shows that in 2008 PMEs for both buyout and venture funds increase significantly, regardless of the performance and fundraising success. This is consistent with funds marking-to-market undervalued investments en masse. However, if this were the case, we would expect PMEs to stay at this new level after being marked up. Instead PMEs drop substantially in 2009 so that the combined net change in PME is close to zero over the period from 2007-2009. Panel

A also shows that the net effect is similar for both funds that are, and are not, successful at raising a next fund though it is more pronounced for those that are not. A likely explanation for the pattern in PMEs is that funds did not mark their portfolios down as far as the public market returns in 2008 nor up as much in 2009. Consequently, PMEs give the appearance of outperforming in 2008 and underperforming in 2009. Panel B shows similar plots based on performance tercile as of 2006:Q1. Panel C shows similar plots based on performance tercile as of the end of a funds life. In all cases fund relative returns as measured by PME appear to jump in 2008 and then drop in 2009 and it is difficult to attribute this return pattern to SFAS 157.

Our second test compares estimates of return autocorrelation before and after the adoption of SFAS 157. Specifically, we estimate the following AR(1) model:

$$NAVret_{it} = \mu + fas157_t + \rho_1 \cdot NAVret_{it-1} + \rho_2 \cdot NAVret_{it-1} \cdot fas157_t + \nu_{i,t}$$

and compare the estimates of ρ_1 and ρ_2. Given our previous analysis (as well as many others in context of marking illiquid assets), we expect to find positive values of ρ_1 consistent with positive return autocorrelation. A material impact from SFAS 157 (in the direction of timely and unbiased marking) would be consistent with a negative ρ_2 and the sum of ρ_1 and ρ_2 being insignificantly different from zero.

Table A.2 reports results from the AR(1) model above for both buyout and venture funds for the full sample of funds and a variety of subsamples. We also examine both raw returns and de-meaned returns (i.e., returns accounting for fund fixed effects). Panel A reveals the expected significant positive values for ρ_1 in most samples. Values for ρ_2 are sometimes negative, but only weakly significant in two cases for de-meaned returns (i.e., specifications 3 and 6 which are for funds with weaker performance). Panel B reports results for venture funds. We again find generally positive and significant coefficients for ρ_1. However, for venture funds values for ρ_2 are often negative and significant. These results suggest that adoption of SFAS 157 may have had an important impact on NAV reporting for venture funds but not for buyout funds. The results for venture funds are consistent with the findings of Cumming and Walz (2009) regarding the effects of accounting standards on the private equity fund financial reporting.

Table A.1: Cross-section of to-date performance: *placebo*

This table reports the parameter estimates a linear regression model estimated separately for buyout (Panel A) and venture (Panel B) funds. The dependant variable measures a fund adjusted return for quarter t if its NAVs were tracking a same style public equity portfolio based Fama-French 100 U.S. equity portfolios. *FundTiming* is the natural log of one plus, essentially, time spent to-date without a follow-on fund in excess of two years. Specifications (1) through (4) have *PeerChasing* is a difference between fund i to-date average public portfolio cumulative return-to-date for the calendar quarter corresponding to $t-1$ quarter of fund i life and that of its peers. *Rookie* is a dummy for whether the PE firm had less than two funds before i. *Top* and *Btm* are dummies denoting if to-date return of the assigned public equity portfolio was in Top(Bottom) tercile by return-to-date as of quarter $t-1$ among those assigned to the fund peers. Control variables in all specifications include funds fixed effects, year-quarter fixed effects as well as fund distributions and capital calls over the current quarter scaled by the end of quarter NAVs. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Buyout				**Panel B** Venture			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
FundTiming	−0.002	0.013	0.007	0.018	0.017	−0.013	−0.005	−0.013
	(−0.08)	(0.51)	(0.36)	(0.61)	(0.73)	(−0.76)	(−0.35)	(−0.61)
PeerChasing	0.039	0.014	0.031**	0.015	−0.011	0.007	−0.009	0.001
	(1.26)	(0.72)	(2.00)	(0.67)	(−0.38)	(0.48)	(−0.56)	(0.06)
Rookie × FundTiming		0.011		0.005		0.007		0.008
		(0.32)		(0.15)		(0.28)		(0.32)
Rookie × PeerChasing		0.009		0.008		−0.001		0.006
		(0.34)		(0.32)		(−0.06)		(0.24)
TopTercile-to-date			−0.030*	−0.029*			−0.008	−0.008
			(−1.86)	(−1.79)			(−0.64)	(−0.67)
Top × FundTiming			0.049	0.036			−0.018	−0.015
			(0.99)	(0.71)			(−0.52)	(−0.41)
Top × PeerChasing			−0.011	−0.000			0.046**	0.035
			(−0.32)	(−0.01)			(2.03)	(1.42)
BtmTercile-to-date				0.003				0.002
				(0.19)				(0.15)
Btm × FundTiming				−0.033				0.011
				(−0.91)				(0.40)
Btm × PeerChasing				0.078				−0.044
				(1.10)				(−1.21)
Controls	Fund FE, Year-Qtr FE, Cash-Flows							
Observations	12,150	12,150	12,150	12,150	15,131	15,131	15,131	15,131
R-squared	0.467	0.477	0.436	0.436	0.191	0.194	0.169	0.169

Table A.2: Autocorrelation of reported returns before and after FAS157

This table reports the parameter estimates for the following linear regression model::

$$NAV\,ret_{it} = \mu + fas157_t + \rho_1 \cdot NAV\,ret_{it-1} + \rho_2 \cdot NAV\,ret_{it-1} \cdot fas157_t + \nu_{i,t}$$

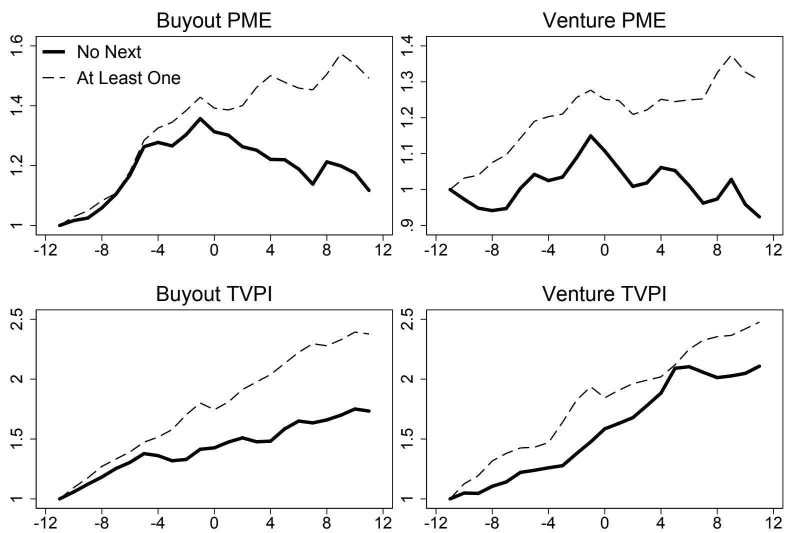
The model is estimated separately for buyout (Panel A) and venture (Panel B) funds. We report results from two estimation methods, *Fund FE* and *Pooled*, and four subsamples. In the Pooled method $NAV\,ret_{it}$ is fund i reported return for quarter t as measured by NAV change adjusted for net distributions during that quarter. In *Fund FE*, $NAV\,ret_{it}$ is fund i reported return for quarter t de-meaned over each funds lifetime. $fas157_t$ is an indicator variable taking a value of one for quarters after 2Q09 and zero otherwise. All includes all Funds in our sample, so that the control group includes funds already resolved by end of 2006 as well as earlier reports by fund that remained active after 2Q09. *Btm*, *Mid*, *Top* are subsamples of funds that remain active end of 2006 and were in the respective performance tercile according to reported IRR-to-date. We drop reports for 10 quarters between 1Q07 and 2Q09 for all funds in each subsample to insure that our inference is not confounded by developments during the adoption period, the onset of the 2008 crisis and the subsequent rebound in liquid market prices. Also, we drop all reports by funds younger than 8 quarters since inception. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Fund FE				Pooled			
	All	Btm'06	Mid'06	Top'06	All	Btm'06	Mid'06	Top'06
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A: Buyout				
ρ_1	0.137***	0.204*	0.023	0.130***	0.116**	0.207*	0.001	0.0943**
	(3.30)	(2.02)	(0.44)	(3.18)	(2.20)	(1.98)	(0.02)	(2.24)
ρ_2	−0.069	−0.278**	−0.149	0.041	−0.030	−0.236	−0.026	0.228
	(−0.80)	(−2.44)	(−1.29)	(0.39)	(−0.50)	(−1.76)	(−0.19)	(1.65)
Pr(F-stat> $[\rho_1+\rho_2]$)	0.423	0.356	0.203	0.237	0.145	0.766	0.820	0.078
Observations	9,181	1,675	2,047	1,867	9,181	1,675	2,047	1,867
				Panel B: Venture				
ρ_1	0.063	0.172***	0.108*	0.182***	0.0781*	0.190***	0.112*	0.178***
	(1.62)	(6.18)	(1.93)	(5.15)	(1.93)	(7.59)	(1.95)	(4.83)
ρ_2	−0.216***	−0.344***	−0.279**	−0.292***	−0.125	−0.322***	−0.241	−0.180***
	(−3.75)	(−3.93)	(−2.43)	(−5.83)	(−1.45)	(−3.69)	(−1.76)	(−3.19)
Pr(F-stat> $[\rho_1+\rho_2]$)	0.000	0.090	0.131	0.034	0.490	0.230	0.316	0.965
Observations	15,230	2,624	2,873	3,430	15,23	2,624	2,873	3,430

