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ABSTRACT

Lifetime incomes of private equity general partners are affected by their current funds' performance through both carried interest profit sharing provisions, and also by the effect of the current fund's performance on general partners' abilities to raise capital for future funds. We present a learning-based framework for estimating the market-based pay for performance arising from future fundraising. For the typical first-time private equity fund, we estimate that implicit pay for performance from expected future fundraising is approximately the same order of magnitude as the explicit pay for performance general partners receive from carried interest in their current fund, implying that the performance-sensitive component of general partner revenue is about twice as large as commonly discussed. Consistent with the learning framework, we find that implicit pay for performance is stronger when managerial abilities are more scalable and weaker when current performance contains less new information about ability. Specifically, implicit pay for performance is stronger for buyout funds compared to venture capital funds, and declines in the sequence of a partnership's funds. Our framework can be adapted to estimate implicit pay for performance in other asset management settings in which future fund flows and compensation depend on current performance.

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I. Introduction

Compensation agreements in private equity (PE) partnerships typically give general partners (GPs) a management fee that is a percentage (usually 1 to 2%) of the amount of capital committed to the fund, as well as "carried interest" equal to a percentage of the profits (usually 20%). The carried interest, together with the GP's own equity contribution to the fund, links GP compensation to performance to a much greater extent than is typical in public corporations. This strong pay for performance, and the resulting explicit incentives to make value-maximizing decisions, is commonly thought to be an important driver of the success of private equity firms.[1]

Yet, these explicit compensation formulas represent only part of the total pay for performance faced by private equity GPs. GPs' lifetime incomes are highly dependent on their ability to raise capital in the future, which in turn is a function of the performance of the GPs' current funds. Consequently, in addition to the carried interest and the partners' own investment in the fund, general partners' lifetime incomes are substantially affected by their funds' performance through its impact on subsequent fundraising. GPs' total pay for performance equals the sum of pay for performance features of the explicit compensation contract and the implicit, market-based pay for performance caused by the relation between today's performance and the ability to raise capital in the future.

This type of indirect pay for performance is not specific to private equity; indeed, it is a substantial source of incentives in many settings.[2] Yet, despite the widespread theoretical interest in implict incentives and their importance to real-world organizations, little is known about their actual magnitude. This gap in our knowledge is surprising given that understanding the size of the pay for performance relation through market-based rather than compensation-based mechanisms is essential to drawing inferences about managers' motivations.

In this paper, we estimate the magnitude of implicit pay for performance in the private equity industry. To do so, we exploit the fact that in the private equity industry, GPs' explicit compensation

[1] See, for example, Jensen (1989), Kaplan (1989), and Kaplan and Stromberg (2009).

[2] Examples include promotion or elimination tournaments inside corporations (e.g. Lazear and Rosen, 1981; Green and Stokey, 1983; 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 securities analysts will be promoted or fired depending on the accuracy of their forecasts (Hong and Kubik, 2000; Hong, Kubik, and Solomon, 2003). Like the private equity industry, market-based pay for performance in other asset management settings such as mutual funds and hedge funds arises from a relation between performance and future inflows of new investment.

is given by well-known formulas that are a function of fund size and the fund's return. In addition, we observe a time series of a partnership's funds and their performance, so it is possible to estimate the extent to which a fund's current return affects its general partners' future fundraising, and hence their expected future income.

Our estimates allow us to address a number of important questions about the private equity industry. In particular, for every extra percentage point of returns (or every extra dollar) earned for the current fund's investors, how much, in expectation, does the lifetime income of the fund's general partner change? How strong is this implicit pay for performance relation relative to the much-discussed explicit one? Theoretically, what factors ought to affect the size of change in partners' lifetime incomes as a function of fund returns? Do these predicted patterns appear true in the data? More generally, how do today's returns affect the ability of partnerships to raise capital subsequently? How important is future fundraising to the total (explicit plus implicit) pay-performance relation facing private equity general partners?

To answer these questions, we formalize the logic by which good performance today could lead to higher future incomes for GPs through an effect on expected future fundraising. We assume that a private equity partnership potentially has an ability to earn abnormal returns for their investors, but this ability is unknown. Given an observation of returns, 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 our framework, there is a maximum number of future funds the GP can potentially manage in sequence, and failure to raise a follow-on fund at any point in the sequence means that the GP is unable to raise any more funds subsequently. We derive predictions about the relation between the performance of a particular fund and the fund's partners' abilities to raise capital in the future. Intuitively, the more informative the fund's performance is about GPs' abilities, the more sensitive future fundraising should be to today's performance. In addition, the way in which abilities can be "scaled" will affect investors' willingness to commit higher quantities of capital for a given level of managerial ability. These larger funds will lead, in expectation, to higher compensation for the partners, since PE compensation agreements almost always change linearly with fund size. Given this setup, we derive an explicit formula calculating the effect of an incremental increase in fund performance today on expected future GP compensation.

We test these predictions using a sample of 843 private equity partnerships who manage 1,745 buyout, venture capital, and real estate funds for which we have information on fund performance. The ability of managers to translate their skills to larger funds depends on the nature of the production process. Given Metrick and Yasuda's (2010) finding that buyout funds are more scalable than venture funds, our theoretical framework suggests that the future fundraising of buyout funds should be more sensitive to performance than that of venture capital funds. In addition, learning about ability suggests that the performance of later funds (for example, a partnership's third or fourth fund) should have less impact on the assessment of ability and hence be less strongly related to future inflows of capital than would similar performance in a partnership's first fund.

Our empirical results are consistent with these predictions. For buyout, venture capital, and real estate funds, both the probability of raising a follow-on fund and the size of the follow-on conditional on raising one are significantly positively related to the performance of the current fund. The magnitude of these relations varies with the scalability of the investments. Buyout funds, which are the most scalable, have the strongest relations, while venture capital funds, which are the least scalable, have the weakest relation.

