Pay for Performance from Future Fund Flows: The Case of Private Equity*

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Abstract

Lifetime incomes of private equity general partners (GPs) are affected by their current funds' performance not only through direct carried interest profit sharing provisions, but also indirectly by the effect of the current fund's performance on GPs' abilities to raise capital for future funds. We estimate the magnitude of this market-based indirect pay for performance in the context of a rational learning model, which we show better matches the empirical relations between future fundraising and current performance than behavioral alternatives. The estimates indicate that indirect pay for performance from future fundraising is of the same order of magnitude as direct pay for performance from carried interest. Consistent with the learning framework, indirect pay for performance is stronger when managerial abilities are more scalable and weaker when current performance is less informative about ability. Specifically, it is stronger for buyout funds compared to venture capital funds, and declines in the sequence of a partnership's funds. Our findings suggest that total pay for performance in private equity is both considerably larger and much more heterogeneous than implied by the carried interest alone. Our framework can be adapted to estimate indirect pay for performance in other asset management settings in which future fund flows depend on current performance.

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I. Introduction

Compensation agreements in private equity (PE) partnerships typically give general partners (GPs) a fixed management fee that is a percentage (usually 1.5% to 2.5%) of the amount of capital committed to the fund, as well as a variable "carried interest" equal to a percentage of the profits (almost always 20%). Many observers credit pay for performance from carried interest as an important driver of the success of private equity firms (e.g., Jensen, 1989; Kaplan and Strömberg, 2009). Others, especially in the popular press, argue that pay for performance from carried interest is not strong enough to provide adequate incentives to GPs, especially because fixed management fees alone are often a source of considerable income.[1]

Missing from these arguments is the fact that explicit compensation formulas provide only part of the total pay for performance in private equity. GPs' lifetime incomes depend on their ability to raise capital in the future, which in turn depends on the performance of their current funds. Consequently, GPs' total pay for performance is also impacted by the indirect, market-based pay for performance caused by the relation between today's performance and future fundraising.

Indirect pay for performance is not specific to private equity; it is a potentially important source of incentives in many settings.[2] Yet, despite the widespread theoretical interest in indirect incentives and their importance to real-world organizations, little is known about their actual magnitude or the nature of the economic forces that give rise to them. This gap in our knowledge is important because understanding the magnitude of indirect pay for performance, and how it varies over time and across firms, is essential to drawing inferences about managers' motives.

This paper seeks to understand the economic forces that lead to a relation between performance and future fundraising in private equity, and to estimate the magnitude of the resulting indirect pay for performance. We first present a rational learning model in which the ability of a GP to earn profits is uncertain and rationally inferred by market participants. We develop testable predictions from this model about the way a fund's current performance affects the partnership's ability to raise subsequent funds. Using a database of fund sizes and returns, we estimate the relations between fund

[1]See for example, "It's the Fees, not the Profits", The Wall Street Journal, Sept. 13, 2007.

[2]Examples include promotion or elimination tournaments inside corporations (e.g. Lazear and Rosen, 1981; Rosen, 1986; Han et al., 2009), the possibility that a CEO will be fired for poor performance (e.g. Jensen and Murphy, 1990; Hermalin and Weisbach, 1998), and the possibility that the careers of securities analysts depend on the accuracy of their forecasts (Hong and Kubik, 2000; Hong et al., 2003). Market-based indirect pay for performance in other asset management settings can also arise from a relation between current performance and future fund flows.

performance and future fundraising, and evaluate the predictions of our learning model relative to those of behavioral alternatives. We next provide an approach that tranforms the empirical relations between fund performance and future fundraising into estimates of indirect pay for performance in private equity. We present estimates of the magnitude of indirect pay for performance and the way in which it varies across types of partnerships and over a given partnership's lifecycle. We present our estimates both in absolute magnitude and, to gauge their relative importance, relative to the much-discussed direct (explicit) pay for performance from carried interest.[3] Finally, we construct estimates of the total pay for performance facing private equity GPs and show that these incentives are both much larger than commonly believed, and also vary substantially across types of partnerships and over time within a given partnership.

We begin by presenting a rational learning model in the spirit of Berk and Green (2004) to formalize the logic by which good performance in the current fund could lead to higher future incomes for GPs through an effect on expected future fundraising. In the model, a private equity partnership potentially has an ability to earn (abnormal) returns for its investors, but this ability is unknown. Given a performance signal, investors update their assessment of the GP's ability and, in turn, decide whether the GP is able to raise another fund and if so, how much capital to allocate to it (in the presence of diminishing returns to scale).

The rational learning framework predicts that both the likelihood of raising a follow-on fund and the size of the follow-on if it is raised depend on current performance, and offers intuitive cross-sectional predictions that have not been tested in the literature. First, when abilities are more "scalable", investors are willing to commit more capital for a given assessment of managerial ability. Second, the more informative the fund's performance (signal) about GPs' abilities, the more sensitive future fundraising is to today's performance. Third, holding performance fixed, follow-on fundraising is more likely when the prior assessment of ability is greater.

These predictions suggest that the future fundraising of buyout funds should be more sensitive to performance than that of venture capital funds, both because buyout funds are more scalable (Metrick and Yasuda, 2010a), and because the variance of buyout returns is lower (informativeness is higher) than that of venture capital returns. In addition, because ability is known with more preci-

[3]It is sometimes argued in the literature that GPs' indirect incentives are strong enough to motivate their behavior (e.g., Gompers, 1996; Gompers and Lerner, 1999). Our work is the first to estimate the strength of these incentives.

sion as a partnership ages, the performance of later funds should have less impact on the assessment of ability and hence be less strongly related to future inflows of capital than the performance of earlier funds. Thus the learning model predicts that the sensitivity of future fundraising to performance should decline in the sequence of a partnership's funds. Finally, for a given performance, later sequence funds should be more likely to raise a follow-on fund because the average assessment of ability will be higher in later sequence funds than in earlier ones for the simple reason of their survival.

Our estimates from a sample of buyout, venture capital, and real estate private equity funds from 1969-2009 are consistent with these predictions, and favor the rational learning model over behavioral alternatives of "naive reinvestment" or "return chasing", each of which is consistent with prior results in the literature. For all types of funds, we find that both the probability of raising a follow-on fund, and the size of the follow-on if one is raised, are significantly positively related to the final performance of the current fund, even though final performance is generally not known with certainty at the time of fundraising.[4] These findings reject the "naive reinvestment" hypothesis that limited partners do not have or are too unsophisticated to use information about what final fund performance is likely to be when deciding whether to allow a GP to raise a subsequent fund. While Lerner, Schoar, and Wongsunwai (2007) show that some LPs are performance-insensitive in their reinvestment decisions, our results imply that information about expected final performance is nevertheless important to whether a GP raises a follow-on fund at all.[5]

We also find that the relation between future fundraising and current performance is strongest for buyout funds, which relative to venture capital funds are both more scalable and likely have more informative returns. This relation is stronger for younger partnerships compared to older, so the sensitivity of future fundraising to current performance declines in the sequence of a partnership's funds. Controlling for performance, older partnerships are more likely to raise a follow-on fund. All

[4]In our tests, we use a fund's ex post realized final performance (IRR) as our empirical proxy for investors' expectation at the time of subsequent fundraising about what final performance will turn out to be. This is analogous to the common practice in asset pricing studies of using ex post realized returns to proxy for ex ante expected returns. We discuss performance measurement issues in detail in Section IV. C.

[5]While Kaplan and Schoar (2005) and subsequently others find a positive relation between follow-on size and performance in tobit specifications with left-censoring at zero, such specifications do not allow for separate identification of the effect of performance on the likelihood of raising a follow-on fund, which is key to rejecting the "naive reinvestment" hypothesis. Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) find that intermediate (but not final) fund performance is positively related to the likelihood of raising a follow-on fund in a sample of venture capital funds. Their finding leaves open the question of whether expected final performance influences the ability to raise a follow-on fund.

of these results match the predictions of the learning model.

In contrast, our findings are inconsistent with behavioral "return chasing" or "dumb money" explanations for private equity fund flows, in which investors chase returns without regard to their informativeness or disproportionately react to the performance of older, more famous partnerships. These explanations predict, contrary to our results, either a flat or an increasing sensitivity of future fundraising to current performance in the sequence of a partnership's funds.

We next turn to estimating the magnitude of total pay for performance in private equity, and evaluate the relative magnitudes of its direct (from contractual carried interest) and indirect (from future fundraising) components. Our theoretical framework provides an explicit formula for the sensitivity of GPs' lifetime incomes to the return of the current fund. Our calculations use this formula, our estimates of the sensitivity of future fundraising to current performance, parameters reflecting the characteristics of our sample of private equity funds, and estimates of expected GP revenue as a fraction of fund size from Metrick and Yasuda (2010a).

For an average-sized first-time buyout fund in our sample ($417.5 million), we estimate that for an extra percentage point of return (IRR) to limited partners in the current fund, general partners receive on average an extra $3.32 million[6] in direct carried interest, assuming a carried interest of 20%.[7] For the same incremental percentage point of IRR in this current fund, our estimates of the present value of expected incremental revenue from future funds range from $4.27 million to $7.81 million, depending on whether we assume the GP potentially runs up to three or up to five more funds, resulting in estimated ratios of present values of indirect to direct pay for performance of 1.29 to 2.35. These estimates suggest that indirect pay for performance from future fundraising is at least as large as direct pay for performance from carried interest for first-time buyout funds.

We also perform the same calculations for venture capital and real estate funds. Expected compensation from future fundraising is less sensitive to current performance for these types of

[6]All dollar amounts and ratios are present values using annual discount rates of 9% for buyout and real estate funds, and 15% for venture capital funds. While the exact estimates of pay for performance do vary with the chosen discount rate, our key cross-sectional conclusions are robust to alternative choices. We discuss these issues in Sections V. A and V.C.

[7]Carried interest rarely differs from 20%, especially during the post-1990 time period that covers the bulk of our sample. For example, in Gompers and Lerner's (1999) sample of 419 venture capital funds raised before 1992, 81% have carry between 20%-21%. In Metrick and Yasuda's (2010a) sample of 238 funds from 1993-2006, 95% of venture capital funds and 100% of buyout funds have carry equal to 20%. In Robinson and Sensoy's (2011) sample of 910 funds from 1984-2010, carry is equal to 20% for 89%, 97%, and 97% of venture capital, buyout, and real estate funds, respectively and the average carry is 20.44%, 19.96%, and 20.14%, respectively.

funds than for buyout funds, with venture capital funds displaying the least sensitivity. For an average-sized first-time venture capital fund, our estimates of the ratio of indirect to direct pay for performance range from 0.39 to 0.44, and for an average first-time real estate fund they range from 1.37 to 1.96.

Consistent with the learning framework, the ratio declines in the sequence of funds for all types of funds. The decline is fairly weak for buyout funds, sharper for real estate funds, and sharpest for venture capital funds. Assuming the GP potentially runs up to five more future funds, our estimates of the present values of the ratios of indirect to direct pay for performance for buyout funds are 2.35 if the current fund is the first in a buyout partnership's sequence, 2.10 if it is the second fund in a buyout partnership's sequence, and 1.75 if it is the third. For real estate funds, the corresponding ratios are 1.96, 1.39, and 1.12, while for venture capital funds, they are 0.44, 0.35, and 0.18. Figure 1 depicts these patterns graphically, and Figures 2-4 show that our cross-sectional conclusions are robust to reasonable alternative discount rates used to compute present values.

Overall, our results are consistent with indirect pay for performance from future fundraising in private equity being driven by rational learning about ability. They suggest that indirect pay for performance is of the same order of magnitude as the often-discussed direct, explicit pay for performance coming from carried interest. For the typical first-time private equity fund, the estimates indicate that GP lifetime income increases by about \$0.50 for every \$1 increase in LP income in the current fund, double the \$0.25 implied by a 20% in-the-money carry alone. In short, total pay for performance in private equity is much stronger, by a factor of about 2, than implied by the carried interest alone. Consequently, discussions of the incentives of private equity GPs that focus on carried interest alone are substantially incomplete.

Our estimates also imply that total pay for performance in private equity exhibits substantially more heterogeneity than suggested by the carried interest alone. Given that carried interest typically does not change much over time, the results imply that total pay for performance in private equity declines as funds mature.[8] Why does the carry remain relatively flat over time despite the declining indirect pay for performance, instead of increasing to compensate for career concerns over time as

[8] Gompers and Lerner (1999) argue that the dynamics of GP compensation are also consistent with learning, and are the first to show that the largest and most successful venture capital funds do sometimes raise their carried interest above 20%. The average effect is however much too small to compensate for the declining indirect pay for performance we document. They find that the average carry among first-time venture capital funds is 20.5%, and 21.4% among partnerships older than eight years.

models such as Gibbons and Murphy (1992) predict? One possibility is that because of learning, low-ability agents are forced out of the profession over time. The remaining high-ability agents could require lower total incentives, possibly because learning-by-doing decreases the marginal cost of effort, or because effort and ability are substitutes in generating profits from private equity investments. Another possibility is that the carried interest reflects rent-splitting between GPs and LPs rather than agency problems. In this case, the observed pay-performance relations are a consequence of this rent-splitting together with learning about ability, rather than the solution to an agency problem. An important topic for future research is to understand whether the pattern of explicit compensation over a partnership's lifecycle is efficient, given the declining indirect pay for performance that we find.

Our work is related to the large literature, surveyed by Frydman and Jenter (2010), studying the magnitude of the pay-performance incentives of CEOs. Important contributions to this literature are Jensen and Murphy (1990) and Hall and Liebman (1998) for public company CEOs and Leslie and Oyer (2009) for CEOs of private equity portfolio companies. We are the first to estimate the magnitude of the total pay for performance incentives of private equity general partners.