Figure A.1: Alternative definitions of the fundraising event date

Panel A plots values starting 25 quarters preceding the minimum of the fund resolution quarter or the funds 10^{th} anniversary. Panel B plots values since the quarter that corresponds to inception plus the median time it took to raise a follow-on fund by the fund's vintage-year peers. As described in equations (1) and (2), the change in a given quarter is a mean PME-to-date change (or TVPI-to date change) from the previous period across a subset of funds multiplied by the average ratio of NAV to market-adjusted paid-in capital to date. *No Next* (*At Least One*) denotes the subset of funds without (with) at least one follow-on fund for in our sample.

Panel A: Event = 12 quarters before the resolution



Panel B: Event = 12 quarters after the median fundraising

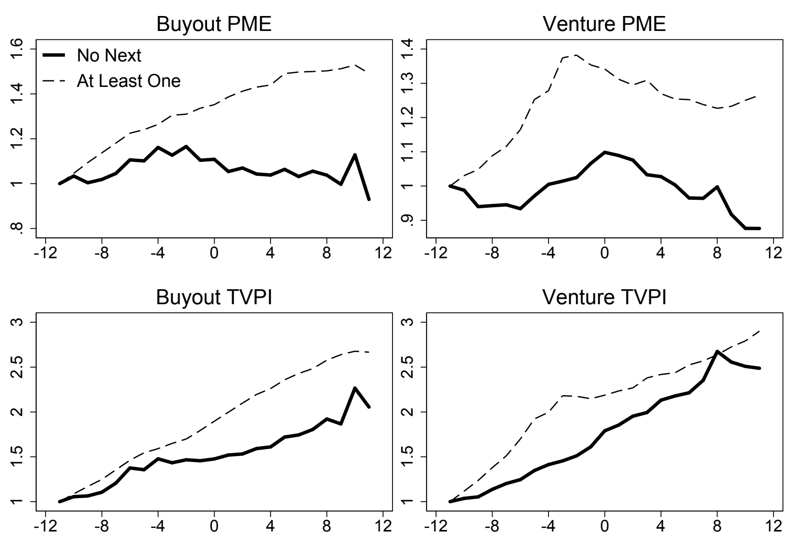
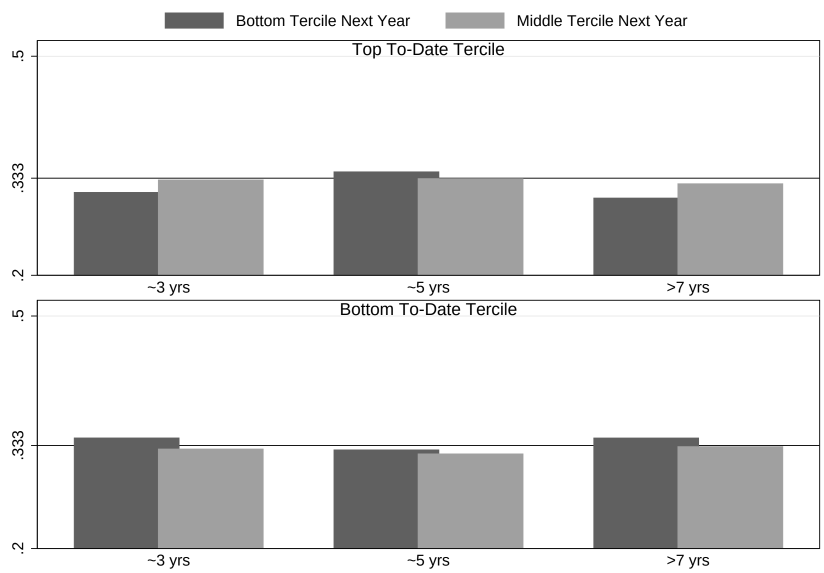


Figure A.2: Next year PME growth conditional on to-date performance: placebo

This figure reports the probabilities of a fund's excess returns over the next 4 quarters being in the top (bottom) tercile conditional on the fund's to-date performance tercile. We plot results separately for Buyout (Panel A) and Venture funds (Panel B). We define the fund peer group for to-date and next year terciles as all funds of the same strategy incepted within one year from the fund vintage year. The top chart of each panel reports results for top to-date tercile funds as of 8 to 17 quarters since inception (∼3yrs), 18 to 27 quarters since inception (∼5yrs), and more than 27 quarters (>7yrs). The bottom chart of each panel reports values for the bottom tercile to-date funds. Unlike Figure 4 which uses actual fund returns and IRRs-to-date, here we randomly assign public equity portfolios to the same set of funds and compute to-date performance as the average return of that portfolio since the fund inception. Public equity portfolios returns are constructed using subsets of Fama-French 100 U.S.

Panel A: Buyout funds mimicking portfolios



Panel B: Venture funds mimicking portfolios

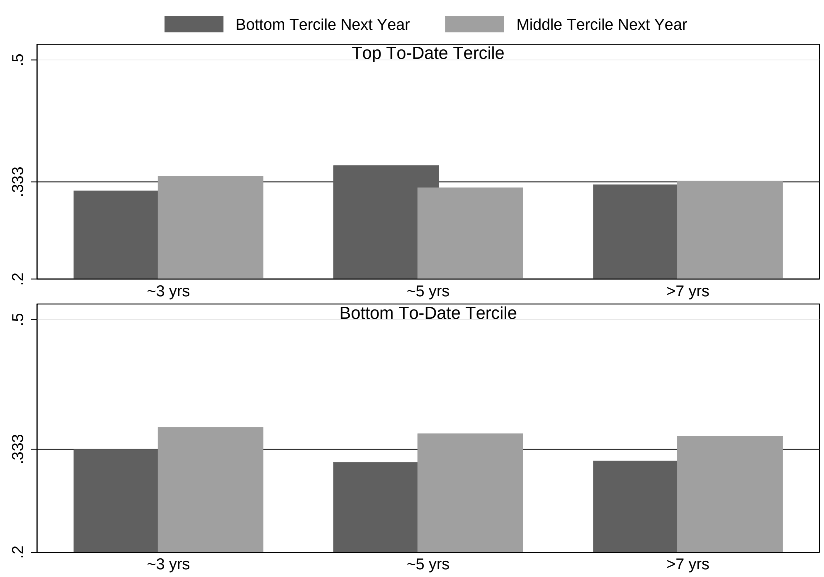
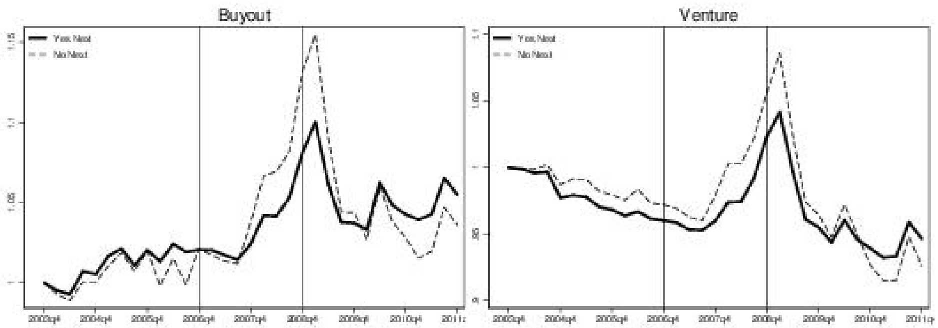