Importantly, we find that these relations are stronger for funds that are earlier in a partnership's sequence of funds, that is, younger partnerships have stronger relations between future fundraising and current fund returns than older partnerships. This suggests that fund flows in the private equity industry reflect learning about ability over time, and that the strength of the market-based, implicit pay for performance facing a private equity partnership depends on the extent of its prior track record.[3]

Given these estimates of the sensitivity of future fundraising to current performance, we next turn to calculating the magnitude of the pay-performance relation facing general partners, and consider the relative magnitudes of its explicit (from carried interest in the current fund) and implicit (from future fundraising) components. Our theoretical framework provides an explicit formula for the change in general partners' lifetime incomes as a function of the return of the current fund. To perform the calculations, we use this formula, our estimates of the sensitivity of future fundraising to current performance, parameters reflecting the characteristics of our sample of private equity

[3] It is likely that similar patterns hold in the flow-performance relations for other asset mangement settings, in which learning is likely to play an important role in determining fund flows, such as mutual funds (e.g. Berk and Green, 2004) and hedge funds. In the mutual fund literature, the possibility that the sensitivity of flows to performance depends on fund age is generally ignored. A notable exception is Chevalier and Ellison (1997), who find that the sensitivity is indeed larger for younger funds.

funds, and estimates of expected carried interest and management fees taken from Metrick and Yasuda's (2010) simulations.

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 $3.75 million in direct fees in the current fund.[4] For this fund, estimates of expected incremental revenue from future funds for each additional percentage point of IRR in the current fund (using the median of the expected compensation estimates from Metrick and Yasuda (2010)), vary from $5.42 million if we assume the GP potentially runs up to three more funds to $11.30 million if instead the GP potentially runs up to five more funds. An alternative approach is to calculate the expected incremental GP revenue from future funds per extra dollar returned to limited partners in the current fund. For every extra dollar returned to LPs in the current fund, the GP earns $0.25 in carry (assuming that the carry is "in the money")[5], while estimates of incremental revenue from future funds for the average first-time buyout fund are $0.315 to $0.657. Both approaches yield the same ratios of estimated implicit to explicit pay for performance, which are 1.45 to 3.02.

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 funds than for buyout funds, with venture capital funds displaying the least sensitivity. For an average-sized first-time venture capital fund, estimates of incremental GP revenue from future funds per incremental dollar of returns to LPs in the current fund range from $0.105 to $0.133, depending on whether the GP potentially runs up to three or up to five more funds. For an average-sized first-time real estate fund, the corresponding estimates are $0.329 to $0.516. The corresponding ratios of estimated implicit to explicit pay for performance are 0.48 to 0.61 for venture capital funds and 1.51 to 2.37 for real estate funds.

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 future funds in addition

[4]For consistency with Metrick and Yasuda (2010), all dollar amounts are present values using a discount rate of 5%.

[5]Using a typical carry of 20%, for LPs to receive an extra dollar, the fund must earn an extra $1.25 in profits, with $0.25 going to the GPs.

to the current fund (regardless of the current fund's position in a partnership's sequence of funds), our estimates of the ratios of implicit to explicit pay for performance for buyout funds are 3.02 if the current fund is the first in a buyout partnership's sequence, 2.62 if the current fund is the second in sequence, and 2.13 if the current fund is the third in sequence. For real estate funds, the corresponding ratios of implicit to explicit pay for performance are 2.37, 1.70, and 1.37. For venture capital funds, they are 0.61, 0.44, and 0.18.

Overall, the estimates indicate that implicit pay for performance from future fundraising is an important component of the total pay for performance relation facing private equity GPs, and of approximately the same order of magnitude as explicit pay for performance from carried interest. Consistent with the learning framework, which suggests that the sensitivity of future fundraising to current performance should depend on the extent to which current performance adds incremental information to the market's assessment of the general partners' abilities, we find that implicit pay for performance, relative to the explicit component, declines in a partnership's sequence of funds. Indeed, we find that if we calculate implicit pay for performance using estimates of the relation between future fundraising and current performance that ignore sequence effects, the estimates we obtain are significantly larger, particularly for venture capital funds.

This paper is related to a number of different literatures. Our finding that implicit pay for performance from future fundraising is an important component of total pay for performance in private equity buttresses the arguments in prior work that the incentives of GPs are an important reason for value improvements in private equity transactions. Kaplan (1989) and Smith (1990) document that operating profitability increases following buyouts, although this pattern appears weaker for more recent buyouts (Guo, Hotchkiss, and Song, 2010). Jensen (1989) and Kaplan and Stromberg (2009) attribute these value increases in large part to the incentives facing general partners, although both focus on direct rather than indirect incentives. Kaplan and Stromberg (2001, 2003, 2005) and Hart (2001) emphasize the role of GPs' value-maximizing incentives in explaining the complexity and optimality of venture capital financing contracts. Kaplan and Schoar (2005), in perhaps the most related analysis to that done here, emphasize the talent of particular partnerships and find that the size of future funds is positively related to historical performance, but do not explictly consider how performance affects the ability to raise future funds as opposed to the size of future funds, nor how this sensitivity varies in the cross-section of partnerships or in the sequence of funds raised by a given partnership. None of this work attempts to estimate the magnitude of the effect of today's performance on GPs' future income.

Our results are also related to Metrick and Yasuda (2010), who find, based on the explicit terms of the partnership agreement, that approximately two-thirds of expected revenue to GPs from the current fund comes from fixed-revenue components that are not sensitive to performance. Our results suggest that their calculations understate the total incentive compensation that general partners have, and that performance-based compensation in private equity partnerships is larger than previously thought.

Our results on the declining strength of implicit pay for performance in the sequence of funds are also consistent with the darker view of implicit pay for performance in private equity advanced by Gompers (1996), who shows that younger venture capital partnerships are more likely to "grand-stand" by taking portfolio companies public prematurely in an effort to boost performance to aid in fundraising. While Gompers (1996) implicitly assumes that fundraising is more sensitive to performance for younger partnerships, our paper is the first to document this relation this empirically. An interesting topic for future research is to understand how young buyout partnerships, who we show have the strongest implicit pay for performance relation among different types of private equity funds, respond to the resulting incentives.

Closely related to this work is a large literature on mutual fund inflows and their relation to historical performance. Ippolito (1992), Chevalier and Ellison (1997), Sirri and Tufano (1998), Barclay, Pearson and Weisbach (1998), and Sensoy (2009) all estimate regressions predicting the inflows to mutual funds as a function of a fund's historical performance, and find a strongly positive (nonlinear) relation. While our framework is couched in terms of the private equity industry, our approach can be readily adapted to other settings in which implicit pay for performance stems from the effect of current performance on inflows of new investments, such as the mutual fund and hedge fund industries. Adapting our framework to quantify the total pay for performance relations facing mutual fund and hedge fund managers is an interesting topic for future research.