Closely related to our work is a large literature, beginning with Ippolito (1992), investigating mutual fund inflows and their strongly positive relation to historical performance. Chevalier and Ellison (1997) find that the sensitivity of mutual fund flows to performance is greater for younger funds, consistent with our results. Berk and Green (2004) rationalize many of these findings with a learning model of investor behavior similar to our approach. However, there is also considerable evidence that mutual fund investors chase returns in a manner difficult to reconcile with rational theories (e.g. Frazzini and Lamont (2008) and Sensoy (2009)). Our work is also closely related to Chevalier and Ellison (1999), who find that younger mutual fund managers are more likely to be terminated for poor performance than older ones, consistent with our results. No prior work has attempted to quantify the total pay for performance relations facing managers in other asset management settings in light of the flow- and termination-performance relations in those industries. An additional contribution of this paper is to provide an approach and framework that can be readily adapted for use for these interesting topics for future research.

The remainder of this paper proceeds as follows. Section II lays out the theoretical learning framework. Section III describes the data. Section IV presents estimates of the effect of current performance on future fundraising, and contrasts the predictions of the learning model with those of behavioral alternatives. Section V transforms these estimates into pay for performance sensitivities, using the formula derived in Section II as a basis for the calculations. Section VI discusses the implications of this work and concludes.

II. Theoretical Framework

In this section we present a theoretical framework based on rational learning in which investors assign cash flows to private equity partnerships based on their perceptions of GPs' abilities to earn profits. This framework provides intuitive cross-sectional predictions that contrast with behavioral alternatives and guide our empirical tests. This framework also enables us to derive a formula expressing GP total pay for performance (direct from carried interest plus indirect from future fundraising) in terms of quantities we can estimate from the data. We assume that investors observe signals about the performance of a partnership, and based on their posterior estimate of GP ability decide whether the GP is able to raise another fund, and if so, how much to invest in it. This capital allocation process leads to a strong relation between performance in a current fund and GPs' future compensation.

A. Setup

We assume that a particular GP currently manages a fund and could potentially manage up to N more funds in the future (e.g., the GP will retire after managing N more funds). The GP has ability to earn returns through private equity investing equal to θ.[9] Ability θ is unobservable and there is symmetric information, so all agents, including the GP, have the same estimate of its value.[10] We assume that θ is constant over time for a particular partnership, which abstracts away from issues of changing partnership composition, investment environments, or changing ability over time due to health or other considerations. Before any returns are observed, the commonly held prior

[9]It is possible that GPs could be rewarded through future fundraising for either absolute or relative (abnormal) returns. Our empirical analysis examines both possibilities.

[10]The assumption that there is symmetric information about managers' abilities dates to Holmstrom (1999), and has been used in similar learning models by Gibbons and Murphy (1992), Hermalin and Weisbach (1998, 2010), Berk and Green (2004), and others. Implicitly, the idea is that anyone who can become a GP is smart, hard-working, well-educated, etc., but the key factor determining who can earn returns is an unobservable match between the individual and the tasks associated with earning profits as a general partner.

assessment of θ is $\theta_0 \sim N\left(\theta, \frac{1}{\tau}\right)$.[11]

The parameter θ can be thought of as the ability to generate returns in absence of decreasing returns to scale. With decreasing returns to scale, greater fund size erodes the ability to translate θ into returns. To capture this idea, let the net return to LPs of the i^{th} fund managed by the GP be given by $r_i = \theta - c(q_i) + e_i$, where q_i is the size (committed capital) of fund i, $c(.)$ is an increasing, convex, and differentiable function (representing the return cost of each unit of capital) and is common knowledge, and $e_i \sim N\left(0, \frac{1}{s}\right)$ for all i, where s is the precision of the distribution.

A. 1. Updating beliefs

Under these assumptions, after observing the returns on i funds, the market's updated assessment of θ, θ_i, is given by:

$$\theta_i = \frac{\tau\theta_0 + s\sum_i \left[r_i + c(q_i)\right]}{\tau + is} \tag{1}$$

for all i (DeGroot (1970) provides a derivation of this Bayesian updating formula). In other words, θ_i is the expectation (posterior mean) of θ conditional on observing the returns on i funds. Note that because q_i and $c(.)$ are known to all, observing r_i is equivalent to observing $r_i + c(q_i)$.[12]

A. 2. Follow-on fund size, conditional on raising a follow-on

Given that it is raised, the conditional expected return on fund $i+1$ is given by $Er_{i+1} = \theta_i - c(q_{i+1})$. The equilibrium q_{i+1}, denoted q^*_{i+1}, is obtained by imposing the equilibrium condition that investors allocate capital so that the expected return on fund $i+1$ is equal to their cost of capital, which for simplicity we normalize to zero. In equilibrium, then, $Er_{i+1} = 0$, and consequently q^*_{i+1} is given implicitly by $c\left(q^*_{i+1}\right) = \theta_i$. For our purpose, it is more convenient to invert this function. Define $f(.) = c^{-1}(.)$, so that $q^*_{i+1} = f(\theta_i)$.

[11] The assessment θ_0 represents the expected skill of a particular GP conditional on all observable characteristics prior to any returns being observed. Different GPs will have different values of θ_0 and consequently raise initial funds of different sizes.

[12] While we speak of investors observing returns for convenience of exposition, in practice the final performance of a private equity fund is generally not known with certainty at the time a follow-on fund is raised. A more flexible interpretation of our model is that the "return" r_i that investors observe is actually a signal about what eventual performance will be. In our empirical analysis, we use a fund's actual final performance, known only ex post, as an empirical proxy for the information about performance that investors have at time of fundraising. We discuss this measurement issue in detail in Section IV.

A. 3. Probability of raising a follow-on

We further assume that there is a minimum viable fund size, so funds smaller than this size are not raised. This minimum size could occur as a result of, for example, a minimum investment scale in the industry or a fixed cost of running a fund. Since the factors that determine a fund's minimum size change over time, a fund's minimum viable size varies through time following exogenous shocks to these parameters. That is, at the time a follow-on to fund i, fund $i+1$, is potentially raised, we assume there exists a $\bar{q}_{i+1}$ such that the follow-on is not raised if θ_i is such that $f(\theta_i) < \bar{q}_{i+1}$. Because the shocks are not observed until the time fund $i+1$ is to be (potentially) raised, the GP does not know ex ante (at the time fund i is raised) whether a given return r_i will suffice to pass the hurdle for raising fund $i+1$.[13] Denote by $p(\theta_i)$ the ex ante probability that fund $i+1$ will be raised if, ex post, the assessment of ability turns out to be θ_i.

B. Cross-sectional implications

This learning formulation characterizes the way in which fund returns affect future fundraising and, consequently, the future expected compensation for the funds' partners. Conditional on the sequence of returns earned in the first i funds, the expected size of the next fund is given by $Eq_{i+1} = p(\theta_i) f(\theta_i)$ for $i \leq N$, and zero for $i > N$.

B. 1. Sensitivity of future fundraising to current performance across partnership types

The sensitivity of future fundraising to current performance is governed by the derivatives of $p(\theta_i)$ and $f(\theta_i)$ with respect to r_i, which are equal to $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$, respectively. Intuitively, a more steeply sloped $f(.)$ function means that for a small increase in the assessment of ability, the market is relatively more willing to allocate capital to a fund. More formally, by the definition of $f(.)$, we have $f'(.) = 1/c'(.)$, where $c'(.)$ represents the degree of diminution of returns for a given increase in fund size. In other words, greater $c'(.)$ represents lower "scalability" of the investment technology, so greater $f'(.)$ represents greater scalability. Holding i fixed, a larger weighting term $\frac{s}{\tau+is}$ reflects a greater relative infomativeness of the return to the market's perception of the GP's ability.

[13] If the minimum viable fund size were known ex ante, raising a follow-on would be a deterministic function of r_i.

We expect buyout funds to be more scalable, and hence have a larger $f'(.)$, than other types of funds, particularly venture funds. If a GP of a buyout partnership is shown to be talented at increasing value by buying out companies, he can potentially employ the same skills to buy out larger companies and increase their value, and hence make effective use of a larger pool of capital. In contrast, if a venture capitalist has demonstrated that she is talented at investing in startup companies, she is not able to increase fund size as much because the size of startup investments is not scalable (and because, given the time-consuming value-added nature of the private equity investing process, it is not feasible to simply increase the number of investments). Metrick and Yasuda (2010a) present evidence consistent with greater scalability of buyout compared to venture capital. Further consistent is the observation that the largest buyout investments in portfolio companies are on the order of tens of billions of dollars, whereas the largest venture capital investments rarely exceed a few tens of millions of dollars. Moreover, the most successful buyout funds such as KKR and Blackstone have steadily increased the size of their funds to the point where the largest funds are between $15 and $20 billion in committed capital, while the most successful Silicon Valley venture capitalists such as Kleiner Perkins and Sequoia have remained at or under $1 billion in committed capital in a given fund.

We also expect that the informativeness of returns about ability is likely to be greater for buyout funds than for venture capital funds. If a venture fund performs particularly well, this performance likely comes from the success of a small number of investments in the fund's portfolio. As a result, there is likely to be a greater variance of returns to specific investments in venture capital than in buyouts, implying a lower precision of the estimate of the fund-level return. In addition, the cross-sectional standard deviation of fund returns (IRR) is much lower in buyout (20.7% in our data) compared to venture capital (52.5%), which also suggests greater informativeness of buyout returns relative to venture capital returns.

It is less clear how $p'(.)$ should vary across types of funds. Nonetheless, it seems likely that $p'(.)$ would be higher for buyout funds than for venture capital funds for similar scalability reasons. In the buyout industry, marginal underperformers are potentially more likely to be shut out of future fundraising completely because the more successful buyout partnerships can scale up to absorb the demand of investors to a greater extent than is possible in the venture capital industry.

For all of these reasons, we expect the sensitivity of future fundraising to current performance to be greater for buyout funds than venture capital funds.

B. 2. Sensitivity of future fundraising to current performance in the sequence of funds within a partnership

Holding θ_i fixed, both $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ are decreasing in i because of the weighting term $\frac{s}{\tau+is}$. Intuitively, as partnerships progress through time, the partnership's θ becomes known more precisely. The optimal updating rule therefore implies that subsequent θs do not change as much as earlier θs for a given return. Consequently, in the data we expect to observe the sensitivity of future fundraising to current performance to decline as a given partnership manages subsequent funds.

B. 3. Sensitivity of future fundraising to the sequence of funds within a partnership

Holding performance r_i fixed, the updated assessment of ability θ_i will be greater when the just-prior assessment of ability θ_{i-1} is higher. Because the probability of raising funds throughout a partnership's life depends on the market's assessment of its ability, later sequence funds will on average have higher prior assessments of ability θ_{i-1} than earlier sequence funds. Consequently, in the data we expect to observe that holding performance fixed, later sequence funds are more likely to raise a follow-on fund, so the probability of raising a follow-on fund should increase with the sequence number of the current fund.

C. Lifetime compensation of GPs

Let $k(r_i)$ be the fraction of the size of fund i that accrues as revenue to the GP with performance of r_i, including management fees, carried interest, and other income earned by the fund, such as additional fees earned by funds for managing portfolio companies.[14]

The total expected revenue earned by the GP over his lifetime is then given by:

$$TR = k(r_1) f(\theta_0) + k(r_2) p(\theta_1) f(\theta_1) + k(r_3) p(\theta_1) p(\theta_2) f(\theta_2) + \ldots + k(r_{N+1}) \prod_{i=1}^{N} p(\theta_i) f(\theta_N). \quad (2)$$

As stated above, this formulation assumes that the GP can run a maximum of N future funds.

[14] We refer to revenue and compensation synonymously throughout the paper. While private equity partnerships do have some costs that create a wedge between revenue and partner compensation, many of these costs are more or less fixed and do not affect marginal compensation. We discuss potential omitted marginal costs in Section V. D.

If the GP ever fails to raise a follow-on fund, he is unable to raise any funds subsequently and earns no subsequent income from managing private equity investments. For example, a third fund cannot be raised unless a second fund is raised. Hence the expected revenue from the third fund depends on the probability that the third fund is raised conditional on the assessment of ability following the second fund ($p(\theta_2)$), multiplied by the probability that the second fund is raised ($p(\theta_1)$).

We are interested in calculating the magnitude of the total pay-performance relation facing general partners. This pay-for-performance relation is made up of a direct component, from carried interest in the current fund, and an indirect component, from the greater probability of raising future funds and greater future fund size conditional on raising future funds.

The total pay-performance relation is the sensitivity of total lifetime revenue to r_1:

$$\begin{aligned}\frac{\partial TR}{\partial r_1} = \; & k'(r_1)\, f(\theta_0) \; + \\ & k(r_2)\left[p'(\theta_1)\, f(\theta_1) + p(\theta_1)\, f'(\theta_1)\right] \tfrac{s}{\tau+s} \; + \\ & k(r_3)\left[p'(\theta_1)\, p(\theta_2)\, f(\theta_2)\tfrac{s}{\tau+s} + p(\theta_1)\, p'(\theta_2)\, f(\theta_2)\tfrac{s}{\tau+2s} + p(\theta_1)\, p(\theta_2)\, f'(\theta_2)\tfrac{s}{\tau+2s}\right] \; + \\ & \ldots \; + \\ & k(r_{N+1})\left[f(\theta_N)\textstyle\sum_{i=1}^{N}\left(p'(\theta_i)\tfrac{s}{\tau+is}\prod_{j=1,i\neq j}^{N} p(\theta_j)\right) + \prod_{i=1}^{N} p(\theta_i)\, f'(\theta_N)\tfrac{s}{\tau+Ns}\right]. \end{aligned} \tag{3}$$

The terms above have natural interpretations. The first line represents the direct effect from carried interest in the current fund. The subsequent lines together make up the indirect component. The second line is the incremental expected revenue from the next fund. Intuitively, improving performance has two effects on incremental revenue from the next fund. The first term in brackets represents the increase in the probability that a follow-on fund will be raised multiplied by the size of the follow-on fund conditional on one being raised. The second term in brackets represents the probability of raising a follow-on multiplied by the increase in fund size conditional on one being raised. Similarly, the third line is the incremental expected revenue from the third fund. The three components in brackets represent, respectively, the increments to expected fund size from the increase in probability of raising the second fund, the increase in probability of raising the third fund, and the increase in size of the third fund. The weighting terms, of the form $\frac{s}{\tau+is}$, represent the extent to which an incremental change in r affects the update of θ. The $k(.)$ terms represent the expected fraction of future fund sizes that accrues to the GPs as revenue.