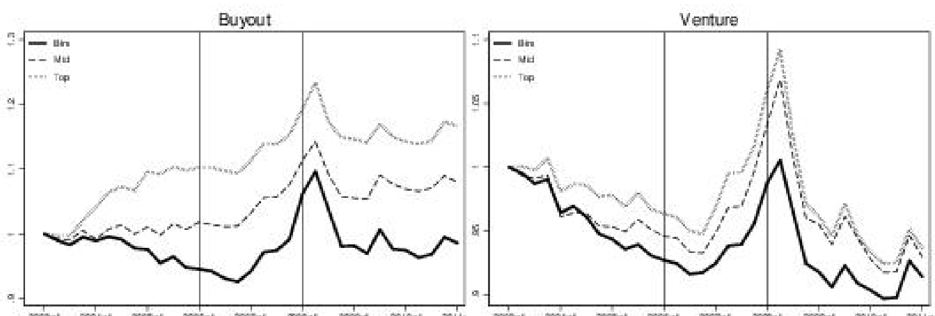
Figure A.3: Median fund performance over SFAS157 adoption period

This figure reports cumulative excess returns over a public equity index as measured by PME around SFAS157 adoption period. We plot results separately for buyout and venture funds. Panel A splits the sample into groups based on whether or not a follow-on fund was raised. Panel B (C) splits the sample into groups based on performance rank as of the end of 2006 (upon resolution). A change in a given quarter is a median PME-to-date change from the previous period across the respective subset of funds.

Panel A: By fundraising success



Panel B: By performance tercile as of 4Q'06



Panel C: By performance tercile end of life

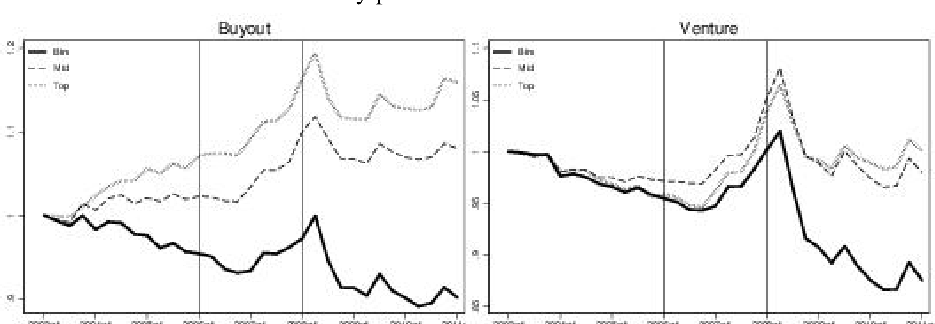
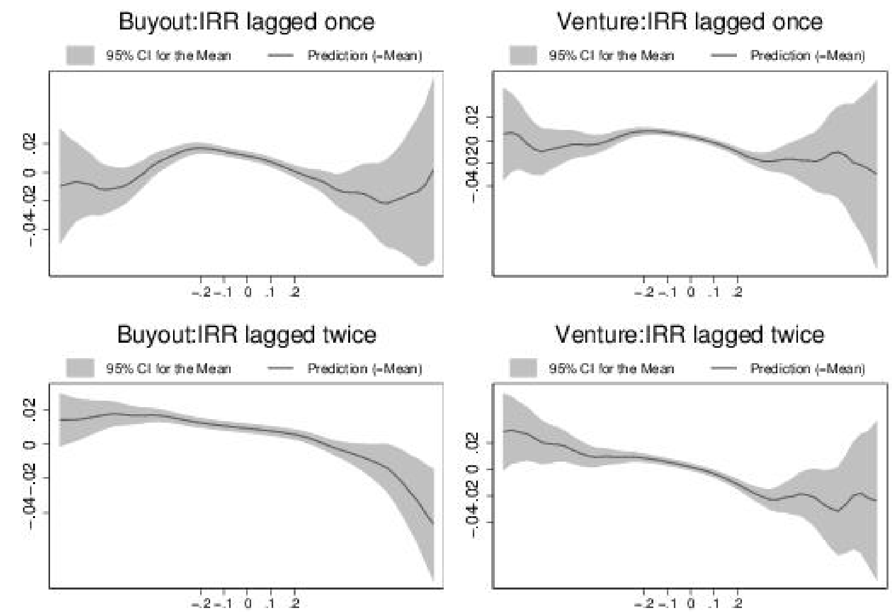


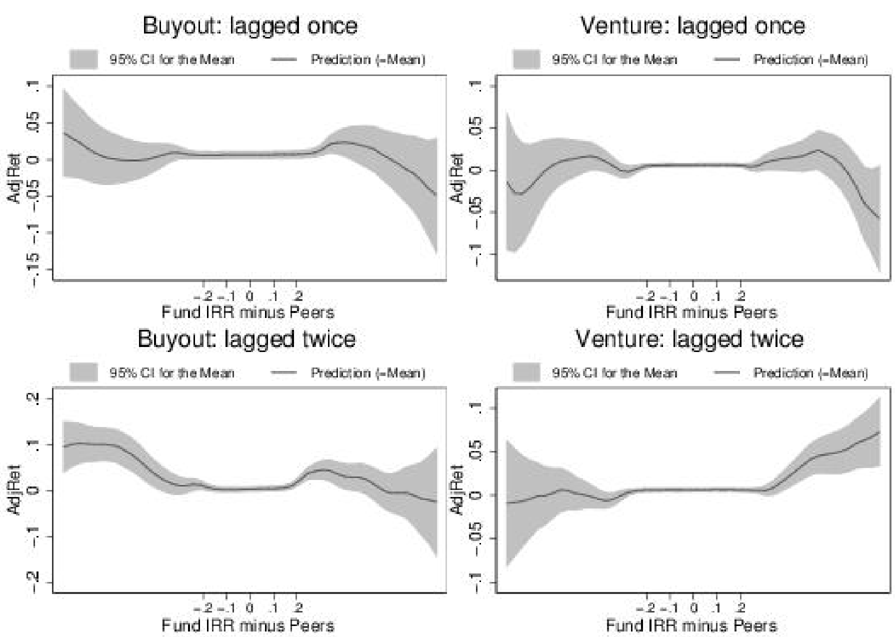
Figure A.4: Peer chasing: non-parametric evidence

This figure reports local polynomial regression fits of fund excess returns on lagged to-date IRR relative to that of peer median. The models are estimated separately for buyout and venture funds. Reported returns orthogonalized with respect to fund cash flows are in Panel A with one and two period lagged IRR being in the top and bottom row, respectively. Panel B reports results from a similar exercise based on placebo returns. Placebo returns are constructed using subsets of Fama-French 100 U.S.

Panel A: Actual data



Panel B: Placebo - public equity portfolios



Internet Appendix.

In this Appendix, we provide details and derivations of key variable and conduct additional empirical tests to better motivate our choices in the paper and demonstrate the robustness of our results.

I.1. Headwinds to measuring valuation bias empirically

We start by explaining why simple measures such as average changes in IRR-to-date and PME-to-date can provide misleading metrics (where 'to-date' measures utilize the NAV at a particular date as though it were the final cash flow from a fund). Figure I.5 illustrates the inconsistency of IRR-to-date for the purpose of measuring NAV bias by studying the cash flow and abnormal return patterns of two hypothetical funds (1 and 2). Fund 1 considers a hypothetical fund in existence from 1993 through 2003 and Fund 2 considers a different hypothetical fund in existence from 1998 through 2008. The value process in both cases is defined as, $FundValue_t = FundValue_{t-1}(1 + r_{S\&P500,t} + \alpha_t) + C_t - D_t$. That is, the fund's return over a period equals the return to the S&P 500 plus an abnormal return (α_t).

Panel A of I.5 plots the alpha and the cash-flow patterns for both cases. For Fund 1, the alpha is fixed at 4% across all periods. Whereas for Fund 2, the alpha is initially 5% per period but than decays to zero over the life of the fund. Panel B plots the total return to the S&P 500 index over each hypothetical fund's life. Panel C plots the resulting PMEs-to-date and IRRs-to-date. These two cases show that IRR-to-date may provide completely misleading indications of when 'gaming' of fund NAVs could be taking place. Specifically, the fund with constant alpha (Fund 1) exhibits an apparent decline in IRR-to-date after the fund's fifth year. In contrast, the fund with declining alpha (Fund 2) shows an increasing IRR-to-date after the fund's fifth year. The PME-to-date analysis exhibits nearly similar patterns for each fund and therefore may not be informative either. These examples show the challenges of measuring interim abnormal performance for closed-in investment vehicles like buyout and venture funds. Consequently, we subsequently develop a method for identifying abnormal returns that unwinds the flattening effect that intermediate distributions have on the PME-to-date.