More generally, our work adds empirical evidence on the idea pioneered by Fama (1980) that market-based mechanisms can be an important source of pay for performance incentives. Despite the potential importance of implicit incentives in a variety of settings, little is known about their actual magnitudes. The explicit (and observable) compensation formulas in private equity partnerships, together with the empirical relation between fund performance and future fundraising, allow for quantification of both implicit and explicit pay for performance in private equity, which in other contexts clearly exist but are hard to measure. In doing so, our work is in the spirit of Gibbons and Murphy (1992), who emphasize the importance of understanding total, rather than only explicit, pay for performance. Given the magnitude of the decline in implicit pay for performance over a partnership's life, our estimates imply that total pay for performance declines over a partnership's life. The extent to which this compensation system is efficient, and why explicit pay for performance does not typically adjust enough in later funds to offset this decline, is an interesting question for future research.

The remainder of this paper proceeds as follows: Section II lays out the theoretical framework described above. Section III describes the database of private equity funds used in the analysis. Section IV presents estimates of the effect of today's fund returns on future fundraising. Section V performs calculations that transform these estimates into pay for perforamance relations, using the theoretical framework 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 in which investors assign cash flows to private equity partnerships based on their perceptions of GPs' abilities to earn profits. Investors observe the returns earned by a partnership, and based on their posterior estimate of GP ability collectively decide first, whether to invest in the GP's next fund (i.e., whether the GP is able to raise another fund), and second, how much to invest. Given that the compensation system in private equity partnerships is almost always a linear function of fund size (Gompers and Lerner, 1999)[6], we show that this capital allocation process leads to a strong relation between performance in a current fund and that fund's general partners' future compensation.

[6] Gompers and Lerner (1999) document that the most successful partnerships are sometimes able to increase their carry percentage in future funds. We do not have information on the carry percentage of specific funds, and therefore cannot formally incorporate this effect into our empirical analysis. Because this effect results in higher compensation in future funds for a given level of performance, by omitting it we understate the magnitude of the effect of current performance on future compensation, especially for first-time funds. We thank Josh Lerner for pointing this out.

A. Setup

To formalize this idea, we assume that a particular GP currently manages a fund and could potentially manage up to N more funds in sequence in the future. The GP has ability equal to θ, which is a measure of his ability to earn returns through private equity investing.[7] We assume that θ is unobservable and that there is symmetric information, so all agents, including the GP himself, have the same estimate of its value.[8] We also 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.

Let i denote the sequence of funds managed by a given GP, r_i be the net return to LPs for fund i, I_i be the size (committed capital) of fund i, and $I_i * k(r_i)$ be the total revenue earned by the GP for managing fund i, where $k(r)$ is an increasing and differentiable function, representing the fraction of the initial size of the fund that is earned by the GP if performance is r. The function $k(r)$ represents the total profits from running a fund that has a return equal to r, including management fees, carried interest, and other income earned by the fund, such as additional fees earned by funds for managing portfolio companies. We characterize GP compensation in this manner following Metrick and Yasuda (2010), who provide estimates for $k(.)$ using a simulation approach.

We assume that the fund returns are increasing (in expectation) with the GP's ability, θ, specifically, that $r_i \sim N\left(\theta, \frac{1}{s}\right)$ for all i, where s is the precision of the distribution. Before any returns are observed, the commonly held prior assessment of θ is $\theta_0 \sim N\left(\theta, \frac{1}{\tau}\right)$.[9] Under these assumptions, after observing the returns on i funds, the market's updated assessment of θ, θ_i, is given by:

$$\theta_i = \frac{\tau\theta_0 + s\sum_i r_i}{\tau + is} \tag{1}$$

for all i (DeGroot, 1970 provides a derivation of this Bayesian updating formula).

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

[8] The assumption that there is symmetric information about managers' abilities dates to Holmstrom (1982), and has been used in similar learning models by Gibbons and Murphy (1992), Hermalin and Weisbach (1998, 2009), 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 (abnormal) returns is an unobservable match between the individual and the tasks associated with earning profits as a general partner.

[9] θ_0 represents the expected skill of a particular GP conditional on all observable characteristics prior to any returns being observed. Different GPs will therefore have different values of θ_0 from one another and consequently can raise initial funds of different sizes.

We assume that investors base their decision about whether and how much capital to allocate to the GP's fund based on this updated assessment of θ. Specifically, a GP is able to raise a follow-on fund to fund i with probability $p(\theta_i)$, where $p(.)$ is a weakly increasing, differentiable function with range $[0,1]$. If investors decide to allocate capital to the GP's next fund, the amount they allocate is given by $f(\theta_i)$, where $f(.)$ is a weakly increasing, differentiable function with range $(0,\infty]$. We assume the GP could potentially run a total of $N+1$ funds over his lifetime (i.e, the initial fund plus up to N more). Thus the expected size of the follow-on fund is equal to $p(\theta_i) f(\theta_i)$. The upper bound on the number of future funds, N, is exogenously determined (e.g., a function of the GP's initial age). Importantly, we assume that if the GP ever fails to raise a follow-on, he cannot raise any funds subsequent to that point.

B. Cross-sectional implications

This simple learning model characterizes the way that 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 $EI_{i+1} = p(\theta_i) f(\theta_i) = p\left(\frac{\tau\alpha_0 + s\sum_i r_i}{\tau + is}\right) f\left(\frac{\tau\alpha_0 + s\sum_i r_i}{\tau + is}\right)$, 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 $p(.)$ function means that for a small increase in ability, the market is relatively more willing to allocate capital to a fund, presumably because the fund can profitably invest relatively large increases in capital, i.e., the fund is more "scalable". 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.