D. Empirical Implementation

We test the predictions of our learning model against those of behavioral alternatives using regressions that estimate the sensitivities to current performance of both the probability of raising a follow-on fund, and the size of the follow-on fund conditional on raising one. These equations also yield estimates of the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms in Equation (3). We estimate other terms in Equation (3) as follows: Incremental expected revenue to the GPs from the current fund, $k'(r_1)$, is based on the standard 20% carried interest, which as Robinson and Sensoy (2011) document involves only a slight approximation. For the $k(.)$ terms for future funds, we use the estimates provided by Metrick and Yasuda (2010a), who estimate the expected revenue to GPs as a fraction of a fund's size using simulations. For the $p(.)$ and $f(.)$ terms, we use the respective fund type- and sequence-specific averages in our data: the fraction of funds that raise a follow-on, and the average size of follow-on funds conditional on raising one. Finally, we discount future compensation using a range of fund type-specific discount rates.

III. Data

Our analysis uses fund-level data provided by Preqin for the three major types of private equity funds: buyout, venture capital, and real estate. There are a total of 9,523 funds in Preqin as of June 2009, which, according to Preqin's documentation, covers about 70% of all capital ever raised in the private equity industry. In addition, in private communication Preqin informs us that about 85% of their data is collected via Freedom of Information Act (FOIA) requests made to limited partners subject to the Act, and thereby is not subject to self-reporting biases.[15] In all of our analysis, we

[15] Harris, Jenkinson, and Stucke (2010) demonstrate than Preqin has better coverage than other commercially available private equity databases, particularly of buyout funds, and perform a comprehensive comparison of performance statistics across different data sources. Despite the broad coverage, Preqin could be subject to a bias if the types of LPs subject to the FOIA, the most notable type of which is public pension funds, invest in private equity funds that systematically differ from the population of funds. Lerner, Schoar, and Wongsunwai (2007) provide reassuring evidence that public pension funds have middle-of-the-road (i.e., representative) performance, and report that Preqin has also been successful in obtaining performance information from a number of successful, established partnerships. In addition, any bias from self-reporting by non-FOIA sources would likely oversample funds with good performance that do raise a follow-on fund. This effect would lead to downward-biased estimates of the fundraising/performance relation. In the limit, if every fund in the sample raises a follow-on, then performance is unrelated to the likelihood

exclude funds without vintage year data (64), without fund size data (1,137), and which are still being raised (78), and we construct our sample from the remaining 8,244 funds.

We begin by constructing a sample of "preceding", or current, funds. To obtain estimates of the sensitivity of future fundraising to current performance, we require a sample of funds for which performance (IRR) data are available. From this sample of funds, we follow Kaplan and Schoar (2005) and drop funds with less than $5m (in 1990 dollars) in committed capital (9 funds), to reduce the influence of potentially extreme growth rates of small funds on our results. In addition, to allow for sufficient time to ascertain whether a fund raises a follow-on, we drop funds raised after 2005.

Finally, when a private equity firm raises multiple funds in a given year, we aggregate funds in that year and compute the fund size weighted IRR. There are two exceptions to this rule. The first is a few cases in which the same partnership manages, for example, both buyout and real estate funds. In these cases, we treat the partnership for econometric purposes as two separate partnerships, one each for buyout and real estate funds. The second (rare) exception is when the same partnership manages funds of the same type but different geographical focus, such as a fund focusing on European buyouts and another focusing on U.S. buyouts. In this case, we treat the European buyout funds and U.S. buyout funds as two separate partnerships.

This process leaves us with a sample of 1,745 preceding funds, consisting of 645 (37%) buyout funds, 851 (49%) venture capital funds, and 249 (14%) real estate funds. The preceding funds range from 1969-2005, with 91% in the 1990-2005 period.

For each of these preceding funds, we determine whether there is a follow-on fund in the full sample of 8,244 funds. We define a follow-on fund as the next fund raised by the same partnership for which we have information on fund size (we do not require information on the performance of the follow-on fund). If we do not observe a follow-on fund by the end of our sample period (June 2009), or if the data indicate a follow-on fund but do not provide size information, we treat this as if the partnership did not raise a follow-on fund. The working assumption we use throughout the paper is that the absence of a follow-on fund with size information in the data means the partnership was unable to raise one.[16] Of the 1745 preceding funds, 1469 (84.2%) raise a follow-on fund.

of raising a follow-on.

[16]This assumption has the effect of downward biasing our estimates of the relation between current performance and future fundraising. Undoubtedly some partnerships do raise follow-on funds that are missing from the data because the data are incomplete. Additionally, in practice partnerships sometimes dissolve even though the market would have been willing to provide capital for a follow-on fund had the partnership desired one.

Table I presents descriptive statistics for this sample of preceding and follow-on funds. Panel A reports that the sample represents 843 distinct partnerships: 314 buyout, 412 venture capital, and 117 real estate. The distribution of number of preceding funds per partnership is clearly skewed, with many partnerships having just one or two preceding funds and a few substantially more (the maximum in the sample is 12 preceding funds). Note that these are the numbers of preceding funds used in our analysis, not the actual number of funds per partnership.

Panel B of Table I reports additional descriptive statistics. The mean (median) preceding fund size is $497.9 ($210.0) million for all funds taken together, $866.4 ($380.0) million for buyout funds, $217.7 ($125.0) million for venture capital funds, and $501.0 ($314.9) million for real estate funds. These statistics show that buyout funds are typically larger than venture capital funds, and that the distribution of private equity fund size is highly skewed.

The mean (median) preceding fund performance (IRR) is 15.1% (10.6%) for all funds taken together, 16.5% (14.3%) for buyout funds, 14.1% (5.8%) for venture capital funds, and 14.6% (14.1%) for real estate funds. The mean (median) growth in fund size from preceding to follow-on fund, conditional on raising a follow-on, is 92.4% (53.8%) for all funds taken together, 110.9% (70.0%) for buyout funds, 78.6% (42.9%) for venture capital funds, and 89.7% (48.9%) for real estate funds.

The time between successive fundraisings averages 3.3 years for the entire sample, 3.8 years for buyout funds, 3.3 years for venture capital funds, and 2.4 years for real estate funds.

Table II reports the same fund characteristics broken out by the focal fund's position in the partnership's sequence of funds in the full Preqin database. Table II shows that higher sequence number funds are substantially larger than lower sequence number funds, both because they represent successful partnerships and also because they tend to be located later in time when funds were larger. The growth rate in fund size from preceding to follow-on funds tends to decrease in the sequence of funds. The time between successive fundraisings generally decreases in the sequence of funds, suggesting that older partnerships are more able to raise new funds on the basis of their past track records and rely less on performance in the current fund. The percentage of preceding funds that raise a follow-on is generally increasing in the sequence of funds. All of these patterns are consistent with the learning framework discussed in Section II.

IV. The Empirical Relations between Current Performance and Future Fundraising

In this section, we estimate the sensitivities of the probability of raising a follow-on fund, and the size of the follow-on if one is raised, to current performance. All of our estimates in this section use a fund's realized final performance (IRR) as our measure of performance. We are therefore using the realized final IRR as a proxy for investors' expectation at the time of subsequent fundraising about what final performance of the current fund will turn out to be, even though final IRR is not generally known with certainty at that time. In other words, we use ex post realized returns to proxy for ex ante expected returns, in keeping with common practice in asset pricing studies. We discuss the measurement issues implicit in this proxy in more detail in Section IV. C, and present results using the interim IRR available at the time of fundraising for robustness in the Appendix.

A. Estimates without sequence effects

Table III reports estimates of the relation between future fundraising and current performance that do not allow for the possibility that the sensitivities can vary in the sequence of funds. In Table III, columns labeled "(1)" use the IRR of the "current" (preceding) fund as the sole regressor, and columns labeled "(2)" contain vintage year (of the preceding fund) fixed effects to control for any market-wide, time-varying factors that potentially affect the ability to raise a follow-on fund, and to control for systematic differences in fund performance across different vintage years. These factors are likely to be important in light of the well-documented cyclicality of the private equity market (e.g. Gompers and Lerner, 1998). In all specifications, we cluster standard errors at the partnership level, following Kaplan and Schoar (2005).[17]

Panel A of Table III presents marginal effects, evaluated at the mean of all independent variables, from probit specifications predicting the probability of raising a follow-on fund as a function of current (preceding) fund performance (IRR). The relation between current performance and the likelihood of raising a follow-on is statistically significantly positive for all fund types. The point

[17] In addition, we estimate but to conserve space do not report specifications using as the independent variable the preceding fund IRR minus the preceding fund's benchmark IRR provided by Preqin. Preqin defines the benchmark IRR as the average IRR of all funds of the same type, vintage year, and geographic focus. Our results using this "risk-adjusted" measure of IRR are virtually identical to those reported below.

estimates from the specifications with vintage year fixed effects are slightly larger than those from the specifications without. The marginal effects for the "All Funds" regressions imply that a one percentage point improvement in IRR relative to the sample mean is associated with a 0.316-0.324 percentage point increase in the probabilty of raising a follow-on fund. Consistent with the learning framework, the estimated marginal effects are larger for buyout funds (0.467-0.588 percentage points) than for venture capital funds (0.288-0.297 percentage points), and the differences in the probit coefficients between buyout funds and venture capital funds are statistically significant (p-value 0.057), as are the differences between real estate and venture capital funds (p-value 0.086).[18] The differences between buyout and real estate are not statistically significant (p-value 0.633). In unreported analysis, we obtain statistically and economically similar results using linear probability (OLS) models instead of probit.

These findings reject the "naive reinvestment" hypothesis that limited partners on average do not have or are too unsophisticated to use information about what final fund performance is likely to be when deciding whether to allow a GP to raise a subsequent fund. Consistent with naive reinvestment, Lerner, Schoar, and Wongsunwai (2007) find that some LPs are performance-insensitive when deciding whether to participate in a GP's next fund. Our results suggest that such LPs do not dominate the fundraising process; information about expected final performance is nevertheless important to whether a GP raises a follow-on fund at all. These findings are consistent with Kaplan and Schoar (2005) and subsequently others who find a positive relation between follow-on size and performance in tobit specifications with left-censoring at zero. However, these prior specifications do not allow for separate identification of the effect of performance on the likelihood of raising a follow-on fund, which is key to the "naive reinvestment" hypothesis.

Panel B of Table III presents OLS estimates of equations predicting the growth in fund size from preceding to follow-on fund as a function of IRR, for the subsample of preceding funds that raise a follow-on fund. Growth in fund size is defined as follow-on fund size divided by preceding fund size minus one. The estimates indicate that current performance is strongly positively related to follow-on fund size, consistent with Kaplan and Schoar (2005).The coefficients are all positive and are all

[18] Here and in all similar tests, we assess statistical significance by pooling the observations of different fund types into a single regression, and including an interaction of IRR with a dummy variable indicating fund type (either). A significant coefficient on the interaction term indicates a significant difference across fund types. We report p-values based on the specifications with vintage year fixed effects, which are estimated more precisely.

statistically significant except those for venture capital funds. The magnitudes of the coefficients in the "All Funds" regressions imply that a one percentage point increase in IRR is associated with a 0.623-0.663 percentage point increase in fund growth. As in Panel A, the estimated effects for buyout funds (2.152-2.314 percentage points) are considerably larger than those for venture capital funds (0.426-0.492 percentage points), with real estate in between (1.723-1.955 percentage points). The differences between buyout and venture capital, and between real estate and venture capital, are statistically significant (p-values 0.016 and 0.062, respectively), while the differences between buyout and real estate are not (p-value 0.635).

Panel C of Table III reports estimates of similar equations in which the dependent variable is the natural logarithm of follow-on fund size divided by preceding fund size plus one. (We add one to avoid taking the logarithm of a number close to zero.) Because the distribution of growth rates in the data is skewed, a logarithmic specification is likely to fit the data better, which is confirmed by the fact that the R^2 values in Panel C are generally considerably higher than those in Panel B. The estimates again indicate that current performance is strongly positively related to follow-on fund size.[19] The coefficients are all positive and statistically significantly different from zero. Similar to the results reported above, the estimates are significantly larger for buyout compared to venture capital, and for real estate compared to venture capital (p-values 0.004 and 0.024, respectively), while the difference between buyout and real estate is statistically insignificant (p-value 0.858).

Overall, the estimates in Table III confirm two of the main predictions from the learning framework. First, both the likelihood of raising a follow-on fund and the size of that fund if one is raised are strongly positively related to performance in the current fund. Second, the sensitivity of future fundraising to current performance is larger for buyout funds than for venture capital funds.

B. Sequence-specific estimates

The estimates presented in Table III do not consider a key prediction of the learning framework, that the sensitivity of future fundraising to current performance is declining in the sequence of funds managed by a given partnership. To test this prediction, in Table IV we reestimate the equations from Table III, including variables for the preceding fund's sequence number as well as the sequence

[19]In unreported analysis, we test whether future fundraising is nonlinear in performance. We find a statistically significantly negative coefficient on the square of IRR, indicating concavity, but the effects are economically tiny.

number interacted with IRR.[20]

Panel A of Table IV presents estimates of equations predicting the probability of raising a follow-on fund. In Panel A, we focus on linear probability models because of the difficulty of interpreting marginal effects of interaction terms in probit specifications (and the potential bias in coefficient estimates resulting from including fixed effects in probit specifications).[21] As in Panel A of Table III, we find that current performance is positively related to the probability of raising a follow-on fund when all fund types are pooled, for buyout funds separately, and for venture capital funds separately. The coefficients are of similar magnitude to those in Table III, and once again the difference between the coefficients for buyout and for venture capital funds is statistically significant (p-value 0.001). The coefficient on IRR for real estate funds is similar to the one reported in Table III, but is estimated less precisely, is not statistically significant, and is significantly different from the coefficient for buyout funds but not from that for venture capital funds (p-values 0.006 and 0.708, respectively).