Next, we show how the intuitive approach of regressing the fund-level changes in NAVs on dummies measuring the time since fundraising is prone to revealing non-existent patterns in excess returns. Using our sample of funds discussed in the main text, we examine the finding of Jenkinson et al. (2013) with regards to the unrealized performance peaking around the quarter of a follow-on fund closing. Specification (1) in Panel A of Table I.3 replicates the Jenkenson et al. methodology. Using their interpretation of the results, the evidence of NAV overstating around the new fund launch dates appears convincing. Just as in Table 3 of Jenkinson et al., quarters shortly before the new fund launch have significantly positive coefficients, suggesting abnormally positive growth rate in NAVs of the existing fund while GPs are seeking new capital commitments from investors. Meanwhile, the negative coefficients on years after fundraising indicate abnormally low growth rate in NAVs, consistent with the previously built-up upward valuation bias getting gradually unwound. We note also that the coefficient estimates on cash flows and market returns are also very similar to those in Jenkinson et al.

However, specification (2) and (1) of Panel A of Table I.3 should raise concerns about consistency of these estimates. Dropping cash flows and market return should increase the noise in the disturbance (if no NAV overstating is indeed the null hypothesis of this statistical model). Instead, we see that the humped shape in the reported returns around the next fund launch gets more pronounced. To determine if these results are caused by mispecification of the Jenkinson et al. model, we apply their methodology to funds where the actual growth in NAV is replaced with a placebo based on public equity portfolios (defined in detail later in this appendix). The results of this experiment are reported in Panel B of Table I.3. Similar to Panel A, we see that some coefficients are significantly positive in the quarters before launch of a new fund and some are significantly negative after the launch of a new fund in. Just as in Panel A, we see that the humped-shape returns trajectory gets more pronounced as we remove cash flow controls in specification (2), and then the market return in specification (3). These results indicate that the methodology of Jenkinson et al. is likely generating at least part of the pattern of excess returns they document.

The inconsistency of estimates in Table I.3 arises from two sources: (i) a positive correlation between public market returns and private equity fund formation, and (ii) the correlation between cash flow measurement and the dependant variable. The former is essentially the result of insufficient risk adjustment. Specifically, controlling for contemporaneous market returns should be absorbing market risk, however, unlike the placebo series in Panel B, the actual fund quarterly returns are subject to appraisal smoothing as evidenced by a very low coefficient on the market return in Panel A (implying a beta of just 0.26). Thus, including just the contemporaneous market return results in an insufficient risk adjustment. As for (ii), section 5 discusses why this measurement error is present in the panel when the dependant variable is a function of fund-level NAVs (and how our analysis navigates this challenge). With such correlated events like PE fund distributions and fundraising, it is hard to assess the impact of this measurement error. For example, as one can see from specification (3) of Panel B, a dummy variable for the fourth (calendar) quarter is a significant explanatory variable for excess returns when the placebo series are not risk-adjusted. So the "Santa Clause Effect" that Jenkinson et al. document is also likely to be (at least partially) driven by the combination of (i) and (ii) rather than a tendency for PE funds to indeed report higher returns in the December quarter.

Even absent econometric biases, the interpretation of results in the framework of Jenkinson et al. is difficult because the fund (and time since inception) fixed effects obscure the inference about whether the abnormal returns are on average negative after fundraising. The negative coefficients in Table I.3 only say that the changes in NAVs tend to be lower than the average of other periods. Meanwhile, as discussed in section 4.4.1, lower but still positive abnormal returns after fundraising, are consistent with many other alternative explanations besides the NAVs being overstated ahead of the launch of a follow-on fund.

I.2. Key Variable Definitions

Without loss of generality, assume that fund cash flows occur in the end of each period t. We start by considering the Kaplan and Schoar (2005) Public Market Equivalent index

$$PME = \frac{\sum_{t=0}^{T-1}\{D_t \prod_{\tau=t}^{T-1} R_{\tau+1}\} + D_T}{\sum_{t=0}^{T-1}\{C_t \prod_{\tau=t}^{T-1} R_{\tau+1}\} + C_T}, \tag{I.1}$$

where D_t and C_t are, respectively, the fund distributions and capital calls end of period t while R_τ is public market gross return over period τ. While PME is typically calculated using all cash flows associated with a fund (i.e., the full life of a fund), our analysis requires the use of an interim measure of performance. Consequently, we define a measure of performance from fund inception through an interim date that is analogous to PME. Intuitively, we think of it as a measure of PME-to-date for any time $t*$, $0 < t* < T$. To construct the measure we simply consider the stated net asset value (NAV) at date $t*$ as a terminal distribution and ignore all subsequent cash flows. Thus, we can define PME-to-date at time $t*$ as

$$\begin{aligned} PME_{t*} &= \frac{\sum_{t=0}^{t*-1}\{D_t \prod_{\tau=t}^{t*-1} R_{\tau+1}\} + D_{t*} + NAV_{t*}}{\sum_{t=0}^{t*-1}\{C_t \prod_{\tau=t}^{t*-1} R_{\tau+1}\} + C_{t*}} \\ &= \frac{\sum_{t=0}^{t*-1}\{D_t \prod_{\tau=t}^{t*-1} R_{\tau+1}\} + D_{t*}}{\sum_{t=0}^{t*-1}\{C_t \prod_{\tau=t}^{t*-1} R_{\tau+1}\} + C_{t*}} + \frac{NAV_{t*}}{\sum_{t=0}^{t*-1}\{C_t \prod_{\tau=t}^{t*-1} R_{\tau+1}\} + C_{t*}} \end{aligned} \tag{I.2}$$

To simplify the notation, we can rewrite I.2 as:

$$PME_t = PME_t^{exNav} + \frac{NAV_t}{fv_t(C)}, \tag{I.3}$$

so that $fv_t(C)$ represents the time t future value of all capital calls calculated using the public market returns from the respective date of each capital call while PME_t^{exNav} is the PME-to-date value as of time t if NAV is assumed to be 0.

The change in PME-to-date from the previous period can be thought of as a product of the abnormal fund return over the period t and the ratio of NAV_t to the future value of cumulative capital calls to date. This is the case because, absent capital calls at t, it follows from I.1 and I.2 that:[1]

[1] The assumption that $C_t = 0$ applies through equation I.7 only and does not affect the intuition. If we drop this assumption, (I.3) will in addition have $-(C_t \cdot PME_{t-1}^{exNav})(fv_{t-1}R_t + C_t)$ on the right-hand (as the denominator of PME_t^{exNav} is not just a R_t scale of PME_{t-1}^{exNav} in this case) while (I.7) will have three additional terms: $C_t/fv_t(C) \quad + (k_t - 1)PME_{t-1}^{exNav} \quad + (R_t^{nav} - R_t)NAV_{t-1}/fv_t(C)$, where $k_t = fv_{t-1}(C)R_t/fv_t(C) \in (0,1)$ (e.g. for $t = 3$, $k_t = [(C_1R_2 + C_2)R_3]/[C_1R_2R_3 + C_2R_3 + C_3]$. The first term is positive and tends to be large when $k_t \ll 1$, the second term has a negative sign and cancels out with the first term when $PME_{t-1}^{exNav} = 1$. The sign on the third term is negative while the magnitude increases in the first term too. We study the implications of this measurement error via a simulation.

$$\begin{aligned} PME_t^{exNav} &= PME_{t-1}^{exNav} \cdot \frac{R_t}{R_t} + \frac{D_t}{fv_t(C)} \\ &= PME_{t-1}^{exNav} + \frac{D_t}{fv_t(C)} \end{aligned} \tag{I.4}$$

where we are adding the ratio of period t distributions to the period t value of cumulative capital calls to-date to PME_{t-1}^{exNav}. Because we can express reported return, R_t^{nav}, as a solution to

$$NAV_t = NAV_{t-1}R_t^{nav} - D_t + C_t, \tag{I.5}$$

the change in PME from $t-1$ to t can written as

$$\begin{aligned} \Delta PME_t &= PME_t^{exNav} - PME_{t-1}^{exNav} + \frac{NAV_t}{fv_t(C)} - \frac{NAV_{t-1}}{fv_{t-1}(C)} \\ &= \frac{D_t}{fv_t(C)} + \frac{NAV_t}{fv_t(C)} - \frac{NAV_{t-1}}{fv_{t-1}(C)} \cdot \frac{R_t}{R_t} = \frac{D_t}{fv_t(C)} + \frac{NAV_t}{fv_t(C)} - \frac{NAV_{t-1}R_t}{fv_t(C)} \\ &= \frac{NAV_t + D_t - NAV_{t-1}R_t}{fv_t(C)}. \end{aligned} \tag{I.6}$$