We expect buyout funds to be more scalable, and hence exhibit a larger $f'(.)$, than other types of funds, particularly venture funds. For example, if a manager is shown to be talented at buying out companies and increasing value, he can likely buy out larger companies and increase value similarly to what he has done with smaller companies if the market is willing to fund these investments. In contrast, if a manager has demonstrated that she is talented at investing in startup companies, she is unlikely to be able to increase fund size much because the size of startup investments is not scalable (and because it is not feasible to simply increase the number of investments given that increasing value is a time-consuming process).[10] It is less clear for what types of funds we would expect $p'(.)$ to be greater. We conjecture that $p'(.)$might be higher for buyout funds than venture for the same scalability reasons. In buyout, marginal underperformers may be 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. In contrast, even the most successful venture capital partnerships can only deploy a relatively limited pool of capital effictively, which limits the ability of partnerships to leverage high returns into substantially larger future funds. We also conjecture that the informativeness of returns is likely to be greater for buyout funds than for venture capital funds, to the extent that if a venture fund outperforms, it is typically due to the success of a small number of investments in the fund's portfolio. It is generally more difficult to tell skill from luck if the bulk of returns are generated by a few extremely successful investments.

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, so that the optimal updating rule means that subsequent θs do not change as much as earlier θs for a given return. For this reason, it seems likely that both the sensitivity of the probability of raising a follow-on fund to current performance and the sensitivity of follow-on size to future performance are decreasing in fund sequence. The weighting term strictly decreases as the numerator is s in each one, while the denominator increases with the sequence number. If $p(.)$ or $f(.)$ is linear, the prediction is unambiguous. However, if $p(.)$ or $f(.)$ is convex and $\theta_{i+1} > \theta_i$, or if $p(.)$ or $f(.)$ is concave and $\theta_{i+1} < \theta_i$, the pattern may go the other way. That said, even if the functions are highly nonlinear, on average we would not expect θ_{i+1} to differ much from θ_i, so it seems likely that the weighting term effect will dominate. Consequently, in the data we expect to

[10] Consistent with this logic is the fact that 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. Metrick and Yasuda (2010) also find consistent evidence examining the organizational structure of buyout partnerships compared to venture capital partnerships.

observe a decreasing sensitivity of future fund size to current performance as a given partnership manages subsequent funds.

C. Lifetime compensation of GPs

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

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

This formulation assumes that, following practice, GPs are compensated with a combination of management fees, which are a function of committed capital, and carried interest, which is a function of returns times the amount of capital in the fund. We think of the $k(.)$ function as incorporating these two elements, plus other fee income that is likely to be proportional to fund size. We assume that the maximum number of funds the GP will ever run is $N+1$. If the GP ever fails to raise a follow-on fund, he earns no future income from managing private equity investments. For example, income from the third fund is only obtained if a second fund is raised. Hence the expected revenue from the third fund is a function of the probability that the third fund is raised conditional on the assessment of ability following the second fund (which is given by $p(\theta_2)$) multiplied by the probability that the second fund is raised (which is given by $p(\theta_1)$).

We are interested in calculating the magnitude of the pay-performance relation facing general partners and decomposing it into the direct component, from carried interest in the current fund, and the indirect component, from greater probability of raising future funds and greater future fund size conditional on raising future funds. In other words, we are interested in calculating how much of incremental profits GPs expect to keep, and how much of this additional revenue comes in the form of direct vs. indirect compensation.[11]

The pay-performance relation facing the GP is the sensitivity of total lifetime revenue to r_1, which is given by:

[11] We refer to revenue and compensation synonymously throughout the paper. In fact, private equity partnerships do have some (but not many) costs that create a wedge between revenue and partner compensation. However, many of these costs, such as the costs of renting an office and hiring support staff, are more or less fixed and do not affect marginal compensation. In addition, our focus is on the indirect aspects of compensation and its size relative to direct compensation and it seems unlikely that this ratio would be substantially affected by ignoring direct costs in our calculations.

$$\frac{\partial TR}{\partial r_1} = k'(r_1) f(\theta_0) +$$

$$k(r_2)\left[p'(\theta_1) f(\theta_1) + p(\theta_1) f'(\theta_1)\right] \tfrac{s}{\tau+s} +$$

$$k(r_3)\left[p'(\theta_1) p(\theta_2) f(\theta_2) \tfrac{s}{\tau+s} + p(\theta_1) p'(\theta_2) f(\theta_2) \tfrac{s}{\tau+2s} + p(\theta_1) p(\theta_2) f'(\theta_2) \tfrac{s}{\tau+2s}\right] +$$

$$\ldots +$$

$$k(r_{N+1})\left[f(\theta_N) \textstyle\sum_{i=1}^{N} \left(p'(\theta_i) \tfrac{s}{\tau+is} \prod_{j=1,i\neq j}^{N} p(\theta_j)\right) + \prod_{i=1}^{N} p(\theta_i) f'(\theta_N) \tfrac{s}{\tau+Ns}\right]. \quad (3)$$

The terms above have natural interpretations. The first line in the expression above is the direct effect from carried interest in the current fund. This is the explicit component of the total pay-performance relation facing the GP. The following lines give the implicit 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. These terms are declining in the sequence of returns because the prior estimate of ability is more precise when more returns have been observed. The $k(.)$ terms outside the brackets represent the expected fraction of future fund sizes that accrues to the GPs as revenue.

Our goal is to provide empirical estimates of the derivative $\frac{\partial TR}{\partial r_1}$, and to compare the magnitude of the first term, which represents explicit pay for performance in the current fund, to that of the sum of the following terms, which represent implicit pay for performance stemming from the effect of current performance on future fundraising.

D. Empirical Implementation

We base our estimates of incremental expected revenue to the GPs from the current fund, $k'(r_1)$, on the standard 2% management fee plus 20% carried interest fee structure. For the $k(.)$ terms for future funds, we use the estimates provided by Metrick and Yasuda (2010), who calculate via simulation the expected fraction of a fund's total committed capital (size) that accrues as revenue to the GPs. For the $p(.)$ and $f(.)$ terms, we use the respective averages in our data sample: the fraction of funds that raise a follow-on, and the average size of follow-on funds conditional on raising a follow-on. Where appropriate, we compute these averages within fund type and/or sequence number. We obtain estimates of the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms using regressions that estimate the sensitivities of, respectively, the probability of raising a follow-on fund, and the size of the follow-on fund conditional on raising one, to current performance. We present the data we use to obtain these estimates, and describe the estimation methodology in more detail, in the the sections below. First, we discuss the generalizability of our framework to related settings.