For all funds taken together, and for buyout and venture capital funds individually, the coefficients on sequence number in Panel A of Table IV are positive and statistically significant. The coefficients on the interaction of sequence number with IRR are negative and statistically significant. This pattern of coefficients matches the predictions of the learning framework of Section II. Higher sequence numbers are associated with funds that have done well historically and hence have high current assessments of ability, so they are more likely to raise a follow-on regardless of current performance. In addition, ability is estimated more precisely over time, so the incremental effect of current performance on a fund's ability to raise a follow-on fund grows smaller over time.

Panel B of Table IV presents OLS regressions predicting growth in fund size conditional on raising a follow-on fund, similar to those of Panel B of Table III. The coefficients on IRR are positive, statistically significant (with one exception), and generally larger in magnitude than those in Panel B of Table III. The coefficients on sequence number are all positive but not statistically significant. With the exception of buyout funds, the coefficients on the interaction of sequence number with IRR are negative and statistically significant.

[20] As in Table III, results are similar if we use the preceding fund's benchmark-adjusted IRR. The results are also unaffected by controlling for the time between successive fundraisings in the fund growth specifications, which addresses the concern that the declining sensitivity in the sequence may be confounded by the fact that older partnerships raise follow-on funds faster on average (Table II Panel E).

[21] See Ai and Norton (2003) and Greene (2000).

Panel C of Table IV presents estimates of similar equations in which the dependent variable is the natural logarithm of growth in fund size plus two. As in Table III, the R^2 values indicate that these specifications fit the data better than those of Panel B. The coefficients on IRR are all positive, statistically significant, and larger in magnitude than those in Panel C of Table III. The coefficients on the interaction of sequence number with IRR are all negative and, with the exception of buyout funds, statistically significant. In both Panels B and C, the coefficients indicate that the sensitivity of fund growth to performance is greater (but not significantly so) for first-time buyout funds than for first-time venture capital funds, and that the gap between them grows quickly in the sequence of funds.

For all fund types, Table IV shows that the sensitivity of future fundraising to current performance is significantly decreasing in the sequence number of the current fund. For all funds taken together, and for venture capital funds individually, the effects are statistically significant for both the probability of raising a follow-on fund and the growth in fund size if a follow-on is raised. For buyout funds, the effect is significant only through the probability of raising a follow-on, and for real estate, only through the growth in follow-on fund size.

All of our results continue to hold when controlling for vintage year fixed effects, and all match the predictions of the learning model. In contrast, our findings are inconsistent with a behavioral "return chasing" or "dumb money" explanation for private equity fund flows, by which investors chase returns without regard to their informativeness or disproportionately react to the performance of older, more famous partnerships. These explanations predict, contrary to our results, either a flat or an increasing sensitivity of future fundraising to current performance in the sequence of a partnership's funds. Prior work, beginning with Kaplan and Schoar (2005), finds as we do that follow-on fund size is positively related to current performance, but this result alone cannot distinguish behavioral return chasing from rational learning.

Overall, the evidence in Tables III and IV suggests that the rational learning framework better describes the empirical relations between fundraising and performance than behavioral "naive reinvestment" or "return chasing" explanations. Investors appear to utilize information about what final fund performance is likely to be when deciding on whether a GP can raise a subsequent fund, and the size of that fund conditional on raising it. Later sequence funds are more likely to raise a follow-on fund controlling for performance, the sensitivity of future fundraising to current performance is greater for buyout funds compared to venture capital funds, and this sensitivity declines in the sequence of a partnership's funds. All of these findings match the predictions of the learning framework.

C. Measurement issues

In all of the estimates presented above, we use the fund's final IRR as the measure of the fund's performance. A concern with doing so is that a fund's ultimate performance is not known with certainty at the time the next fund is raised. The summary statistics presented in Table I show that the typical fund that raises a follow on fund does so after three years of life, while final fund performance is not known until the end of the fund's life. An important question is whether the fund's final IRR is a reasonable proxy for the information about performance that a fund's investors use at time of subsequent fundraising in deciding whether and how much capital to allocate to a partnership's next fund. There are several reasons to believe that the answer is "yes".

First, Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) present a model in which a fund's current investors have soft information about the likely profitability of a fund's investments (obtained, for example, from close communication with the GPs), and use it when deciding whether to allocate capital to the partnership's next fund. This soft information about performance is not reflected in the hard information about performance, "interim IRR", available at that time, and is not observable to the econometrician. Soft information becomes observable to the econometrician only ex post, as it is reflected in the fund's final IRR. Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) find evidence supporting this idea: The performance of the follow-on fund (if one is raised) is strongly correlated with the first fund's final IRR, but uncorrelated with the interim IRR that was available at the time the follow-on was raised. Given this result, it seems likely that a fund's final IRR is a better proxy than its interim IRR for the information about performance investors use in deciding whether to allocate capital to the partnership's next fund.

Second, even if the interim IRR were the more desirable measure, in the Appendix we show that interim IRR (at time of fundraising) and final IRR are highly correlated, with a correlation coefficient of about 0.6. Similarly, Kaplan and Schoar (2005) find correlation coefficients of about 0.8-0.9 between interim IRR at 5 years and final IRR, consistent with the first few exits (or, in the case of venture capital, follow-on investments in portfolio companies) being strongly indicative of a fund's ultimate performance. Moreover, to the extent that interim IRR is the preferable measure and is imperfectly correlated with final IRR, the standard errors-in-variables effect implies that we will understate, not overstate, the sensitivity of future fundraising to performance.

Notwithstanding these arguments, in the Appendix we present estimates of sensitivities of fundraising to performance in which we use the interim IRR at time of fundraising as our measure of fund performance. While we have interim IRR data for only somewhat less than half of our sample funds, we nonetheless obtain results similar to those presented in this section.

V. Estimating Direct and Indirect Pay for Performance

In this section, we use the theoretical framework discussed in Section II, together with the regression estimates presented in Section IV, to estimate the magnitude of the total pay for performance relation facing private equity GPs. We compare the magnitudes of its direct component, from carried interest in the current fund, and its indirect component, from future fundraising. We consider two measures of pay for performance: the incremental revenue to GPs for an incremental dollar returned to LPs, and the incremental revenue to GPs for an incremental percentage point improvement in IRR.

A. Discounting future GP compensation

Our estimates require a discount rate for future GP compensation. Unfortunately, the literature has yet to converge on a set of widely agreed upon estimates of the cost of capital for different types of private equity funds, making it difficult to know what discount rate to use. The main problem in estimating discount rates is the lack of objective market values at sufficient frequency with which to compute a covariance of returns with public markets.

At the same time, in the literature, estimates of buyout betas tend to be close to 1, and estimates of venture capital betas tend to be in the range of 2-3 (Korteweg and Sorensen, 2010). Metrick and Yasuda (2010b) estimate that the beta of venture capital is about 2, leading to a cost of capital of about 15%, assuming a risk-free rate of 3% and a market risk premium of 6%. A buyout beta of 1 then leads to a cost of capital of about 9%. We use a discount rate of 9% for real estate as well. For calculations involving all funds taken together, we use a weighted average of these costs of capital (weighted by the number of funds in our sample), which works out to 12%. The results reported below in Tables V and VI and Figure 1 use these discount rates.[22]

Our main conclusions are robust to alternative choices of discount rates based on the range of estimates reported in the literature, as discussed in Section V.C. below and presented in Figures 2-4. Collectively, we believe Figures 1-4 do a good job in spanning the range of beta estimates in the literature. In addition, by following the approach described below, calculations analagous to the ones we present can be performed using any potential discount rate.

B. Direct (explicit) pay for performance

In this subsection we estimate direct pay for performance in the current fund, which is represented by the first term in equation (3) in Section II. Our calculations assume that the fund has the standard 20% carry, and we use the relevant means in our sample (by fund type and sequence) as the baseline levels of performance and fund size. It is straightforward to perform analagous calculations for different breakpoints of fund size and performance using the sample distributions given in Table II. Panel A of Table V shows that for first-time funds of all fund types, the sample mean IRR is positive and greater than a potential hurdle rate of 8%, so the carry is in the money. A 20% carry implies that GPs earn \$0.25 (undiscounted) for an incremental \$1 earned for LPs.[23]

To calculate the incremental revenue to GPs for a percentage point improvement in IRR, it is necessary to make further assumptions. We assume that the fund's capital is called in equal annual installments, and the distribution corresponding to each capital call occurs T years later. The resulting IRR is algebraically equal to the IRR obtained by assuming that there is a single capital call and a single distribution spaced T years apart, which we take to be three years.

Under these assumptions, the net-of-fee total dollar return to limited partners in the first fund, D, is given by $D = \left[(1+r_1)^T - 1\right] I_1$, where r_1 is the IRR (which is a net-of-fee measure) of the first fund and I_1 is the size of the fund. Let R be the revenue earned by the GP. By the chain rule:

[22] We thank Andrew Metrick for suggesting these choices of discount rates.

[23] Our use of the standard 20% carry is motivated by evidence in the literature that carried interest rarely differs from 20%, especially in recent times matching the bulk of our sample. In Gompers and Lerner's (1999) sample of 419 venture capital funds raised before 1992, 81% have carry between 20%-21%. In Metrick and Yasuda's (2010a) sample of 238 funds from 1993-2006, 95% of venture capital funds and 100% of buyout funds have carry equal to 20%. In Robinson and Sensoy's (2011) sample of 910 funds from 1984-2010, carried interest is equal to 20% for 89%, 97%, and 97% of venture capital, buyout, and real estate funds, respectively and the average carry is 20.44%, 19.96%, and 20.14%, respectively. Consequently, assuming a carry of 20% simply amounts to rounding the figures provided by Robinson and Sensoy (2011), who have the largest and most recent sample, to the nearest whole percentage.

$\frac{\partial R}{\partial D} = \frac{\partial R}{\partial r_1} \frac{\partial r_1}{\partial D}$. Inverting D and differentiating yields:

$$\frac{\partial R}{\partial D} = \left[\frac{1}{TI_1} (1 + r_1)^{1-T} \right] \frac{\partial R}{\partial r_1}. \tag{4}$$

We use this formula to convert incremental revenue per extra dollar returned to LPs to incremental revenue per incremental percentage point of IRR, and vice versa.

Panel A of Table V displays the direct pay for performance calculated using this formula with $\frac{\partial R}{\partial D} = 0.25$, corresponding to 20% carry, and the displayed sample parameters. For the average first-time fund in our sample (size \$262.3 million), improving IRR from a baseline of 15.75% to 16.75% results in \$2.636 million in incremental revenue to the GP, or \$1.876 million in present value. For buyout funds the present value is larger, \$3.323 million, reflecting both the larger average size of buyout funds and the higher baseline level of performance. The present value for venture capital funds is the smallest (\$0.795 million), and real estate funds fall in the middle (\$2.290 million).

C. Indirect pay for performance from future fundraising

We now turn to estimating indirect pay for performance arising from the effect of current performance on future fundraising. This effect corresponds to the second and following lines in equation (3) of Section II.

We require estimates of the $k(.)$ terms, the $p(.)$ and $f(.)$ terms, and the $p'(.) \frac{s}{\tau + is}$ and $f'(.) \frac{s}{\tau + is}$ terms in equation (3). The $k(.)$ terms represent the expected fraction of a fund's size that accrues to GPs as compensation, through a combination of management fees and carried interest. The appropriate values for $k(.)$ are not obvious, and depend on the fee structure as well as the entire distribution of returns. We rely on Metrick and Yasuda (2010a), who perform Monte Carlo simulations to estimate the distribution of $k(.)$ using details of the compensation terms of a recent sample of venture capital and buyout partnerships. We use similar values for real estate funds (not covered by Metrick and Yasuda (2010a)) and the overall sample of funds.

For the $p(.)$ and $f(.)$ terms, we use the type- and sequence-specific averages in our sample. For example, suppose the fund of interest (current fund) is a first-time buyout fund. Then $p(\theta_1)$ and $f(\theta_1)$ are the fraction of preceding buyout funds of sequence number 1 that raise a follow-on fund in our sample, and the average size of the follow-on, conditional on raising one. Panels F and C of

Table II report that these values equal 76.5% and \$685.7 million, respectively. In this way, all of the $p(.)$ and $f(.)$ terms used in our calculations are provided in Table II.

It remains to obtain estimates of the $p'(.)\frac{s}{\tau+is}$ and $f'(.)\frac{s}{\tau+is}$ terms from the regression coefficients in Tables III and IV. In all of our calculations, we use the coefficients from the specifications without rather than with vintage year fixed effects, which lead to smaller estimates of indirect pay for performance.

We begin with the coefficients from Table III. The marginal effects from the probit regressions in Panel A are estimates of the change in probability of raising a follow-on fund for an incremental change in current performance, and so are direct estimates of $p'(.)\frac{s}{\tau+is}$ under the constraint that the estimate is the same for all i, i.e. sequence effects are ignored.

We use the coefficients from the logarithmic specifications in Panel C to obtain estimates of the $f'(.)\frac{s}{\tau+is}$ terms.[24] In Panel C, the dependent variable is the natural logarithm of follow-on fund size divided by preceding fund size plus one, i.e. $ln\left(\frac{f(\theta_i)}{f(\theta_{i-1})}+1\right)$. The estimated regression coefficient, β, is an estimate of the derivative of this quantity with respect to r_i, the IRR of the preceding fund: $\beta = \frac{1}{\frac{f(\theta_i)}{f(\theta_{i-1})}+1} f'(\theta_i)\frac{s}{\tau+is}$. Rearranging, we have $f'(\theta_i)\frac{s}{\tau+is} = \beta\left(f(\theta_{i-1}) + f(\theta_i)\right)$.