After substituting NAV_t from I.5 into I.6, a change in PME can be witten as

$$\Delta PME_t = (R_t^{nav} - R_t)\frac{NAV_{t-1}}{fv_t(C)}. \tag{I.7}$$

The intuition behind this expression is that the excess return of the fund (as a difference between fund return as implied by NAV-change and the public market return) gets scaled down by the prior-period NAV as a percent of paid-in-capital adjusted for the market returns. Thus, keeping the mean and variance of excess return unchanged, one would observe a leveling-out in abnormal performance (as measured by PME-to-date) once a fund starts distributions, as the ratio of $NAV_{t-1}/fv_t(C)$ will typically drift downwards. That is, ΔPME_t will keep the sign but trend toward 0 over time, all else the same.[2] The same leveling-out will occur to the money-multiple ($TVPI$) which can be thought of as a special case of PME-to-date where R_τ is assumed to equal 1 for all τ.

When analyzing a cross-section of funds, the ΔPME_t is a useful metric since it effectively represents a weighting scheme for fund returns. The weight is proportional to the sensitivity of the performance-to-date to NAV. Multiplying the cross-sectional mean ΔPME_t by mean $NAV_{t-1}/fv_t(C)$ removes the downward bias due to the scale effect and obtains the average fund returns weighted by the fraction of unrealized NAVs

[2] Again, with net-negative cash flows in period t the expression get less clear but the intuition remains the same: ΔPME_t tends to be positive so long as $R^{nav} - R$ is positive. In simulation (section I.2.1), we verify that the additional terms (when C_t are positive) do no affect the inference about the path of the PME to-date pooled over a cross-section of funds.

in the market-return-adjusted sum of capital calls-to-date. The same re-weighting can be applied to mean money-multiple changes. Similarly, weighted-ΔPME_t nests mean fund *NAV*-returns and excess returns $(R_t^{nav} - R_t)$ as special cases with $NAV_{t-1}/fv_t(C)$ being equal across funds in both cases (and market returns being zero in the former).

We design a Monte-Carlo experiment to study the time-series properties of weighted PME-to-date. We draw a fund's β from two normal distributions, $N(1, 0.125)$ and $N(2, 0.166)$ whereas α's come from a common distribution, $N(0.05, 0.05)$. Here α and β are in the context of the standard market model. The same Poisson process drives all cash flows independent of market and idiosyncratic shocks to returns. Figure I.6 suggests that a misspecification of fund-level β does not confound inference about the question of interest, i.e., the trajectory of cross-sectional mean abnormal returns. Also, it follows that if more successful funds (higher α) tend to not distribute capital as fast as their less successful peers, WPME should be convex in time since inception under the null hypothesis of constant lifetime excess returns. This is because funds with higher excess returns tend to have relatively higher ratios of residual NAV-to-capital as fund life progresses. Introducing heteroscedasticity and reasonable correlations in the data generating process does not change these conclusions.

I.2.1. Monte Carlo Experiment

Because our weighted *PME* change measure of returns has not been utilized in previous studies, we conduct a series of Monte-Carlo experiments and examine how this measure of excess returns compares to simpler measures based on raw returns and money-multiples (that we show to be its special cases). For this exercise, we assume that fund *i* asset value at time *t* ($V_{i,t}$) evolves as:

$$V_{i,t} = V_{i,t-1} exp\{\alpha_i + \beta_i r_{m,t} + e_{i,t}\},$$

where $\alpha_i = \bar{\alpha} + e_\alpha$ is the abnormal return for fund *i*; $\beta_i = \overline{\beta_{H(L)}} + e_{H(L)}$ is the level of systematic (factor) risk for fund *i*; $r_{m,t} = \mu + e_{m,t}$ is the net return on the market index; $e_{(\cdot)}$ are all independently drawn from a normal distribution $N(0, \sigma^2_{(\cdot)})$. For our experiments we let $\mu = 0.04\, per\, annum$ and $\bar{\alpha} = 0.05\, per\, annum$. The specification for β_i allows us to have funds with low risk ($\overline{\beta_L} = 1.0$) or high risk $\overline{\beta_H} = 2.0$). We set the standard deviations of $e_{(\cdot)}$ al follows: $\sigma_i = \sigma_m = 0.300\, per\, annum$; $\sigma_L = 0.125$; $\sigma_H = 0.167$; $\sigma_\alpha = 0.05$.

At time *t* fund *i* distributions, D_{it}, and contributions, C_{it}, are independent Poisson processes. The parameters of the cash flow process are calibrated so they closely match the cross-sectional moments of actual funds cash flows in our sample. Specifically, we set

$$D_s = V_s \varphi \eta_{ds}\; if\; s > \lfloor f_d \cdot T \rfloor$$
$$C_s = \varphi \eta_{cs}\; if\; s < \lfloor f_c \cdot T \rfloor,$$

where we set $T = 300$ as a fund? maximum life in bi-weekly intervals, $\eta_{(\cdot)}$ are independent Poisson distributions $Pois(\lambda_{(\cdot)})$ with $\lambda_d = 0.1$ and $\lambda_c = 0.07$. We let $f_c = 0.5$, $f_d = 0.3$, and $\varphi = 0.2$.

For our experiment we draw 30 paths of market returns, $r_{m,t}$, at a daily frequency. For each market path we draw 40 α_i and β_i, half with a mean of $\overline{\beta_L}$ and half with $\overline{\beta_H}$. Given the set of α_i and β_i, we draw 40 paths of idiosyncratic returns at a daily frequency, and 40 paths of distributions and contributions at a bi-weekly frequency. We then construct the series of quarterly NAVs and cash flows for each market path. Finally, we compute PMEs-to-date for the simulated funds and average ΔPME_q and $NAV_{q-1}/fv_q(C)$ across all (30×40) market paths and funds. Results are presented in Figure I.6 and discussed in Appendix AI.2.

I.3. A proxy for NAV bias change

Central to our analysis is the idea that reported NAV can be a biased estimate of the true value. We next formulate our specific measure of the NAV bias that we examine in our empirical tests in section 5. We start by defining V_t as the true (unbiased) asset value at the end of period t and Γ_t as a gross valuation bias such that reported $NAV_t \equiv V_t \cdot \Gamma_t$. We next define the gross abnormal return in period t as $R_t^\varepsilon = exp\{\delta \cdot \varepsilon_t\}$ where δ is a constant (for a given fund) and ε_t is a mean-zero random error arbitrary distributed. If we further define $R_{\beta,t}$ as gross return due to risk factor (market) exposure β then,

$$V_t + D_t = V_{t-1} R_t^\varepsilon R_{\beta,t} + C_t. \tag{I.8}$$

Recalling that D_t and C_t are, respectively, the fund distributions and capital calls at t, we define the evolution of the gross valuation bias as $\Gamma_t = \Gamma_{t-1} e^{g(\cdot)}$. Substituting this definition into I.8 yields the following NAV identity:

$$NAV_t = NAV_{t-1} R_t^\varepsilon R_{\beta,t} e^{g(\cdot)} + \Gamma_{t-1} e^{g(\cdot)} (C_t - D_t). \tag{I.9}$$

We assume that returns $R_{\beta,t+1}$ and ε_{t+1} are unpredictable. We would like to estimate per period change in bias, $g_i(\cdot)$, for each fund (henceforth we add subscript i to each variable) from the following model:

$$log\left[\frac{NAV_{i,t}}{NAV_{i,t-1} R_{\beta_i,t} - \frac{\Gamma_{i,t-1}}{R^\varepsilon i,t}\left(D_{it} - C_{it}\right)}\right] = g(\cdot)_{i,t} + \delta_i + \varepsilon_{i,t}. \tag{I.10}$$

Since we have relatively few observations per fund and do not know β_i and $\Gamma_{i,t-1}/R^\varepsilon_{i,t}$, a feasible alternative to estimating I.10 is an average effects linear panel model:

$$\widetilde{\Delta bias}_{it} \equiv log\left[\frac{NAV_{i,t}}{NAV_{i,t-1} R_{\beta=1,t} - D_{it} + C_{it}}\right] = \gamma' X_{i,t} + \delta_i + \eta_i + \varepsilon_{i,t} + \zeta_{i,t}, \tag{I.11}$$

where η_i and $\zeta_{i,t}$ are (additional to δ_i and $\varepsilon_{i,t}$) fund fixed effects and disturbance shocks that arise due to the mismeasurement of the left-hand side and the misspecification of the right-hand side of I.11 relative to I.10.[3] We note that the measurement error also constrains the set of covariates $X_{i,t}$ to not be contemporaneously correlated with market returns and fund cash flows, D_{it} and C_{it}.