E. Generalizing to other settings

An advantage of the theoretical framework outlined above is that it can be readily adapted to other settings, notably other asset management applications, in which implicit pay for performance arises from a relation between current performance and inflows of new investments, together with a compensation structure that pays managers, at least in part, as a function of assets under management. Both mutual funds and hedge funds share this feature with private equity in practice, and both are settings in which implicit pay for performance is likely to be an important component of total pay for performance.

A key difference between mutual funds and hedge funds compared to private equity is that the former are typically open-ended, and so fundraising in these industries is in fact a continuous process, and not a discrete event as in private equity. However, because the econometrician cannot observe fund flows continuously, the adaptations necessary to apply our framework to this case are modest. To account for this difference in our framework, one could imagine a manager potentially managing a fund for a some upper bound number of time periods (where the periodicity corresponds to the unit of observation for fund flows, e.g. years), and in each time period both flows and the likelihood of being fired are a function of past returns. Our learning setup, and the consequent decreasing sensitivity of flows to performance with age, seems appropriate for these settings as well.[12]

A complicating factor is that in these industries, unlike private equity, there is potentially an important wedge between the compensation of the fund managers (even taken as a group) and the fund management company. For example, while mutual fund companies receive a percentage of assets under management as revenue and cannot be fired except by a reduction of fund size to zero, mutual fund managers themselves can be fired, and little is known about their compensation structure conditional on remaining employed.[13] For these reasons, it may be easier to obtain reliable estimates of the implicit pay for performance relation facing mutual fund companies rather than the mutual fund managers themselves.

III. Data

To provide estimates of the total pay-performance relation facing private equity GPs, and the relative magnitudes of its explicit and implicit components, we rely on fund-level data provided by Preqin. We consider the three major types of private equity funds: buyout, venture capital, and real estate. There are a total of 9,523 buyout, venture capital, and real estate funds in Preqin as of June 2009, which, according to Preqin, 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 requests made to limited partners subject to the Act and thereby is not subject to self-reporting biases. While we cannot independently verify these claims, our data appear similar on key dimensions (notably performance) to that used in prior work.[14]

In all of our analysis, we exclude funds without vintage year data (64), without fund size (committed capital) data (1,137), and which are still being raised (78). We begin by constructing a sample of "preceding", or current, funds. To obtain estimates of the sensitivities of the likelihood of raising a follow-on fund, and the size of the follow-on conditional on raising one, to current

[12]Berk and Green (2004) present a model of mutual fund flows based on learning.

[13]Chevalier and Ellison (1999) explore agency problems between mutual fund managers and mutual fund management companies.

[14]In addition, any selection bias would likely oversample funds with good performance that do raise a follow-on fund. This would have the effect of downward-biasing our estimates of the relation between future fundraising and current performance. In the extreme, if every fund in the data raises a follow-on, the relation between current perforamance and ability to raise a follow-on fund is zero.

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, 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. The first is a few cases in which the same partnership manages, say, both buyout and real estate funds. In those cases, we treat the partnership as two separate partnerships, one each for buyout and real estate funds. We do so to ensure, for example, that a real estate fund cannot be a follow-on fund to a buyout fund. 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 on European buyouts and another focusing on Asian buyouts. In this case, we treat the European buyout funds and Asian buyout funds as two separate partnerships.

This sample construction leaves us with a final sample of 1,745 preceding funds. The sample consists of 645 (37%) buyout funds, 851 (49%) venture capital funds, and 249 (14%) real estate funds. For each of these preceding funds, we ask whether we observe a follow-on fund in the database. 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). Thus each preceding fund is allowed to have at most one follow-on fund. If we observe a follow-on fund raised by the end of our sample period (June 2009), we record the size of the follow-on fund and compute the growth rate in fund size from the preceding fund to the follow-on fund. If we do not observe a follow-on fund in the data, or if the data indicate follow-on funds 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.[15] Of the 1745 preceding funds, 1469 (84.2%) raise a follow-on fund. By fund type, the breakdown is 549 of 645 buyout funds (85.1%), 681 of 851 venture capital funds (80.0%), and 239 of 249 real estate funds (96.0%).

[15]This assumption has the effect of downwardbiasing 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, i.e., those that meet the data requirements described above, and therefore understate the true number of funds per partnership.

Panel B of Table I reports descriptive statistics on preceding fund size and performance (IRR), follow-on fund size and growth in size from preceding to follow-on funds, and the time elapsed between successive fundraisings, i.e. the difference between the vintage years of the preceding and follow-on funds. The latter three statistics are all conditional on raising a follow-on fund.

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 distributions mirror the familiar facts that buyout funds are typically larger than venture capital funds (with real estate in between), and that the distribution of private equity fund size is right-skewed.

The mean (median) preceding fund performance 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. These numbers are similar to those in Kaplan and Schoar (2005), who report average returns of 19% for buyout funds and 17% for venture capital funds (p. 1798). The similarity with Kaplan and Schoar (2005), who use a different data source (Venture Economics) and a different time period (their sample ends in 2001), is reassurance that our data do not suffer from important biases missing from data used in prior work.

The mean (median) follow-on fund size, conditional on raising one, is $792.2 ($314.0) million for all funds taken together, $1,465.3 ($632.6) million for buyout funds, $283.9 ($181.0) million for venture capital funds, and $694.2 ($425.0) million 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. These statistics show that follow-on funds are much larger than preceding funds, and are suggestive of the importance of implicit pay for performance through future fundraising in private equity.

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 fund's position in the partnership's sequence of funds. We compute a fund's sequence number relative to all funds of a given partnership in the 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. Performance generally increases in the sequence of funds, indicating that partnerships with good performance, and for whom performance is more likely to persist, are more likely to raise follow-on 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 realized performance in the current fund to raise new funds. This is consistent with the learning framework of Section II. Further consistent with this, the percentage of preceding funds that raise a follow-on is generally increasing in the sequence of funds.

IV. The Empirical Relation between Current Performance and Future Fundraising

In this section, we estimate the sensitivities of the probability of raising a follow-on fund, and the sensitivity of the size of the follow-on fund conditional on raising one, to current performance. In doing so, we have two goals. First, the regressions allow us to test the predictions developed in Section II concerning variation in these sensitivities in the cross-section of funds and in the sequence of funds within a partnership. Second, we use the regression coefficients to obtain estimates of the $p'(\theta_i)\frac{s}{\tau+is}$ and $f'(\theta_i)\frac{s}{\tau+is}$ terms in equation (3), which are necessary inputs to calculating the magnitude of implicit pay for performance arising from the possibility of future fundraising.