Continuing the example of the first-time buyout fund, the expected incremental compensation from the next fund is given in equation (3) as $k(r_2)\left[p'(\theta_1) f(\theta_1) + p(\theta_1) f'(\theta_1)\right]\frac{s}{\tau+s}$. Metrick and Yasuda (2010a) estimate an average $k(.)$ for buyout funds of 17.72%. The marginal effect in Panel A of Table III for a one-percentage point increment in IRR is equal to 0.00467, and the coefficient from Panel C of Table III is equal to 0.00524 (after, in both cases, converting decimal IRR to percentage). As described above, $p(\theta_1) = 76.5\%$ and $f(\theta_1) = \$685.7$ million. Panel A of Table II reports that the average size of preceding buyout funds of sequence number 1 in our sample is $f(\theta_0) = \$417.5$ million. Putting it all together, the incremental expected compensation from the next (second) fund for a one-percentage point improvement in IRR in the current fund is equal to $0.1772 * [0.00467 * 685.7 + 0.765 * 0.00524 * (685.7 + 417.5)]$, or \$1.351 million. This figure is a present value as of the beginning of the life of the second fund (this is how Metrick and Yasuda compute k), so we further discount for the average time between fundraisings (approximately 3 years in our data) to convert to present value as of the beginning of the current fund.

[24] A comparison of Panels B and C of Table III indicates that a logarithmic specification for follow-on fund size fits the data better. Our estimates are higher, generally by about 10%, if we use the coefficients from the raw growth specifications in Panel B instead.

In this way, we calculate the expected incremental compensation from the second, third, etc. follow-on funds following equation (3) of Section II, discounting each appropriately using the fund type-specific discount rates discussed above, and assuming a three-year gap between successive fundraisings. We then add the discounted expected incremental compensation from each future fund to arrive at the total estimated indirect pay for performance.

C.1. Estimates ignoring sequence effects

Panel B of Table V displays estimates of indirect pay for performance using the coefficients from Table III and the methodology described in Section V.C, focusing on first-time funds. We present results for the quartile breakpoints of k reported by Metrick and Yasuda (2010a), which are 15.75%, 17.72%, and 19.60% for buyout funds and 20.24%, 22.84%, and 26.11% for venture capital funds. For all funds taken together and for real estate funds, we use 15%, 20%, and 25%. As shown in equation (3), all of the estimates are proportional to k. We also present results for different values of N, the maximum number of future funds the GP could potentially run (e.g., before retirement). As discussed in Section II, the estimates incorporate the realistic feature that failure to raise a follow-on is a once and for all event, so dropping out is permanent.

In the columns labeled $\delta TR/\delta IRR$, we present estimates of the present value of the expected incremental revenue from future funds resulting from a one percentage point improvement in current fund IRR, and in the columns labeled $\delta TR/\delta D$ we use equation (4) to convert these estimates into those resulting from an extra dollar returned to LPs. To gauge the relative magnitudes of the present values of indirect and direct pay for performance, we present their ratios in the rightmost columns of Panel B of Table V. The ratios do not depend on whether the performance measure is IRR or dollars because the term in brackets in equation (4) drops out when taking the ratio.

It is evident from Panel B of Table V that indirect pay for performance from future fundraising is important in the private equity industry, and of the same order of magnitude as direct pay for performance. The ratios range from a low of 0.42 for venture capital funds with $N = 3$ and $k = 20.24\%$ to a high of 3.09 for buyout funds with $N = 5$ and $k = 19.60\%$. The estimates of indirect pay for performance are largest for buyout funds and smallest for venture capital funds, consistent with the patterns in Tables III.

C.2. Estimates accounting for sequence effects

The estimates presented in Table IV suggest that the indirect incentives calculated in Table V are likely to be strongly affected by the declining sensitivity of future fundraising to current performance in the sequence of a partnership's funds. The learning framework predicts two channels through which sequence effects are likely to be important. First, holding the sequence number of the "current" fund fixed, there is relatively less value from each potential subsequent fund, and hence relatively less value from increasing N. Second, as a partnership ages (the current fund becomes more advanced in the sequence of the partnership's funds), indirect pay for performance will decline.

The indirect pay for performance estimates presented in Table VI strongly support these ideas. We obtain these estimates by applying the methods described in Section V. B., taking sequence effects into account. Wherever we previously used a coefficient from Table III, we instead use the corresponding level effect coefficient plus the product of the coefficient on the sequence interaction and the sequence number of the preceding fund, all from Table IV. For example, when calculating the incremental compensation from the second follow-on fund for buyout funds, the estimate of $p'(\theta_2)\frac{s}{\tau+2s}$ is given by (from Panel A of Table IV) $0.698 - 0.091 * 2 = 0.516$.

In Panel A of Table VI, we calculate the (discounted) direct effect or explicit pay for performance for different sequence number current funds. The effects per incremental dollar returned to LPs are the same as in Table V, but the effect per incremental percentage point of IRR grows with fund sequence reflecting the growth in fund size with sequence.

In Panel B of Table VI, we estimate indirect pay for performance, holding k fixed at its median values from Table V. Two patterns are evident. The estimates are smaller than their counterparts in Table V, though still large, and decline with the sequence number of the current fund. The decline is very strong for venture capital funds and fairly weak for buyout funds, for which indirect pay for performance remains important well into a partnership's sequence of funds.

Figure 1 depicts the patterns in Table VI graphically, and shows that for all funds taken together and for venture capital funds, indirect pay for performance declines to virtually zero by the time the partnership is managing its fourth fund, leaving only the direct component. Overall, the estimates indicate that indirect pay for performance is a substantial component of the total pay for performance relation facing private equity GPs, especially for funds early in a partnership's life.

Figures 2-4 show that our key cross-sectional conclusions are robust to alternative choices of discount rates. First, because GPs hold what is essentially an option on the equity returns of their portfolio, the cost of capital may underestimate the riskiness of the GP claim. For this reason, Figure 2 reports results using discount rates 5 percentage points higher than our base cost of capital estimates. Second, based on the range of beta estimates in the literature it is possible (but unlikely) that venture capital funds have in fact a lower cost of capital than buyout funds. To assess the sensitivity of our conclusions to this possibility, Figure 3 reports results assuming the most extreme low venture capital beta estimate (0.86, Woodward and Hall, 2003) and high buyout beta estimate (1.3, Phallipou and Zollo, 2005). Even with a lower discount rate for venture capital compared to buyout, indirect pay for performance is still larger for buyout funds. Finally, Figure 4 uses high-end beta estimates of 3 for venture capital and 1.3 for buyout. Figures 2-4 continue to show that indirect pay for performance is higher for buyout funds compared to venture capital, and declines in the sequence of a partnership's funds.

Collectively, we believe Figures 1-4 do a good job spanning estimates of discount rates in the literature. The figures show that while the magnitude of indirect pay for performance declines with increased discount rates, the estimates remain considerable in magnitude. Importantly, the figures show that our key cross-sectional conclusions are robust to alternative choices of discount rates.

D. Factors Omitted from the Estimates

There are several factors that could affect the magnitude of our estimates that are not explicitly modeled in the learning framework and which we do not have the data to estimate.[25] First, we ignore costs. Fixed costs do not affect general partners' pay for performance incentives. However, costs do change as private equity funds grow and raise additional capital. In particular, as future funds grow in size, partnerships may hire new partners who receive some share of the revenue. Omitting this growth in the number of partners causes us to overestimate indirect pay for performance. To estimate the magnitude of this effect would require data we do not have: information on the number of partners, as well as the revenue sharing arrangements between partners as partnerships progress through time. To the extent that new partners added on to future funds are likely to receive much

[25] One potential such effect we can test comes from the notion that good performance leads to faster future fundraising. If so, GPs would get revenue from future funds earlier and potentially manage more funds over a career. However, in the data there is no significant relation between a fund's performance and the time between fundraisings.

lower shares of revenue than the original partners who were responsible for good performance in the prior fund, the bias will be small.[26]

Another possibility is that a partnership's carried interest percentage may respond to its prior performance. Hochberg, Ljungqvist, and Vissing-Jorgensen (2010) provide evidence that this adjustment sometimes happens when venture capital firms have extremely good performance. However, the sensitivity of these adjustments to performance is small. Hochberg et al.'s estimates (in their Table 6) imply that carried interest grows by about 8 basis points for an incremental 1 percentage point improvement in IRR. An 8 basis point change is 0.4% of a base carry of 20%, so this effect causes our estimates to understate actual indirect pay for performance very slightly, by about 0.4%.

The impact of good performance on the partners' outside options could also influence estimates of indirect pay for performance. Good performance in a fund likely positively affects a partner's human capital, which she could use to form a new partnership or to leave the private equity industry altogether and pursue other options. Since the value of these other options is likely to be positively related to the fund's performance, this effect leads our estimates to be understated.[27]

Kaplan and Schoar (2005) find evidence of performance persistence. Chung (2010) and Robinson and Sensoy (2011) both find that persistence weakens considerably after the Kaplan and Schoar sample period. Persistence would result in somewhat higher carry dollars in the subsequent fund, suggesting that it may be appropriate to use the upper range of the k estimates given by Metrick and Yasuda (2010) when calculating indirect pay for performance. Our Figures 1-4 use the median k to be conservative. Conversion to other values is straightforward as all estimates are linear in k.

Finally, in all of our calculations, we assume that the direct, explicit pay for performance driven by the carried interest is "in the money", so that GPs receive the full 20% of profits as carried interest. While our calculations are appropriate for the average fund in our sample, whose carry is in the money, this nonetheless represents an upper bound in the cross-section of funds, since many

[26] Metrick and Yasuda (2010b, p.27) report suggestive compensation numbers based on surveys of venture capitalists. Their numbers indicate that, consistent with our intuition, more senior partners (who presumably have been with the partnership since its earlier funds) earn considerably more total compensation than junior partners, and 5-8 times as great a share of the carried interest. We also note that while occasionally experienced general partners leave one firm to join another existing firm, Alter (2009) finds that none of the experienced venture capitalists in his sample do so. His evidence suggests that venture capital firms at least only rarely hire experienced partners with whom they would have to share a large portion of the revenue.

[27] Alter (2009) reports that it is rare for the young California venture capitalists in his sample to defect to raise their own funds, with a cumulative rate of 7% over every 4 year block of time in his data, less than 2% per year. If the rate for buyout partners is even lower than this, which seems unlikely, our estimates of the difference between buyout and venture capital pay-performance sensitivities would be slightly overstated.

funds' performance is such that they earn no carried interest. This effect implies that our estimates of direct pay for performance are an upper bound, and that for some funds the ratio of indirect to direct pay for performance is much larger than for the average fund.

Overall, while costs that rise with fund size cause our estimates of the ratio of indirect to explicit pay for performance to be overstated, all other omitted factors discussed above cause them to be understated. Consequently, our conclusion that the indirect component of pay for performance in private equity is important and substantial in magnitude is likely to be robust to refinements of our estimates. Moreover, such refinements are unlikely to overturn the support in the data for the key cross-sectional differences implied by the learning model: that venture capital funds have lower indirect pay for performance than buyout funds, and that pay for performance declines in the sequence of a partnership's funds.

VI. Conclusion

In the private equity industry, the possibility of future fundraising provides substantial indirect pay for performance incentives to general partners above and beyond the much-discussed incentives from the explicit compensation system. Achieving high returns early on allows a partnership to establish a reputation for being able to generate returns, which is valuable as it allows partners to earn fees on larger funds in the future. We present a learning framework that characterizes this process, and show that its predictions better match the fundraising dynamics in the data than behavioral alternatives based on "naive reinvestment" or "return chasing". In particular, both the likelihood of raising a follow-on fund and the size of that fund if one is raised are strongly positively related to current performance, the relations betwen future fundraising and performance are stronger for buyout funds compared to venture capital funds, and these relations decline in the sequence of a partnership's funds.

From the learning framework we derive an explicit formula which we use to transform our estimates of the sensitivity of future fundraising to current performance into estimates of the size of indirect pay for performance in private equity. Our estimates suggest that the indirect component of pay for performance is of the same order of magnitude as the direct component from carried interest. Indirect pay for performance is particularly important for buyout partnerships compared to venture capital and for newer partnerships who have yet to establish a reputation. Our results are all consistent with the learning framework, and suggest that learning about ability is a key driver of indirect pay for performance in private equity.

This paper contributes to the debate about the incentives of private equity general partners and their effect on value creation. Despite the central importance of general partner incentives to understanding the activities of private equity firms, we are the first to estimate how large their total incentives (direct plus indirect) actually are. Our results suggest that total performance-based compensation in private equity partnerships is larger, by a factor of about two, than commonly discussed, because most discussions focus on the carried interest alone. Total pay for performance in private equity is much larger and exhibits much more variation, both across partnership types and in the sequence of funds, than suggested by the carried interest alone.

While the indirect pay for performance that we find is consistent with our learning framework, our results do not speak directly to whether the resulting total compensation system, including the dynamics of carried interest, is efficient. Understanding whether the total pay-performance relations in private equity, in particular the fact that the direct carried interest typically does not increase much in the face of diminishing indirect pay for performance over time, are efficient and reflect optimal contracting is an important topic for future research.

The analysis in this paper could be applied to other forms of organization. Perhaps the most straighforward application would be to other asset management settings, such as hedge funds, mutual funds, and pension funds, because their explicit fee structures would allow for similar calculation of the returns to managing a larger quantity of funds. Calculating the indirect pay for performance implied by the flow-performance (and termination-performance) relations in these settings would be an important addition to our understanding of these industries.

Most generally, our analysis provides empirical evidence consistent with the idea started by Fama (1980) and Holmstrom (1999) that indirect pay for performance can be an important source of incentives inside firms. An advantage of studying private equity is that it is possible to quantify these incentives. Private equity is also an industry where incentives, both direct and indirect, are particularly important. The extent to which indirect, market-based incentives are important in other industries, both in absolute terms and relative to direct incentives, is likely to be an important topic of future research.