Unlike in I.10, the expression in the logarithm in I.11 is not guaranteed to be positive. Therefore, in our implementation we Winsorize the values at the 2% level which results in all arguments for the log being greater than zero in our sample. In addition, we drop fund-quarters where ending Net Asset Values represent less than 2% of capital committed, and fund-quarters where the previous available report was more than one quarter ago.

To verify that I.11 is a sensible estimator of γ, the average bias loading on the covariates of interest, we also use a placebo dependent variable constructed as follows:

$$\widetilde{\Delta placebo}_{it}^{\{FF100\}} \equiv log\left[\frac{NAV_{it}R_{\{FF100\},t}}{NAV_{it}R_{\beta=1,t} - (R_{\{FF100\},t} - R_{\beta=1,t})(D_{ti} - C_{it})}\right] \tag{I.12}$$

where $R_{\{FF100\},t}$ is the return in period t of a public equity portfolio constructed from Fama-French 100 U.S. Equity Research Portfolios (henceforth, FF100). We randomly select a subset of the FF100 portfolios and take average returns for these to generate a placebo return series for a specific fund. Once assigned, the portfolio remains the same across all periods for the given fund. For buyout funds we limit our selection to the subset of FF100 that includes only the 25 highest Book-to-Market portfolios out of the 50 lowest market value portfolios and scale (lever) each return series by a factor of 2 (by taking gross returns squared).

For venture funds we select returns from the 25 lowest Book-to-Market portfolios out of the 50 smallest market value portfolios. In the random placebo portfolio matching, we only condition on placebo to-date returns for a given fund being in the same tercile among its peers as the actual fund IRR as of the 28^{th} quarter since inception.[4] Peers are funds incepted in the same or adjacent vintage years and having the same strategy (Buyout, Early Stage Venture, Biotech Venture, Other Venture).

We arrive at the expression for $\widetilde{\Delta placebo}_{it}^{\{FF100\}}$ by substituting $NAV_{it}/R_{\{FF100\},t}$ for NAV_{it-1} in I.11 in order to obtain the growth in NAVs from the previous period that would have occurred if $R_{\{FF100\},t}$ had been the return generating process. In addition, I.12 allows us to test whether the cash flow dependency of the disturbance term in I.11 is sufficiently attenuated by controlling for concurrent cash flows. Just as for $\widetilde{\Delta bias}_{it}$, we Winsorize the right-hand side of the expression at the 2% level before taking the log.

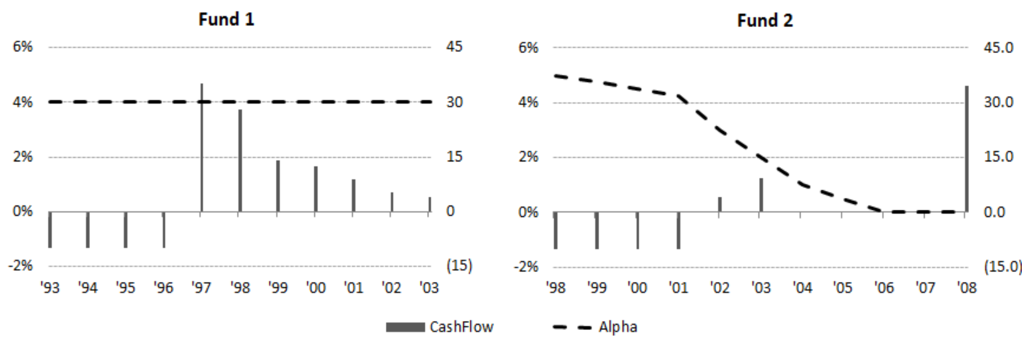
[3] i.e. $log\left[\frac{NAV_{i,t}}{NAV_{i,t-1}R_{\beta_i,t} - \frac{\Gamma_{i,t-1}}{R^{\varepsilon}_{i,t}}(D_{it} - C_{it})}\right] = log\left[\frac{NAV_{i,t}}{NAV_{i,t-1}R_{\beta=1,t} - 1(D_{it} - C_{it})}\right] + \eta_i + \zeta_{i,t}$

[4] or the last quarter in the sample for funds younger than 28 quarters as of the sample end date, December 2011

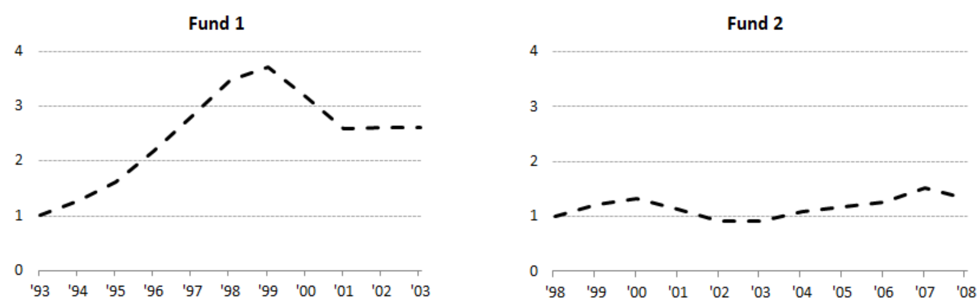
Figure I.5: Why not simply plot IRRs since inception?

This figure illustrates the inconsistency of IRR-to-date for the purpose of NAV bias assessment by studying two hypothetical cash-flow and abnormal return patterns (i.e., funds) described in Appendix AI.2. Panel A plots the alpha and the cash-flow patterns for both cases. Panel B plots the total return to the S&P 500 index over each hypothetical fund's life (rescaled to 1.0 at inception). Panel C plots the resulting PMEs-to-date and IRRs-to-date.

Panel A: Cash-flows and true abnormal returns



Panel B: Public market paths



Panel C: Fund to-date performance indicators

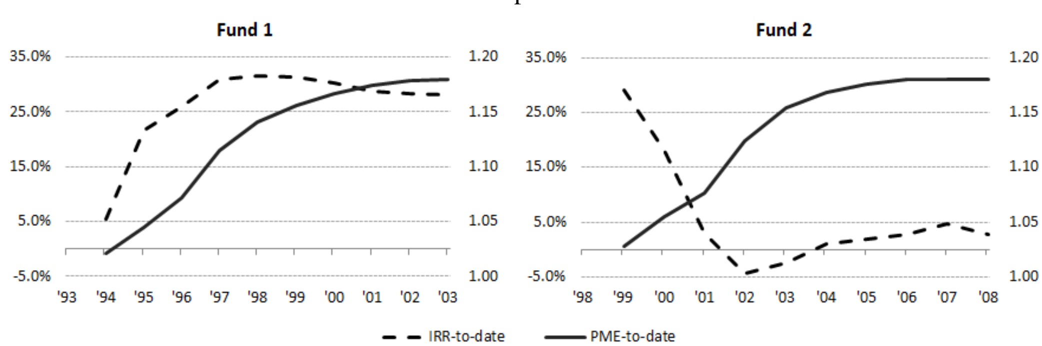
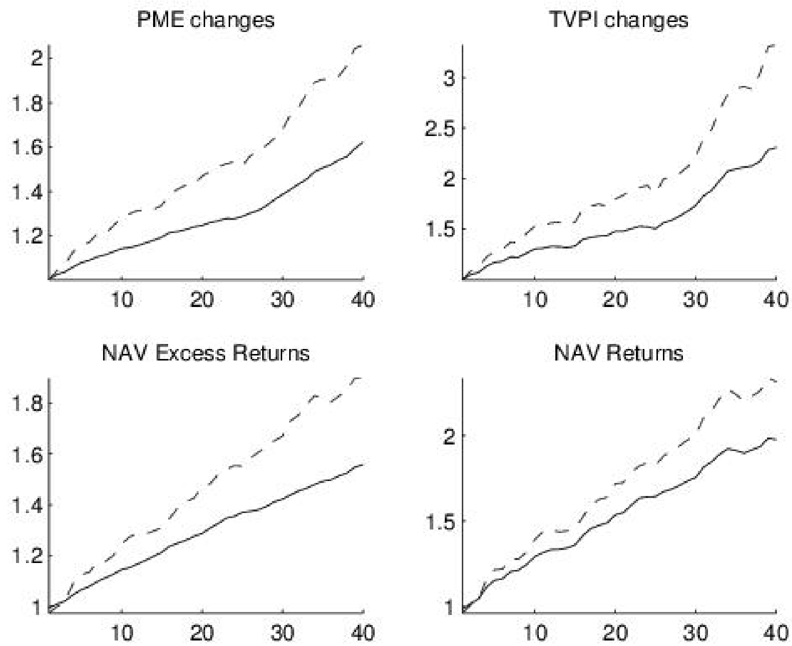