A. Base-case estimates of the sensitivity of future fundraising to current performance

Table III reports estimates of the relation between future and current performance that do not consider the possibility that the sensitivities can vary in the sequence of funds, as predicted by the learning framework presented in Section II. As we discuss in more detail below, these estimates provide a useful benchmark to assess the extent to which estimates of implicit pay for performance in private equity (and likely in related settings) are overstated if the sensitivity of future fund flows to current performance is declining in partnership age.

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 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. In all specifications, we cluster standard errors at the partnership level, following Kaplan and Schoar (2005). In addition, we estimate but to conserve space do not report regressions 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.

Panel A of Table III presents marginal effects, evaluated at the mean, from probit regressions 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 economically and statistically significantly positive for all funds taken as a whole (with fund type dummies included), and for each type of fund (buyout, venture capital, and real estate) considered separately. The point estimates from the specifications with vintage year fixed effects are slightly larger than those from the specifications without, and the regressions have larger R^2. In terms of magnitude, 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 scalability arguments and the theoretical framework of Section II, the estimated marginal effects are larger for buyout funds (0.467-0.588 percentage points) compared to venture capital funds (0.288-0.297 percentage points), and the differences in the probit coefficients between buyout funds and venture capital fundsare statistically significant.[16] The differences between buyout and real estate, and between venture capital and real estate, are not statistically significant. In unreported analysis, we obtain similar results using linear probability (i.e., OLS) models instead of probit. The estimated OLS coefficients are similar in magnitude and statistical significance to the estimated marginal effects at the mean from the probit specifications.

Panel B of Table III presents OLS regressions predicting the growth in fund size from preceding to follow-on fund as a function of IRR, for 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. The coefficients are all positive and are all 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, and statistically significant, while the differences between buyout and real estate are not.

Panel C of Table III reports analogous regressions in which 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. (We add one to avoid taking the logarithm of a number close to zero.) To the extent that the distribution of growth rates in the data is skewed (especially likely for venture capital funds), a logarithmic specification may fit the data better. Consistent with this, the R^2 values in Panel C are generally considerably higher than those in Panel B. Once again, the estimates indicate that current performance is strongly positively related to follow-on fund size. The coefficients are all positive and statistically significant, and the estimated effects for buyout

[16]Here and in all similar tests, we assess statistical significance by pooling the observations of buyout and venture capital funds 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.

funds and real estate funds are significantly larger than those for venture capital funds.

As an additional robustness check, in unreported analysis we repeat the analysis of Table III, eliminating all preceding funds for which the time to next fundrasing is less than three years, and find similar results. Among other things, this adresses the possibility that some large fund companies operate multiple types of funds simultaneously, such as one focusing on American buyouts and another focusing on European ones. The performance of the American funds may be reflective of the ability of the American partners and relatively uninformative about their European counterparts (although to the extent tha ability is partnership-specific rather than person-specific, this is not of concern). In this case, there are likely to be multiple fundraisings shortly after one another but the reason for one being able to raise a large fund may have little relation to the performance of some of the partnership's other funds' performance.

Overall, the evidence in Table III strongly supports the idea that implicit pay for performance from the possibility of future fundraising is likely to be an important component of the total pay-performance relation facing private equity GPs. Both the probability of raising a follow-on fund, and the size of the follow-on conditional on raising one, are strongly positively related to the performance of the current fund. In addition, these sensitivities are statistically and economically larger for buyout funds (and to some extent real estate funds) compared to venture capital funds, consistent with the idea that buyout is the most scalable and venture capital the least. In terms of the theoretical framework in Section II, this result suggests that buyout funds have the largest $p'(.)$ and $f'(.)$, and venture capital funds the least.

B. Sequence-specific estimates of the sensitivity of future fundraising to current performance

The estimates presented in Table III do not consider the prediction of the learning-based framework in Section II, 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 number interacted with IRR. We present results from specifications using the preceding fund's IRR "(1)", and the preceding fund's IRR augmented by vintage year fixed effects "(2)".[17]

[17] As in Table III, results are similar if we use the preceding fund's benchmark-adjusted IRR.

Panel A of Table IV presents regressions predicting the probability of raising a follow-on fund. In Panel A, we focus on linear probability models because of the difficulty interpreting marginal effects of interaction terms in probit specifications (and the potential bias in coefficient estimates resulting from including fixed effects in probit specifications).[18] As in Table III, we find that current performance is positively related to the probability of raising a follow-on fund for all funds taken together, for buyout funds, and for venture capital funds. 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. The coefficient on IRR for real estate funds is similar to that in Table III, but is estimated less precisely and insignificant. For all funds, and for buyout and venture capital funds individually, the coefficient on sequence number is positive and significant and the coefficient on the interaction of sequence number with IRR is negative and significant (the coefficients for real estate funds are insignificant). This pattern of coefficients is consistent with 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, but ability is estimated more precisely over time, so the marginal impact of current returns on 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, analogous 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 significant. With the exception of buyout funds, the coefficients on the interaction of sequence number with IRR are negative and significant.

Panel C of Table IV presents analogous regressions 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, statitically significant. In both Panels B and C, the coefficients indicate that the sensitivity

[18] See Ai and Norton (2003) and Greene (2000)

of fund growth to performance is not significantly greater for buyout funds compared to venture capital funds for first-time funds, but that the gap between grows quickly in the sequence of funds.

Overall, the evidence in Table IV supports the prediction of the learning-based framework in Section II that the sensitivity of future fundraising to current performance is declining in the sequence of funds managed by a given partnership. For all fund types, either the sensitivity of the probability of raising a follow-on fund to current performance is significantly decreasing in sequence number, or the sensitivity of growth in fund size conditional on raising a follow-on fund to current performance is significantly decreasing in sequence number. For all funds taken together, and for venture capital funds indidvidually, both effects are statistically significant. 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. Whether only one effect is significant or both, the implication is that the sensitivity of expected follow-on fund size to current performance is declining in the sequence of funds for all fund types.