Appendix

In this Appendix, we present estimates of future fundraising as a function of a fund's interim, as opposed to final, IRR (see the discussion in Section IV. C.). Preqin provides interim IRR data for a subset of our main sample of preceding funds, but the time-series of interim IRRs for a given fund is almost always incomplete (so it is not possible for us to use these data to estimate, for example, hazard models to predict future fundraising). Similarly, Preqin provides cash flow data for another (partially overlapping) subset, making it possible for us to compute interim IRRs, but the cash flow data for a given fund generally appear to be incomplete. Using these two sources of interim IRR data, we obtain interim IRR at the time of next fundraising for 801 of our 1,745 preceding funds (using the Preqin interim IRR when both are available because the cash flow data are often incomplete). For preceding funds that do not raise a follow-on fund, we use the interim IRR after 3 years of life, matching the average time between successive fundraisings in our data.

Panel A of Table A-I shows that the correlation between this interim IRR for a fund and the fund's final IRR is high. The correlation is 0.607 for all funds taken together, 0.551 for buyout funds, 0.618 for venture capital funds, and 0.228 for real estate funds. In Panel B we estimate probit regressions to explain whether a follow-on fund is raised, analogous to Panel A of Table III. The estimated marginal effects are all positive and significant with the exception of real estate funds. For all fund types, the difference between the marginal effects reported in Panel B of Table A-I and those reported in Panel A of Table III are statistically insignificant. In Panel C of Table A-I we estimate regressions predicting (log) fund growth from preceding to follow-on fund, analogous to those reported in Panel C of Table III. Again, all of the estimated coefficients are positive, all are significant except for buyout funds which narrowly miss significance, and none are statistically significantly different from the analogous coefficients reported in Panel C of Table III.

Overall, the evidence presented in Table A-I suggests that, even if interim IRR were the right way for the econometrican to summarize the information set used by investors in assessing performance at the time of next fundraising (which is questionable, see the discussion in Section IV. C.), our results are unlikely to be materially biased by using the fund's final IRR instead, and by doing so we gain the advantage of a substantially greater number of observations and enhanced statistical power.

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Table I
Descriptive Statistics

Descriptive statistics for the sample funds. Panel A reports the distribution of the number of preceding funds per partnership. Panel B reports the distributions of preceding fund size and performance,follow-on fund size conditional on raising a follow-on, growth in fund size conditional on raising a follow-on (percentage difference between preceding and follow-on size), the time between successive funds (the time elapsed before raising a follow-on), and the percentage of preceding funds that raise a follow-on. Preceding funds meet the following criteria: fund size and performance (IRR) information is available, fund size is at least $5M in 1990 dollars, and the fund is raised before 2006. The follow-on fund for each preceding fund (if one is raised) is the next fund raised by the same private equity partnership.

Panel A: Descriptive statistics for the number of preceding funds per partnership

Fund Type	Number of partnerships	Number of preceding funds per partnership						
		Mean	Median	Std Dev	Min.	Q1	Q3	Max.
All	843	2.07	1	1.65	1	1	3	12
Buyout	314	2.05	1.00	1.56	1.00	1.00	3.00	11.00
Venture Capital	412	2.07	1.00	1.75	1.00	1.00	2.00	12.00
Real Estate	117	2.13	2.00	1.47	1.00	1.00	3.00	9.00

Panel B: Descriptive statistics for fund size, performance, and fundraising

	All Funds				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	1745	497.9	210.0	82.4	500.0
Preceding fund performance (IRR)	1745	15.1%	10.6%	0.5%	22.3%
Follow-on fund size conditional on raising one ($M)	1469	792.2	314.0	136.0	728.4
Growth in fund size conditional on raising a follow-on (%)	1469	92.4%	53.8%	0.0%	123.1%
Time between successive funds (years)	1469	3.3	3.0	2.0	4.0
Percentage of preceding funds that raise a follow-on		84.2%			

	Buyout				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	645	866.4	380.0	169.2	900.0
Preceding fund performance (IRR)	645	16.5%	14.3%	5.9%	25.4%
Follow-on fund size conditional on raising one ($M)	549	1465.3	632.6	289.3	1500.0
Growth in fund size conditional on raising a follow-on (%)	549	110.9%	70.0%	21.7%	140.3%
Time between successive funds (years)	549	3.8	3.0	2.0	5.0
Percentage of preceding funds that raise a follow-on		85.1%			

	Venture Capital				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	851	217.7	125.0	56.0	254.0
Preceding fund performance (IRR)	851	14.1%	5.8%	-5.0%	17.6%
Follow-on fund size conditional on raising one ($M)	681	283.9	181.0	80.0	368.0
Growth in fund size conditional on raising a follow-on (%)	681	78.6%	42.9%	-8.3%	113.6%
Time between successive funds (years)	681	3.3	3.0	2.0	4.0
Percentage of preceding funds that raise a follow-on		80.0%			

	Real Estate				
	Obs	Mean	Median	Q1	Q3
Preceding fund size ($M)	249	501.0	314.9	106.0	622.8
Preceding fund performance (IRR)	249	14.6%	14.1%	7.9%	21.9%
Follow-on fund size conditional on raising one ($M)	239	694.2	425.0	145.0	817.3
Growth in fund size conditional on raising a follow-on (%)	239	89.7%	48.9%	-3.6%	100.6%
Time between successive funds (years)	239	2.4	2.0	1.0	3.0
Percentage of preceding funds that raise a follow-on		96.0%			

Table II

Descriptive Statistics by Fund Sequence

Descriptive statistics by preceding and follow-on fund sequence number. Panel A presents statistics for preceding fund size. Panel B presents statistics for preceding fund performance (IRR). Panel C presents statistics for follow-on size conditional on raising a follow-on. Panel D reports statistics for growth in fund size conditional on raising a follow on (in percent). Panel E reports statistics for the number of years elapsed between successive fundraisings, conditional on raising a follow-on. Panel F reports the percentage of preceding funds that raise a follow-on. All variables are defined in Table I.

Panel A: Descriptive statistics for preceding fund size ($M)

	All Funds					Buyout					Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	612	262.3	112.0	50.0	271.0	247	417.5	220.0	100.0	500.0	290	124.0	75.0	38.7	150.0	75	286.4	202.0	50.0	386.0
2	392	362.9	187.5	75.0	417.0	147	587.8	357.0	165.0	700.0	192	169.9	106.0	54.9	218.5	53	438.0	273.9	126.0	600.0
3	271	488.2	250.0	109.7	518.0	101	812.5	469.0	220.0	900.0	127	216.3	140.0	65.6	279.0	43	530.0	387.1	119.1	831.0
4	186	723.2	355.0	151.0	825.0	65	1397.5	825.0	400.0	1902.0	87	264.6	176.0	100.0	300.0	34	607.7	518.9	225.0	830.0
5	109	861.4	312.5	148.0	750.0	35	1807.4	750.0	331.5	2100.0	52	258.7	169.0	101.5	295.0	22	781.0	509.5	290.0	950.0
6	68	897.2	481.0	202.0	829.0	17	1978.0	1000.0	604.2	3496.9	38	350.3	247.0	170.0	505.0	13	1082.3	567.0	475.0	1000.0
7	41	921.7	444.0	238.0	917.0	11	2041.7	1425.7	470.0	3200.0	23	439.8	300.0	225.0	450.0	7	744.8	570.0	168.0	917.0
8	24	1265.3	787.5	345.5	1868.5	10	2354.4	1950.0	1324.8	3000.0	13	518.5	500.0	311.0	750.0	1	82.0	82.0	82.0	82.0
9	18	2184.3	900.0	305.0	3781.0	7	4483.4	5000.0	3085.0	5300.0	10	787.0	583.0	159.6	1000.0	1	63.0	63.0	63.0	63.0
>=10	24	1536.3	848.9	400.5	1558.0	5	4427.9	5426.1	3272.0	5941.5	19	775.3	526.8	290.0	1100.0					
Total	1745	497.9	210.0	82.4	500.0	645	866.4	380.0	169.2	900.0	851	217.7	125.0	56.0	254.0	249	501.0	314.9	106.0	622.8

Panel B: Descriptive statistics for preceding fund performance (IRR)

	All Funds					Buyout					Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1	612	15.8%	12.2%	3.0%	22.4%	247	17.2%	16.5%	7.2%	26.5%	290	14.0%	8.0%	-1.6%	17.4%	75	17.5%	15.8%	10.9%	24.8%
2	392	13.5%	9.6%	-0.4%	22.1%	147	16.8%	13.9%	4.6%	24.6%	192	10.6%	5.0%	-4.9%	16.5%	53	14.6%	14.1%	8.2%	23.0%
3	271	12.4%	10.3%	0.1%	22.3%	101	15.6%	12.9%	4.2%	25.3%	127	10.1%	4.0%	-6.9%	19.9%	43	11.6%	12.0%	6.9%	18.3%
4	186	19.1%	10.5%	-0.6%	21.1%	65	13.3%	11.9%	4.5%	21.1%	87	26.1%	2.9%	-7.2%	20.6%	34	12.2%	13.6%	6.3%	21.0%
5	109	15.3%	10.0%	-2.2%	26.0%	35	17.5%	12.4%	4.1%	33.2%	52	14.2%	5.6%	-8.6%	21.0%	22	14.6%	13.0%	7.7%	17.7%
6	68	19.6%	9.7%	-2.5%	25.5%	17	16.8%	14.7%	8.9%	23.4%	38	22.5%	2.6%	-5.2%	29.9%	13	15.0%	12.3%	5.6%	25.4%
7	41	16.6%	10.3%	-2.5%	17.9%	11	20.6%	17.9%	10.3%	35.3%	23	16.8%	1.6%	-6.9%	10.4%	7	9.6%	11.6%	5.8%	16.0%
8	24	17.7%	12.2%	-2.5%	40.8%	10	24.6%	21.0%	11.7%	48.8%	13	12.1%	1.1%	-8.5%	16.5%	1	21.5%	21.5%	21.5%	21.5%
9	18	9.9%	6.4%	1.5%	22.8%	7	10.1%	8.8%	1.5%	22.8%	10	7.2%	2.2%	-1.0%	13.4%	1	35.0%	35.0%	35.0%	35.0%
>=10	24	7.2%	1.1%	-4.9%	20.4%	5	0.7%	-2.1%	-7.9%	13.4%	19	8.9%	1.2%	-2.7%	25.1%					
Total	1745	15.1%	10.6%	0.5%	22.3%	645	16.5%	14.3%	5.9%	25.4%	851	14.1%	5.8%	-5.0%	17.6%	249	14.6%	14.1%	7.9%	21.9%

Panel C: Descriptive statistics for follow-on fund size conditional on raising a follow-on ($M)

	All Funds					Buyout					Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
2	462	422.7	215.9	90.0	472.0	189	685.7	390.4	180.0	767.0	201	175.3	114.2	57.2	225.0	72	422.6	304.6	100.0	675.1
3	347	557.6	279.0	116.0	600.0	130	978.8	540.3	252.0	1000.0	167	232.3	154.0	73.0	318.0	50	549.2	326.4	150.0	772.2
4	231	772.2	404.0	165.0	855.7	89	1380.6	850.0	405.0	1550.0	101	273.4	191.0	116.1	375.0	41	680.2	537.9	145.0	846.0
5	163	1039.7	380.0	154.3	900.0	58	2070.4	855.0	392.0	2996.9	72	295.4	199.5	104.0	412.0	33	852.0	530.0	290.0	950.0
6	100	1543.2	474.1	223.5	950.0	34	3505.4	1326.0	473.3	5125.0	44	360.9	247.0	172.5	527.5	22	875.2	506.5	340.0	900.0
7	66	1030.3	464.2	252.9	917.0	17	1777.6	682.6	500.0	3100.0	36	442.4	315.0	234.0	469.2	13	1681.2	707.5	498.0	1325.0
8	38	1658.0	735.0	315.0	1500.0	11	3763.4	1900.0	1170.0	3000.0	21	517.0	400.0	300.0	750.0	6	1791.7	1065.0	594.0	1994.0
9	23	1846.6	800.0	400.0	3085.0	10	3599.6	3433.0	1300.0	5150.3	12	534.3	480.0	232.3	703.0	1	63.0	63.0	63.0	63.0
10	16	1800.3	760.5	237.1	3386.0	6	3985.6	3600.0	3272.0	5941.5	9	533.0	470.7	226.4	650.0	1	95.0	95.0	95.0	95.0
>=11	23	3064.8	1100.0	290.0	2560.0	5	10789.5	12179.5	5426.1	15000.0	18	919.1	691.3	102.5	1450.0					
Total	1469	792.2	314.0	136.0	728.4	549	1465.3	632.6	289.3	1500.0	681	283.9	181.0	80.0	368.0	239	694.2	425.0	145.0	817.3

Panel D: Descriptive statistics for growth in fund size conditional on raising a follow-on