Figure I.6: Average fund performance paths: simulated data

This figure reports results of the Monte Carlo Experiment described in section I.2.1 to suggest a null hypothesis appropriate for average fund to-date performance as measured by the proposed metric: weighted-PME cumulative changes. A change in a given quarter is a weighted average of PME-to-date changes from the previous period across the simulated funds for a given quarter since inception. The weights are ratios of NAV to cumulative capital calls since inception adjusted for market returns. The simulated funds differ by their market betas and abnormal returns. Fund cohorts have different market return paths as well. The solid line represents the mean over 600 funds drawn from a distribution with a high mean β. The dashed line stands for the mean over 600 funds drawn from a distribution with a low mean β. The top-right panel reports weighted money-multiple cumulative changes while bottom-left(right) panel reports mean NAV excess(raw) returns. All are shown to be a special case of the NAV-weighted PME change in Appendix AI.2.



Quarters since inception

Table I.3: NAV-based returns and Fundraising quarter effects

This table reports the parameter estimates a panel regression model of quarterly changes of PE fund NAVs as a function of time periods around the quarter a follow-on fund was raised by the same GP. For example, *I(4th quarter before NF)* is a dummy variable that is equal to zero unless fund i had a follow-on fund started making investments 5 quarters after quarter t. The sample includes all buyout and venture capital non-missing NAV fund-quarters. Distributions and capital calls during quarter t are present as additional explanatory variables in specification (1) while market return in quarter t is included in specifications (1) and (2). All specifications also include a dummy denoting 4^{th} quarter (i.e. ending in December), quarter since fund inception fixed effects, and fund fixed effects. In Panel A, the dependant variable is a change in fund NAV from quarter $t-1$ to t. In Panel B, NAV_t values are replaced with the following placebo counterpart: $NAV_t \cdot R_t^{pla} - NetDistribution_t$, where R_t^{pla} is a gross return of style- and size-matched public equity portfolio. Public equity portfolios returns are constructed using subsets of Fama-French 100 U.S. Equity research portfolios as described in section I.3. NAVs, capital calls, and distributions are normalized by the fund size. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	Panel A Fund returns			**Panel B** Placebo returns		
	(1)	(2)	(3)	(1)	(2)	(3)
Cash in	1.040***			0.957***		
	(39.98)			(22.02)		
Cash out	−0.503***			−0.372***		
	(−7.82)			(−3.14)		
Market return	0.271***	0.262***		1.078***	1.073***	
	(15.10)	(14.50)		(50.26)	(48.24)	
I(Fourth calendar quarter)	0.0040*	0.0041*	0.0116***	0.0050	0.0053	0.0372***
	(1.84)	(1.69)	(4.68)	(1.00)	(1.00)	(6.89)
I(5th quarter before NF)	0.0058	0.0085	0.0105	−0.0009	0.0023	0.0117
	(0.63)	(0.81)	(0.99)	(−0.06)	(0.17)	(0.82)
I(4th quarter before NF)	0.0246***	0.0262***	0.0273***	−0.0023	0.0007	0.0073
	(2.71)	(2.71)	(2.82)	(−0.16)	(0.05)	(0.51)
I(3rd quarter before NF	0.0329***	0.0341***	0.0347***	0.0031	0.0059	0.0152*
	(3.57)	(3.88)	(3.93)	(0.16)	(0.31)	(1.73)
I(2nd quarter before NF)	0.0308**	0.0305**	0.0305**	0.0366**	0.0386**	0.0408**
	(2.27)	(2.15)	(2.13)	(2.09)	(2.22)	(2.29)
I(1st quarter before NF)	0.0212*	0.0183	0.0147	0.0345*	0.0339*	0.0211
	(1.93)	(1.56)	(1.25)	(1.68)	(1.75)	(1.07)
I(Next fund start quarter *[∼ NF]*)	0.0034	0.0185	0.0126	0.0033	−0.0081	−0.0308
	(0.66)	(1.40)	(0.95)	(0.15)	(−0.37)	(−1.39)
I(1st year after NF)	0.0110	−0.0132**	−0.0169***	0.0217**	0.0020	−0.0105
	(1.48)	(−2.05)	(−2.58)	(2.35)	(0.28)	(−1.45)
I(2nd year after NF)	0.0029	−0.0187**	−0.0230***	0.0073	−0.0103	−0.0246***
	(0.43)	(−2.53)	(−3.03)	(0.80)	(−1.46)	(−3.38)
I(3rd year after NF)	−0.0095**	−0.0204***	−0.0250***	0.0030	−0.0105*	−0.0261***
	(−2.26)	(−3.97)	(−4.81)	(0.44)	(−1.74)	(−4.39)
I(4th year after NF)	−0.0068*	−0.0167***	−0.0178***	−0.0085	−0.0203***	−0.0229***
	(−1.71)	(−5.25)	(−5.62)	(−1.41)	(−4.09)	(−4.79)
I(5th year after NF)	−0.0048*	−0.0129***	−0.0116***	−0.0083*	−0.0160***	−0.0095**
	(−1.66)	(−3.89)	(−3.53)	(−1.70)	(−3.32)	(−2.07)
I(6th year after NF)	−0.0038	−0.0072**	−0.0061*	−0.0089*	−0.0139***	−0.0086*
	(−1.18)	(−2.13)	(−1.81)	(−1.76)	(−2.68)	(−1.75)
Controls	Fund fixed effects, Life-quarter fixed effects					
Observations	56,602	56,602	56,602	56,602	56,602	56,602
R-squared (%)	17.6	2.0	1.1	8.0	5.0	0.5

Table I.4: Performance tercile transition probabilities: *PME*

This table reports transition probabilities between interim and final performance terciles. We define performance based on *PME-to-Date* within each fund peer group (vintage year and strategy). Panel A reports results for buyout funds and Panel B reports results for venture funds. Only the funds that have raised a follow-on fund within ten years since inception are included. The first row of each panel reports the probability of being in the respective to-date tercile at the end of a funds life (*Final*), conditional on being in the bottom to-date tercile in the quarter preceding the follow-on funds first capital call (*At Fundraising*). Similarly, the second (third) row reports Final performance tercile conditional on being in the middle (top) performance tercile *At Fundraising*. The last row of each panel reports the unconditional distribution of funds across *Final* terciles, while the last column reports how many funds were in each fundraising tercile and the respective fraction in the total number of funds in this analysis. The peer group is all funds of the same strategy incepted within one year from the fund vintage year. Since follow-on fundraising occurs at a different time for each of the funds and fund life varies, neither *At Fundraising* nor *Final* terciles need to have an equal number of funds.

Panel A: Buyout

		Final				
		Btm	Mid	Top	Fund Count	
At Fundraising	Btm	61.2%	26.9%	11.9%	67	(18.8%)
	Mid	36.9%	42.3%	20.8%	130	(36.5%)
	Top	13.2%	25.2%	61.6%	159	(44.7%)
	All	30.9%	31.7%	37.4%	356	(100%)

Panel B: Venture

		Final				
		Btm	Mid	Top	Fund Count	
At Fundraising	Btm	56.7%	31.3%	11.9%	67	(21.8%)
	Mid	32.0%	43.2%	24.8%	125	(35.8%)
	Top	10.4%	21.6%	68.1%	214	(42.4%)
	All	26.8%	31.0%	42.2%	355	(100%)

Table I.5: Performance quartile transition probabilities: *IRR*

This table reports transition probabilities between interim and final performance *quartiles*. We define performance based on IRR-to-date within each fund peer group (vintage year and strategy). Panel A reports results for buyout funds and Panel B reports results for venture funds. Only the funds that have raised a follow-on fund within ten years since inception are included. The first row of each panel reports the probability of being in the respective to-date quartile at the end of a funds life (*Final*), conditional on being in the bottom to-date quartile in the quarter preceding the follow-on funds first capital call (*At Fundraising*). Similarly, the second (third) row reports Final performance quartile conditional on being in the middle (top) performance quartile *At Fundraising*. The last row of each panel reports the unconditional distribution of funds across *Final* quartiles, while the last column reports how many funds were in each fundraising quartile and the respective fraction in the total number of funds in this analysis. The peer group is all funds of the same strategy incepted within one year from the fund vintage year. Since follow-on fundraising occurs at a different time for each of the funds and fund life varies, neither *At Fundraising* nor *Final* quartiles need to have an equal number of funds.