We conjecture that similar patterns likely hold in the flow-performance relations for other asset mangement settings, in which learning is likely to play an important role in determining fund flows, such as mutual funds (e.g. Berk and Green, 2004) and hedge funds. In the mutual fund literature, with the notable exception of Chevalier and Ellison (1997), the possibility that the sensitivity of flows to performance depends on fund age is generally ignored.

C. Measurement issues

In all of the regressions presented in this section, we use the final or ultimate IRR of the fund 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 does so after 3 years of life, while final performance is not known until the end of the partnership's life. The key question is whether final, ex post IRR is a reasonable proxy for the information about performance that a fund's investors use 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. This soft information becomes observable to the econometrician only ex post, as it is reflected in the fund's final IRR. They find supporting evidence for this idea in that 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, it seems likely that a fund's final IRR is, if anything, a better proxy than its interim IRR for the information about performance investors in deciding whether to allocate capital to the partnership's next fund. Second, even if the interim IRR is the more desirable measure, to the extent that it is imperfectly correlated with final IRR, the standard errors-in-variables problem implies that our estimates will understate the sensitivity of future fundraising to performance. Kaplan and Schoar (2005) provide evidence that interim IRR (at 5 years) and final IRR are highly correlated, with correlation coefficients of about 0.90, 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.

Notwithstanding these arguments, in the Appendix we present regressions analogous to those in this section, but 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 obtain similar results to those presented in this section.

V. Estimating 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, and to compare the magnitudes of its explicit and implicit components. 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. Explicit (direct) pay for performance

We begin by estimating explicit pay for performance, or the change in revenue from the current fund the GP earns from an incremental improvement in performance. This is represented by the first term in equation (3) in Section II. We do this assuming the standard 20% carry, and that the baseline level of performance and fund size to which the increment is applied are equal to the relevant means in our sample (by type and sequence). The first two rows of Panel A of Table V display the relevant sample means for first-time funds. For all fund types, the baseline level of performance is positive (and greater than a potential hurdle rate of 8%), so the carry is in the money. The incremental revenue in the current fund to GPs for an incremental dollar returned to LPs is then \$0.25.[19] This is the metric emphasized by Jensen and Murphy (1990) in the context of CEOs of public companies.

To calculate the incremental revenue to GPs for an incremental percentage point improvement in IRR, it is necessary to make further assumptions. The IRR is an annualized return measure which has well-known problems such as the implicit assumption that intermediate distributions are reinvested at the IRR. To make things as simple as possible, and because our data are not sufficient to make more accurate calculations, we assume that all capital is called at once and all distributions are made at once. That is, we assume that each fund has a single capital call and a single distribution, and the time (denoted T) between the two matches the typical length of time in the data between the call of a dollar and the return of the profits associated with investing that dollar, which we take to be 3 years.

Under these assumptions, the 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 of the first fund and I_1 is the size (committed capital) of the fund. Note that because IRR is a net-of-fee measure, D represents the total dollars to limited partners, not the total dollars earned by the fund (some of which go to the GP in the form of management fees and carried interest). Let R be the revenue earned by the GP. Because $D(.)$ is an invertible function, we can use the chain rule to write: $\frac{\partial R}{\partial D} = \frac{\partial R}{\partial r_1}\frac{\partial r_1}{\partial D}$. Inverting D and differentiating yields:

[19] At a 20% carry, for LPs to receive \$1, the fund must earn \$1.25, with \$0.25 going to GPs.

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

This formula can be used 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 incremental revenue to GPs from extra carried interest in the current fund that arises from an incremental perncentage point improvement in IRR, calculated using this formula (with $\frac{\partial R}{\partial D} = 0.25$) 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 \$2.659 million in incremental revenue to the GP, or \$2.297 million in present value using a discount rate of 5% (applied for three years, the assumed cash in/cash out time interval).[20] For buyout funds the present value is larger, \$3.749 million, reflecting both the larger average size of buyout funds and the higher baseline level of performance (because of compounding, a given increment to returns has a larger effect with a larger baseline). The present value for venture capital funds is the smallest (\$1.054 million), and real estate funds fall in the middle (\$2.991 million). Again, for all fund types, the incremental revenue to GPs for an incremental dollar returned to LPs is \$0.25, or \$0.216 in present value (discounted at 5% for three years).

B. Implicit (indirect) pay for performance

We now turn to estimating implicit pay for performance arising from the effect of current performance on future fundraising. This effect corresponds to the second and above lines in equation (3) of Section II. This equation allows us to interpret our econometric estimates as estimates of the magnitude of implicit pay for performance in private equity. We perform this calcluation both in absolute terms and relative to the direct pay for performance offered by the carried interest in the current fund, and and also consider how the magnitudes vary across fund type and sequence.

To estimate the terms equation (3) of Section II, we require estimates of the $k\left(.\right)$ terms, the $p\left(.\right)$ and $f\left(.\right)$ terms, and the $p'\left(.\right)\frac{s}{\tau+is}$ and $f'\left(.\right)\frac{s}{\tau+is}$ terms. A key component of our calculation are the $k\left(.\right)$ terms, defined as the expected fraction of a fund's size (committed capital) that accrues to GPs as compensation, through a combination of mangement fees and carried interest. The appropriate

[20] We use a discount rate of 5% for consistency with Metrick and Yasuda (2010), because we rely on their estimates, which they obtain using a discount rate of 5%, to calculate implicit pay for performance in the sections below.

values for $k(.)$are not obvious, and depend on the fee structure as well as the entire distribution of returns, which matters because it affects the likelihood of the carried interest being "in the money" and the amount that it will be worth conditional on being in the money. Our analysis relies on the work of Metrick and Yasuda (2010), who perform Monte Carlo simulations to estimate $k(.)$ using details of the compensation structure in the partnership agreements of venture capital and buyout partnerships as well as data on the distribution of fund returns. Metrick and Yasuda (2010) provide estimates of the distribution of $k(.)$ for venture capital and buyout funds, and we use similar values for real estate funds (not considered by Metrick and Yasuda) 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 current fund is a first-time buyout fund. Then $p(\theta_1)$ is the fraction of preceding buyout funds of sequence number 1 that raise a follow-on fund in our sample. Panel F of Table II reports that this value equals to 76.5%. $f(\theta_1)$ is the average size of follow-on funds raised by preceding buyout funds of sequence number 1 (conditional on raising a follow-on fund). Panel C of Table II reports that this is equal to \$685.7 million. 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 vintage year, because they are generally more conservative than those from the specificaitons with vintage year.