	All Funds					Buyout					Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	462	112.6%	71.1%	19.0%	143.9%	189	119.7%	84.1%	38.5%	151.8%	201	97.9%	62.7%	7.4%	140.6%	72	135.1%	60.8%	5.6%	127.6%
2~3	347	83.3%	56.3%	0.0%	125.0%	130	99.9%	77.0%	17.4%	155.5%	167	73.8%	39.6%	-2.0%	113.6%	50	71.7%	51.8%	-8.6%	88.7%
3~4	231	92.4%	51.1%	-0.2%	128.6%	89	122.7%	70.0%	30.8%	170.3%	101	71.9%	33.3%	-11.9%	115.1%	41	77.6%	50.0%	-0.2%	100.0%
4~5	163	40.7%	31.6%	-32.8%	76.8%	58	52.5%	40.7%	-10.5%	88.8%	72	34.1%	25.4%	-35.4%	62.5%	33	34.3%	26.2%	-16.3%	87.5%
5~6	100	125.7%	50.1%	12.0%	99.8%	34	146.8%	66.1%	45.7%	133.1%	44	135.8%	48.9%	0.0%	90.4%	22	72.9%	29.9%	-20.0%	72.2%
6~7	66	62.6%	34.6%	-35.8%	80.6%	17	39.8%	31.7%	-37.5%	82.4%	36	79.2%	37.6%	-32.2%	79.4%	13	46.1%	25.0%	-3.6%	65.6%
7~8	38	150.0%	65.8%	-14.8%	157.8%	11	277.5%	110.4%	-8.2%	300.0%	21	51.3%	35.2%	-20.8%	100.0%	6	262.1%	109.9%	4.2%	181.8%
8~9	23	53.3%	26.0%	-48.7%	100.0%	10	102.5%	42.3%	-48.7%	254.2%	12	18.8%	12.7%	-35.0%	80.9%	1	-23.2%	-23.2%	-23.2%	-23.2%
9~10	16	22.9%	11.3%	-60.1%	58.6%	6	51.2%	1.0%	-55.2%	94.5%	9	0.9%	7.3%	-65.0%	55.5%	1	50.8%	50.8%	50.8%	50.8%
>=11	23	125.4%	-1.0%	-55.8%	164.1%	5	246.7%	105.0%	13.1%	225.1%	18	91.7%	-11.1%	-74.8%	127.3%					
Total	1469	92.4%	53.8%	0.0%	123.1%	549	110.9%	70.0%	21.7%	140.3%	681	78.6%	42.9%	-8.3%	113.6%	239	89.7%	48.9%	-3.6%	100.6%

Panel E. Number of years elapsed between successive funds, conditional on raising a follow-on

	All Funds					Buyout					Venture Capital					Real Estate				
Sequence	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3	Obs	Mean	Median	Q1	Q3
1~2	462	3.93	4.00	2.00	5.00	189	4.43	4.00	3.00	6.00	201	3.95	4.00	2.00	5.00	72	2.60	2.00	1.00	3.00
2~3	347	3.42	3.00	2.00	4.00	130	3.73	4.00	3.00	5.00	167	3.45	3.00	2.00	4.00	50	2.54	2.00	1.00	3.00
3~4	231	3.23	3.00	2.00	4.00	89	3.48	3.00	2.00	5.00	101	3.39	3.00	2.00	4.00	41	2.32	2.00	2.00	3.00
4~5	163	2.89	3.00	2.00	4.00	58	3.36	3.00	2.00	4.00	72	2.88	3.00	2.00	4.00	33	2.09	2.00	1.00	3.00
5~6	100	2.78	3.00	1.00	4.00	34	3.06	3.00	2.00	4.00	44	2.86	3.00	2.00	4.00	22	2.18	2.00	1.00	3.00
6~7	66	2.62	2.00	1.00	4.00	17	3.00	3.00	2.00	4.00	36	2.78	3.00	2.00	4.00	13	1.69	1.00	1.00	2.00
7~8	38	2.32	2.00	1.00	3.00	11	2.36	3.00	1.00	3.00	21	2.43	2.00	1.00	3.00	6	1.83	1.00	1.00	3.00
8~9	23	2.52	2.00	2.00	3.00	10	2.60	2.00	2.00	3.00	12	2.50	2.00	1.00	3.50	1	2.00	2.00	2.00	2.00
9~10	16	2.19	2.00	1.00	3.50	6	2.67	2.50	1.00	4.00	9	2.00	2.00	1.00	2.00	1	1.00	1.00	1.00	1.00
>=11	23	1.91	2.00	1.00	3.00	5	2.20	2.00	1.00	3.00	18	1.83	2.00	1.00	2.00					
Total	1469	3.33	3.00	2.00	4.00	549	3.75	3.00	2.00	5.00	681	3.34	3.00	2.00	4.00	239	2.35	2.00	1.00	3.00

Panel F: Percentage of preceding funds that raise a follow-on

Sequence	All	BO	VC	RE
1	75.5%	76.5%	69.3%	96.0%
2	88.5%	88.4%	87.0%	94.3%
3	85.2%	88.1%	79.5%	95.3%
4	87.6%	89.2%	82.8%	97.1%
5	91.7%	97.1%	84.6%	100.0%
6	97.1%	100.0%	94.7%	100.0%
7	92.7%	100.0%	91.3%	85.7%
8	95.8%	100.0%	92.3%	100.0%
9	88.9%	85.7%	90.0%	100.0%
>=10	95.8%	100.0%	94.7%	
Total	84.2%	85.1%	80.0%	96.0%

Table III
Follow-on Fundraising Regressions

Preceding fund-level regressions to explain follow-on fundraising. Panel A presents probit regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. Marginal effects are reported and z-scores are given in parentheses. Panels B and C present OLS regressions for preceding funds that raise a follow-on fund. In Panel B, the dependent variable is fund growth, defined as follow-on fund size divided by preceding fund size minus one. In Panel C, the dependent variable is the natural logarithm of fund growth plus two, i.e. the natural logarithm of follow-on fund size divided by preceding fund size plus one . In all Panels,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. In Panels B and C, t-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Probit regressions for the probability of raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	0.316***	0.324***	0.467***	0.588***	0.297***	0.288***	0.187***	0.393**
	(4.788)	(4.563)	(4.814)	(4.742)	(3.337)	(3.032)	(2.671)	(2.487)
Number of observations	1,745	1,622	645	560	851	786	249	115
Pseudo R2	0.084	0.146	0.087	0.140	0.043	0.128	0.073	0.166

Panel B: OLS regressions for growth in fund size conditional on raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	0.663**	0.623**	2.314***	2.152***	0.492	0.426	1.955***	1.723***
	(2.088)	(2.045)	(4.119)	(3.316)	(1.634)	(1.413)	(3.029)	(2.724)
Constant	0.984***	1.590***	0.675***	2.034	0.699***	0.887***	0.602***	-0.107***
	(11.545)	(2.770)	(7.390)	(1.569)	(9.902)	(4.489)	(4.810)	(-2.691)
Number of observations	1,469	1,469	549	549	681	681	239	239
Adjusted R2	0.026	0.038	0.058	0.075	0.021	0.027	0.014	0.036

Panel C: OLS regressions for log(fund growth + 2) conditional on raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	0.177***	0.161***	0.524***	0.466***	0.139**	0.101**	0.572***	0.503***
	(2.813)	(2.798)	(5.065)	(3.967)	(2.553)	(2.120)	(3.280)	(2.901)
Constant	0.991***	1.126***	0.926***	1.114***	0.886***	1.003***	0.853***	0.662***
	(52.650)	(12.882)	(45.103)	(6.450)	(59.797)	(13.045)	(23.575)	(60.784)
Number of observations	1,469	1,469	549	549	681	681	239	239
Adjusted R2	0.039	0.070	0.050	0.081	0.033	0.088	0.024	0.073

Table IV
Follow-on Fundraising Regressions: Sequence Interactions

Preceding fund-level regressions to explain follow-on fundraising, with sequence interactions. Panel A presents linear probability regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. Panels B and C present OLS regressions for preceding funds that raise a follow-on fund. In Panel B, the dependent variable is fund growth, defined as follow-on fund size divided by preceding fund size minus one. In Panel C, the dependent variable is the natural logarithm of fund growth plus two, i.e. follow-on fund size divided by preceding fund size plus one. In all Panels,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. T-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Linear probability model for the probability of raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	0.305***	0.287***	0.698***	0.683***	0.214***	0.199***	0.227	0.144
	(4.082)	(4.141)	(5.447)	(4.925)	(3.159)	(3.427)	(1.578)	(1.055)
Preceding fund sequence number	0.033***	0.035***	0.048***	0.048***	0.030***	0.035***	0.004	-0.004
	(7.425)	(7.470)	(5.724)	(5.035)	(5.849)	(5.780)	(0.287)	(-0.338)
Preceding fund IRR*Preceding fund sequence #	-0.051***	-0.051***	-0.091***	-0.075**	-0.034**	-0.039***	0.004	0.041
	(-2.686)	(-2.957)	(-3.500)	(-2.494)	(-2.019)	(-2.777)	(0.087)	(0.888)
Constant	0.738***	0.927***	0.650***	0.802***	0.696***	0.902***	0.915***	0.993***
	(32.868)	(39.113)	(18.709)	(21.140)	(28.294)	(43.013)	(21.005)	(58.993)
Number of observations	1,745	1,745	645	645	851	851	249	249
Adjusted R2	0.072	0.124	0.110	0.135	0.043	0.137	0.015	0.068

Panel B: OLS regressions for growth in fund size conditional on raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	1.950***	1.911***	1.977**	1.537	1.964***	1.936***	3.899***	3.369***
	(3.142)	(3.079)	(2.093)	(1.640)	(2.695)	(2.619)	(2.886)	(2.611)
Preceding fund sequence number	0.040	0.050	0.016	0.011	0.034	0.056	0.036	0.011
	(1.246)	(1.565)	(0.301)	(0.247)	(0.888)	(1.539)	(0.433)	(0.131)
Preceding fund IRR*Preceding fund sequence #	-0.376**	-0.375**	0.127	0.215	-0.423**	-0.433**	-0.708**	-0.603*
	(-2.468)	(-2.501)	(0.355)	(0.610)	(-2.464)	(-2.536)	(-2.103)	(-1.704)
Constant	0.813***	1.333**	0.636***	2.092*	0.562***	0.607***	0.496	-0.183
	(6.011)	(2.322)	(3.768)	(1.657)	(4.221)	(2.588)	(1.604)	(-1.618)
Number of observations	1,469	1,469	549	549	681	681	239	239
Adjusted R2	0.043	0.055	0.056	0.076	0.060	0.067	0.018	0.039

Panel C: OLS regressions for log(fund growth + 2) conditional on raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund IRR	0.400***	0.388***	0.580***	0.466**	0.358***	0.334***	1.179***	1.039***
	(5.390)	(5.282)	(2.761)	(2.197)	(4.288)	(3.800)	(3.598)	(3.219)
Preceding fund sequence number	-0.010**	-0.007	-0.004	-0.006	-0.014**	-0.008	0.011	0.005
	(-2.037)	(-1.534)	(-0.333)	(-0.696)	(-2.512)	(-1.440)	(0.506)	(0.223)
Preceding fund IRR*Preceding fund sequence #	-0.066***	-0.066***	-0.021	-0.001	-0.063***	-0.066***	-0.221**	-0.196**
	(-3.062)	(-3.237)	(-0.305)	(-0.014)	(-2.831)	(-3.057)	(-2.477)	(-2.064)
Constant	1.006***	1.104***	0.935***	1.123***	0.925***	0.991***	0.821***	0.636***
	(45.394)	(13.539)	(23.543)	(6.858)	(39.443)	(14.805)	(10.612)	(19.044)
Number of observations	1,469	1,469	549	549	681	681	239	239
Adjusted R2	0.056	0.085	0.047	0.078	0.063	0.113	0.037	0.085

Table V
Sensitivity of GP Lifetime Revenue to Current Performance

This table presents estimates of the sensitivity of GP lifetime revenue to current performance, assuming the current fund is the first in the partnership's sequence of funds. Panel A presents estimates of the direct effect of a one percentage point improvement in net return to LPs (IRR) in the current fund, relative to the sample average return, on GP revenue from the current fund. Sample means are taken from Table II. We assume that the cash flow distribution that gives rise to the IRR is a single cash in and a single cash out, spaced 3 years apart. The GP revenue share of 25% is based on the standard carry of 20% (for each $1 returned to LPs, GPs receive $0.25). At the baseline level of performance, the carry is in the money. Discount rates of 12%, 9%, 15% and 9% are used for All Funds, Buyout, Venture, and Real Estate, respectively. Present value of GP revenue/dollar is the discounted value of the 25% revenue share.

Panel B presents estimates of the indirect effect of a one percentage point (δTR/δIRR) or one dollar (δTR/δD) improvement in net return to LPs in the current fund on the present value (using the same discount rates) of expected GP revenue from future funds. Estimates are computed using the formulas provided in Sections II and V, using sample parameters from Table II and regression coefficients and marginal effects from Table III. N is the maximum number of future funds the GP could potentially run. k is the expected fraction of future fund sizes that the GP receives as compensation.

Panel A: Direct effect of incremental performance on GP revenue from current fund

	All funds	Buyout	Venture	Real Estate
Current fund is first in sequence				
Mean current fund size ($M)	262.3	417.5	124.0	286.4
Mean current fund IRR	15.75%	17.23%	14.04%	17.50%
Years between cash in/out	3	3	3	3
Revenue share	25%	25%	25%	25%
Incremental GP revenue ($M)	2.636	4.303	1.209	2.965
Discount rate	12%	9%	15%	9%
Present Value of GP revenue ($M)	1.876	3.323	0.795	2.290
Present Value of GP revenue/dollar	0.178	0.193	0.164	0.193

Panel B: Indirect effect of incremental performance on GP expected revenue from future funds

Indirect effect ($M)

All Funds	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
15%	0.884	0.084	1.657	0.157
20%	1.179	0.112	2.210	0.210
25%	1.474	0.140	2.762	0.262

Buyout	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
15.75%	3.650	0.212	8.259	0.480
17.72%	4.107	0.239	9.293	0.540
19.60%	4.542	0.264	10.278	0.597

Venture	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
20.24%	0.337	0.070	0.478	0.099
22.84%	0.380	0.078	0.539	0.111
26.11%	0.434	0.090	0.616	0.127

Real Estate	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
15%	1.827	0.154	3.117	0.263
20%	2.435	0.205	4.156	0.350
25%	3.044	0.257	5.195	0.438

Ratio of indirect to direct effect

All Funds		
k	N=3	N=5
15%	0.471	0.883
20%	0.628	1.178
25%	0.785	1.472

Buyout		
k	N=3	N=5
15.75%	1.098	2.486
17.72%	1.236	2.796
19.60%	1.367	3.093

Venture		
k	N=3	N=5
20.24%	0.423	0.601
22.84%	0.478	0.678
26.11%	0.546	0.775

Real Estate		
k	N=3	N=5
15%	0.798	1.361
20%	1.064	1.815
25%	1.329	2.269

Table VI

Sensitivity of GP Lifetime Revenue to Current Performance in the Sequence of Funds

This table presents estimates of the sensitivity of GP lifetime revenue to current performance, for different assumptions about the placement of the current fund in the partnership's sequence of funds. Discount rates of 12%, 9%, 15% and 9% are used for All funds, Buyout, Venture and Real Estate, respectively. Panel A presents estimates of the direct effect of a one percentage point improvement in net return to LPs (IRR) in the current fund, relative to the sample average return, on GP revenue from the current fund. Sample means are taken from Table II. We assume that the cash flow distribution that gives rise to the IRR is a single cash in and a single cash out, spaced 3 years apart. The GP revenue share is 25%, based on the standard carry of 20% (for each $1 returned to LPs, GPs receive $0.25). At the baseline level of performance, the carry is in the money. Discount rates of 12%, 9%, 15% and 9% are used for All Funds, Buyout, Venture, and Real Estate, respectively.