Panel A: Buyout

		Final					
		Btm	3rd	2nd	Top	Fund Count	
At Fundraising	Btm	55.0%	20.0%	17.5%	7.5%	40	(11.2%)
	3rd	40.7%	34.1%	16.7%	6.6%	91	(25.6%)
	2nd	16.4%	22.7%	40.0%	20.9%	110	(30.9%)
	Top	12.2%	9.6%	22.6%	55.6%	115	(32.3%)
	All	25.6%	21.1%	26.4%	27.0%	356	(100%)

Panel B: Venture

		Final					
		Btm	3rd	2nd	Top	Fund Count	
At Fundraising	Btm	48.1%	27.3%	20.8%	3.9%	77	(15.1%)
	3rd	33.0%	36.5%	20.9%	9.6%	115	(22.5%)
	2nd	18.5%	23.8%	29.1%	28.5%	151	(29.6%)
	Top	7.2%	11.4%	23.9%	57.5%	167	(32.8%)
	All	22.5%	23.1%	24.3%	30.0%	510	(100%)

Table I.6: Additional summary statistics

This table reports summary statistics for the variables defined and used in section 5 of the main text. Section I.3 provides details on variable construction.

Panel A: Buyout sample

	mean	sd	min	p5	p25	p50	p75	p95
$\widetilde{\Delta bias\_it}\vert\beta = 1$	0.0069	0.19	−3.11	−0.19	−0.066	−0.004	0.087	0.26
$\widetilde{\Delta bias\_it}\vert\beta = 1.7$	−0.0047	0.25	−4.10	−0.28	−0.11	−0.021	0.12	0.32
$\widetilde{\Delta bias}_{it}^{placebo}\vert\beta = 1$	−0.0061	0.36	−1.07	−0.65	−0.23	0.015	0.23	0.58
$\widetilde{\Delta bias}_{it}^{placebo}\vert\beta = 1.7$	−0.015	0.34	−0.95	−0.60	−0.24	−0.003	0.21	0.54
FundTiming	1.26	0.38	0	0.56	1.01	1.32	1.56	1.79
Excess FundTiming	1.35	0.39	0	0.56	1.01	1.39	1.66	1.91
PeerChasing	0.004	0.13	−0.30	−0.22	−0.086	0	0.086	0.22
Residual PeerChasing	−0.078	0.20	−1.35	−0.43	−0.18	−0.061	0.036	0.22
Placebo PeerChasing	0.005	0.087	−0.98	−0.11	−0.028	0.007	0.044	0.13
Distributions /NAV	0.059	0.25	0	0	0	0	0.038	0.26
Capital Calls /NAV	0.12	6.07	0	0	0	0.0094	0.072	0.27
Distributions/Fund size	0.030	0.079	0	0	0	0	0.025	0.16
Capital Calls/Fund size	0.031	0.052	0	0	0	0.0054	0.042	0.14
Calender year of the quarter	2004.7	5.24	1987	1994	2002	2006	2009	2011

Panel B: Venture sample

	mean	sd	min	p5	p25	p50	p75	p95
$\widetilde{\Delta bias\_it}\vert\beta = 1$	−0.017	0.16	−2.05	−0.22	−0.089	−0.026	0.050	0.22
$\widetilde{\Delta bias\_it}\vert\beta = 1.7$	−0.043	0.24	−2.12	−0.39	−0.18	−0.062	0.066	0.38
$\widetilde{\Delta bias}_{it}^{placebo}\vert\beta = 1$	−0.0099	0.30	−0.78	−0.50	−0.21	−0.0064	0.19	0.48
$\widetilde{\Delta bias}_{it}^{placebo}\vert\beta = 1.7$	−0.036	0.31	−0.85	−0.55	−0.25	−0.037	0.17	0.48
FundTiming	1.25	0.40	0	0.56	0.92	1.32	1.56	1.83
Excess FundTiming	1.36	0.40	0	0.56	1.10	1.45	1.70	1.91
PeerChasing	−0.0060	0.12	−0.30	−0.21	−0.084	−0.0013	0.072	0.20
Residual PeerChasing	−0.059	0.19	−1.77	−0.39	−0.14	−0.038	0.045	0.21
Placebo PeerChasing	0.0041	0.057	−0.77	−0.069	−0.019	0.0016	0.026	0.083
Distributions NAV	0.035	0.17	0	0	0	0	0	0.18
Capital Calls NAV	0.058	0.087	0	0	0	0.0069	0.093	0.24
DistributionsFundsize	0.022	0.10	0	0	0	0	0	0.11
Capital CallsFundsize	0.027	0.040	0	0	0	0.0042	0.049	0.10
Calendar year of the quarter	2003.2	6.06	1986	1991	2001	2004	2008	2011

Table I.7: Fund timing and peer-chasing: additional specifications

This table reports the parameter estimates a linear regression model estimated separately for buyout (Panel A) and venture (Panel B) funds. The dependant variable measures risk- and cash flow-adjusted changes in NAV for quarter t that is constructed to be unpredictable under the null of reported NAVs being unbiased estimators of true asset values. The market beta of the fund assets is assumed to be 1.7 [2.4] in specifications (6) and (7) for buyout [venture] subsample and 1 everywhere else. Explanatory variables of interest include *FundTiming* which is the natural log of one plus time spent to-date without a follow-on fund in excess of two years, *PeerChasing* which is the difference between fund i reported Internal Rate of Return to-date for the calendar quarter corresponding to $t-1$ quarter of fund i life and its peers as measured by the median IRR-to-date across all funds of the same strategy incepted within one year from fund i vintage year. Specifications (4), (5) and (7) also include the interaction of *FundTiming* and *PeerChasing* variables. All specifications include fund fixed effects, all except (1) include fund distributions and capital calls over the current quarter scaled by the end of quarter NAVs. Specifications (3) and (5) through (7) include year-quarter fixed effects, others have year and quarter fixed effects instead. t-statistics reported in parentheses are robust to heteroskedasticity and autocorrelation, */**/*** denotes significance at 10/5/1% confidence level.

	$\beta = 1$					$\beta = 1.70B/2.4V$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Buyout							
FundTiming	0.060***	0.059***	0.080***	0.038**	0.057***	0.076***	0.053**
	(2.78)	(3.13)	(4.22)	(2.02)	(3.00)	(3.63)	(2.57)
PeerChasing	−0.198***	−0.202***	−0.205***	0.123**	0.131**	−0.202***	0.117**
	(−5.95)	(−6.31)	(−6.51)	(2.31)	(2.55)	(−5.46)	(2.09)
FundTiming × PeerChasing				−0.295***	−0.304***		−0.289***
				(−6.22)	(−6.61)		(−5.62)
Observations	12,150	12,150	12,150	12,150	12,150	12,150	12,150
R-squared	0.046	0.094	0.237	0.098	0.242	0.420	0.423
RMSE	0.184	0.172	0.158	0.172	0.158	0.180	0.180
Panel B: Venture							
FundTiming	0.029**	0.026*	0.051***	0.018	0.043***	0.054***	0.046***
	(2.08)	(1.89)	(3.62)	(1.34)	(3.08)	(3.78)	(3.26)
PeerChasing	−0.151***	−0.168***	−0.175***	0.068*	0.045	−0.180***	0.037
	(−7.91)	(−8.53)	(−9.18)	(1.79)	(1.21)	(−9.21)	(0.99)
FundTiming × PeerChasing				−0.217***	−0.202***		−0.200***
				(−6.88)	(−6.52)		(−6.29)
Observations	15,124	15,124	15,124	15,124	15,124	15,124	15,124
R-squared	0.110	0.118	0.305	0.121	0.309	0.607	0.608
RMSE	0.136	0.135	0.120	0.135	0.120	0.124	0.124
Controls in Both Panels:							
Fund FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cash Flows	No	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	Yes	No	No	No
Quarter FE	Yes	Yes	No	Yes	No	No	No
Year-Qtr FE	No	No	Yes	No	Yes	Yes	Yes