Panel B presents estimates of the indirect effect of a one percentage point (δTR/δIRR) or one dollar (δTR/δD) improvement in net return to LPs in the current fund on the present value (using the same discount rates) of expected GP revenue from future funds. Estimates are computed using the formulas provided in Section V, using sample parameters from Table II and regression coefficients from Table IV which take sequence interactions into account. N is the maximum number of future funds the GP could potentially run. k is the expected fraction of future fund sizes that the GP receives as compensation.

Panel A: Direct effect of incremental performance on GP revenue from current fund

	All funds	Buyout	Venture	Real Estate
Current fund is first in sequence				
Mean current fund size ($M)	262.3	417.5	124.0	286.4
Mean current fund IRR	15.75%	17.23%	14.04%	17.50%
Incremental GP revenue ($M)	2.636	4.303	1.209	2.965
Discounted	1.876	3.323	0.795	2.290
Current fund is second in sequence				
Mean current fund size ($M)	362.9	587.8	169.9	438.0
Mean current fund IRR	13.45%	16.83%	10.56%	14.56%
Incremental GP revenue ($M)	3.503	6.018	1.558	4.311
Discounted	2.493	4.647	1.024	3.329
Current fund is third in sequence				
Mean current fund size ($M)	488.2	812.5	216.3	530.0
Mean current fund IRR	12.41%	15.62%	10.14%	11.59%
Incremental GP revenue ($M)	4.627	8.145	1.967	4.950
Discounted	3.293	6.290	1.294	3.822

Panel B: Indirect effect of incremental performance on GP expected revenue from future funds

Indirect effect ($M)

All Funds

k=20%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	1.034	0.098	1.331	0.126
2	1.164	0.083	1.330	0.095
3	1.063	0.057	0.927	0.050

Buyout

k=17.72%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	4.271	0.248	7.807	0.454
2	6.048	0.251	9.779	0.406
3	8.223	0.252	11.007	0.338

Venture

k=22.84%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	0.309	0.064	0.350	0.072
2	0.332	0.053	0.354	0.057
3	0.250	0.032	0.229	0.029

Real Estate

k=20%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	3.139	0.265	4.482	0.378
2	3.163	0.183	4.639	0.269
3	2.790	0.141	4.291	0.217

Ratio of indirect to direct effect

All Funds

Current fund sequence	N=3	N=5
1	0.551	0.709
2	0.467	0.533
3	0.323	0.281

Buyout

Current fund sequence	N=3	N=5
1	1.285	2.349
2	1.302	2.104
3	1.307	1.750

Venture

Current fund sequence	N=3	N=5
1	0.389	0.440
2	0.324	0.346
3	0.193	0.177

Real Estate

Current fund sequence	N=3	N=5
1	1.371	1.957
2	0.950	1.393
3	0.730	1.123

Table A-I
Correlation between Interim and Final IRRs and Sensitivity of Follow-on Fundraising to Interim Performance

Panel A presents correlations between interim IRR at time of fundraising and final IRR for all preceding funds for which interim IRR data are available. For preceding funds that do not raise a follow-on, we use the interim IRR after three years (the sample average time to next fundraising). Panels B and C present preceding fund-level regressions to explain follow-on fundraising using this interim IRR. Panel B presents probit regressions in which the dependent variable is 1 if a follow-on is raised and 0 otherwise. Marginal effects are reported and z-scores are given in parentheses. Panel C presents OLS regressions for preceding funds that raise a follow-on fund. In Panel C, the dependent variable is the natural logarithm of fund growth plus two. In Panels B and C,"All Funds" regressions include fund type fixed effects and model (2) includes vintage year fixed effects. Heteroskedasticity-robust standard errors are clustered at the PE firm level. In Panel C, t-statistics are given in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Correlation between Interim IRR at time of fundraising and Final IRR

	All Funds	Buyout	Venture Capital	Real Estate
Correlation	0.607	0.551	0.618	0.228
Number of observations	801	304	433	64

Panel B: Probit regressions for the probability of raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.383***	0.459***	0.484***	0.574***	0.345**	0.399**	0.159	1.048*
	(3.165)	(3.400)	(3.361)	(3.437)	(2.117)	(2.229)	(1.486)	(1.738)
Number of observations	801	715	304	255	433	383	64	18
Pseudo R2	0.076	0.124	0.096	0.142	0.055	0.140	0.034	0.198

Panel C: OLS regressions for log(fund growth + 2) conditional on raising a follow-on fund

	All Funds		Buyout		Venture Capital		Real Estate	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Preceding fund interim IRR	0.126**	0.099**	0.203	0.217	0.099**	0.062*	0.816***	0.660***
	(2.369)	(2.247)	(1.631)	(1.611)	(2.086)	(1.741)	(3.887)	(4.129)
Constant	0.947***	1.108***	0.934***	1.125***	0.825***	0.960***	0.685***	0.796***
	(41.144)	(15.555)	(32.282)	(10.530)	(52.100)	(13.148)	(9.497)	(27.411)
Number of observations	651	651	251	251	339	339	61	61
Adjusted R2	0.042	0.116	0.013	0.123	0.018	0.120	0.112	0.263

Figure 1: Ratio of indirect to direct pay for performance
Discount rates: All Funds 12%, Buyout 9%, Venture Capital 15%, Real Estate 9%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The indirect effect is the estimated effect on expected revenue from future funds, while the direct effect comes from carried interest in the current fund. The figure presents estimates computed using the formulas provided in Section V, sample parameters from Table II, and regression coefficients from Table IV. Estimates are computed for all funds taken together, buyout funds, venture capital funds, and real estate funds, for different assumptions about the current fund's placement in the partnership's sequence of funds. All estimates assume N, the number of potential future funds, is equal to five. Discount rates of 12%, 9%, 15%, and 9% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1 for buyout funds, 2 for venture capital funds, and 1 for real estate funds. The discount rate for all funds is a sample-size weighted average of the type-specific discount rates.

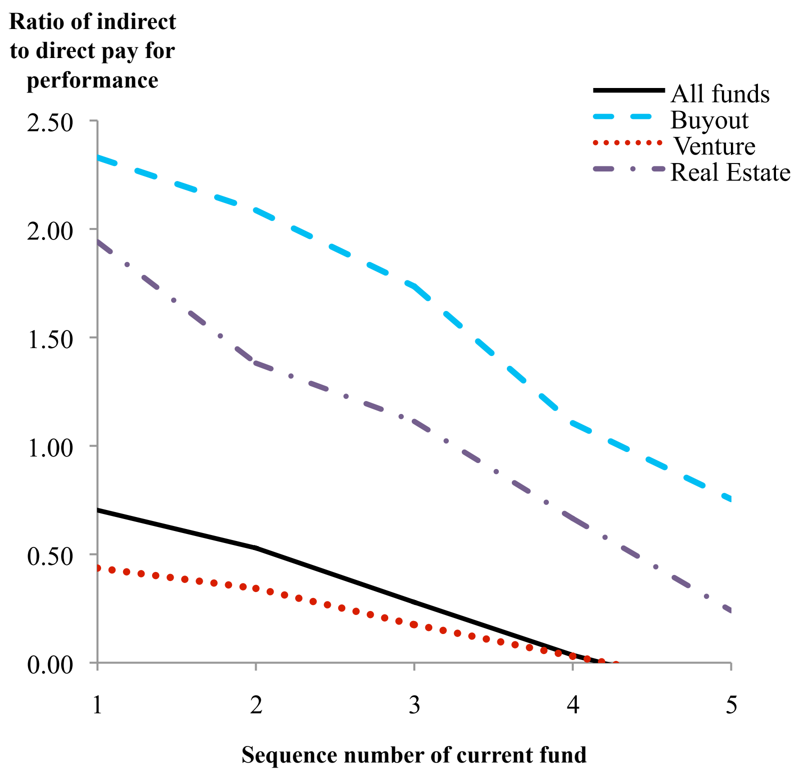

Figure 2: Ratio of indirect to direct pay for performance
Discount rates: All Funds 17%, Buyout 14%, Venture Capital 20%, Real Estate 14%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1 except that it uses different discount rates. Discount rates of 17%, 14%, 20%, and 14% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates are 5 percentage point increments from those used in Figure 1.

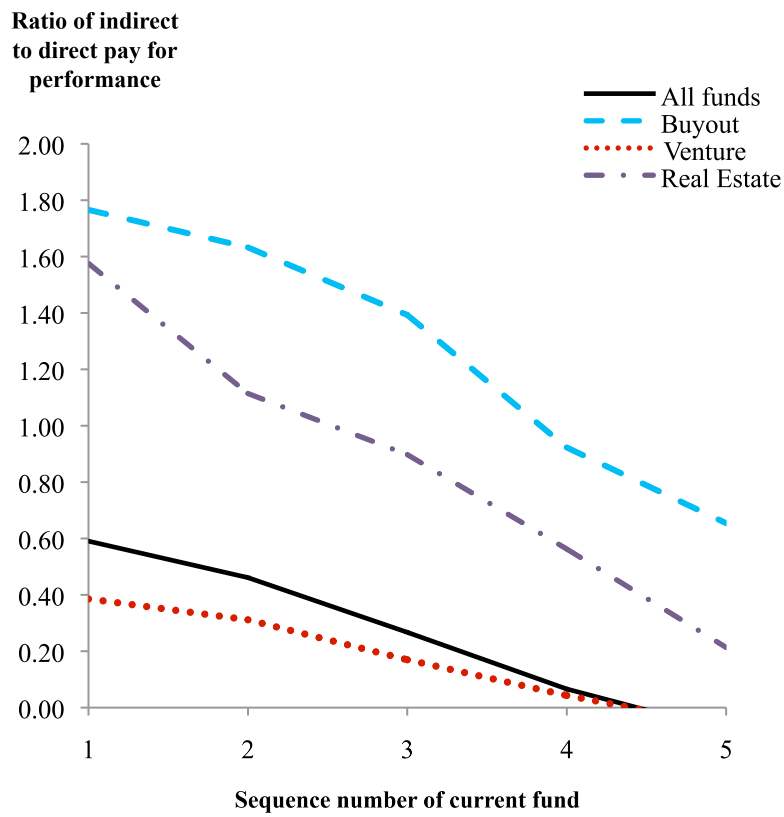

Figure 3: Ratio of indirect to direct pay for performance
Discount rates: All Funds 10%, Buyout 11%, Venture Capital 8%, Real Estate 11%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1 except that it uses different discount rates. Discount rates of 10%, 11%, 8%, and 11% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1.3 for buyout funds, 0.86 for venture capital funds, and 1.3 for real estate funds.

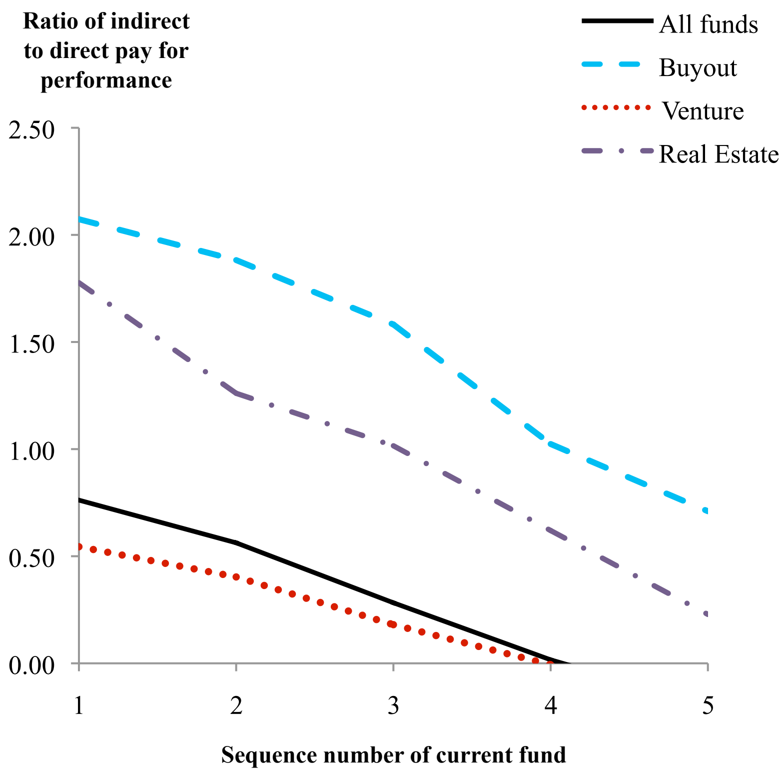

Figure 4: Ratio of indirect to direct pay for performance
Discount rates: All Funds 16%, Buyout 11%, Venture Capital 21%, Real Estate 11%

This figure presents estimates of the ratio of the indirect to direct effect of an incremental improvement in performance in the current fund on GP revenue. The figure is identical to Figure 1 except that it uses different discount rates. Discount rates of 16%, 11%, 21%, and 11% are used for all funds taken together, buyout funds, venture capital funds, and real estate funds, respectively. These discount rates correspond to betas of 1.3 for buyout funds, 3 for venture capital funds, and 1.3 for real estate funds.