We begin by obtaining estimates of these terms using the coefficients from Table III (which ignore sequence interactions). 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 $p'(.)\frac{s}{\tau+is}$, in which the constraint is imposed that the estimate is the same for all i, i.e., sequence is ignored.

Because a comparison of Panels B and C of Table III indicates that a logarithmic specification for follow-on fund size fits the data better, we use the coefficients from Panel C to obtain estimates of the $f'(.)\frac{s}{\tau+is}$ terms.[21] In the regressions 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

[21] In doing so, we are conservative. Our estimates of implicit pay for performance are higher, generally by about 10%, if we use the raw growth specification coefficients instead.

estimated regression coefficient, β, is an estimate of the derivative of this quantity with respect to r_i, the IRR of the preceding (ith) fund: $\beta = \frac{1}{\frac{f(\theta_i)}{f(\theta_{i-1})}+1} f'(\theta_i) \frac{s}{\tau+is}$. Rearranging, we have $f'(\theta_i) \frac{s}{\tau+is} = \beta (f(\theta_{i-1}) + f(\theta_i))$. As described above, we estimate the $f(.)$ terms using the type- and sequence-specific averages for preceding and follow-on funds in our sample. Note that even though the coefficient β is constrained to be the same across sequence number in these specifications, the estimates of $f'(.) \frac{s}{\tau+is}$ will differ with sequence number because of the differing $f(.)$ terms.

Continuing the example of the first-time buyout fund, the expected incremental compensation from the next (first follow-on) fund is given in equation (3) as $k(r_2)[p'(\theta_1) f(\theta_1) + p(\theta_1) f'(\theta_1)] \frac{s}{\tau+s}$. Metrick and Yasuda (2010) 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 (in the regression, IRR is expressed as a decimal rather than a percentage), and the coefficient from Panel C of Table III (again, converting decimal to percentage) is equal to 0.00524. 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 the present value as of the beginning of the life of the second fund (this is how Metrick and Yasuda compute $k(.)$), so to convert to present value as of the beginning of the current fund requires discounting at our discount rate (5%) for the average number of years elapsed between fundraisings (approximately 3 years in our data).

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 at 5% assuming a 3 year gap between successive fundraisings. We then add the discounted expected incremental compensation from each future fund to arrive at the total estimated implicit pay for performance. We first perform the calculations as described above, using the coefficients from Table III that ignore sequence interactions. We then repeat the calculations using the analogous coefficients from Table IV, that account for sequence interactions. The only change in the calculation described above is that, 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 (third fund overall) for buyout funds, the estimate of $p'(\theta_2)\frac{s}{\tau+2s}$ is given by (from Panel A of Table IV) $0.698 - 0.091 * 2 = 0.516$.

B.1. Estimates ignoring sequence effects

Panel B of Table V displays estimates of the implicit pay-performance relation facing private equity GPs, calculated using the coefficients from Table III (which ignore sequence effects) and the methodology described above. In Table V, we focus on first-time funds. We present results for all funds taken together, and for each fund type individually. We present results for different values of $k(.)$. For buyout funds, we use 15.75%, 17.72%, and 19.60%, which are, respectively, the 25th, 50th (median), and 75th percentiles calculated by Metrick and Yasuda (2010). For venture capital funds, the corresponding numbers calculated by Metrick and Yasuda (2010) are 20.24%, 22.84%, and 26.11%. The numbers for venture capital funds are higher because of the higher volatility of venture investments compared to buyout, which increases the value of the option on the investment portfolio implied by the carried interest. For all funds taken together and for real estate funds, we use 15%, 20%, and 25%. As shown in equation (3) in Section II, all of the estimates are linear in $k(.)$.

We also present results for different values of N, which as explained in Section II has the interpretation of the maximum number of funds the GP could potentially run (e.g., before retirement). Recall also that the thereotical framework in Section II incorporates the realistic feature that failure to raise a follow-on is a once and for all event (i.e., dropping out is permanent), and the formula for expected incremental GP compensation (equation (3)), and hence our resulting estimates, takes this into account.

In the columns labeled $\delta TR/\delta IRR$, we present estimates of the present value (at 5%) of the expected incremental revenue from furture funds resulting a one percentage point improvement in current fund IRR, and in the columns labeled $\delta TR/\delta D$ we convert these estimates into those resulting from a extra dollar returned to LPs using the formula (and the same assumptions) as in Section V. A., above. A convenient way of characterizing this effect is to take the ratio of these indirect incentives to the direct incentives from the carried interest in the current fund. This ratio is the same whether the performance measure is IRR or dollars (because the term in brackets in equation (4) drops out when taking the ratio). We present these ratios in the rightmost columns of Panel B of Table V.

It is evident from Panel B of Table V that implicit pay for performance from future fundraising is important in the private equity industry. The ratios reported in Panel B suggest that implicit pay for performance is at a minimum of the same order of magnitude as explicit pay for performance. The ratios range from a low of 0.563 for venture capital funds with $N = 3$ and $k = 20.24\%$ to a high of 4.113 for buyout funds with $N = 5$ and $k = 19.60\%$.

The variation in the magnitude of implicit pay for performance across different types of funds is consistent with the scalability arguments of Section II and the regression results of Tables III and IV. Implicit pay for performance is largest for buyout funds and smallest for venture capital funds, both in absolute terms and relative to explicit pay for performance.

Another way to view these results is to add explicit and implicit performance to obtain an estimate of total pay for performance for private equity general partners. Recall that under our assumptions, given that the carry is in the money, the discounted direct effect on GP compensation on returning an extra \$1 to LPs is \$0.216. To this we can add the numbers from the columns labeled $\delta TR/\delta D$, which range from \$0.213 to \$0.896, to obtain a total discounted change in GP wealth per extra (undiscounted) dollar returned to LPs ranging from \$0.429 to \$1.102, which by any metric is a strong pay-performance relation, and is at least two orders of magnitude larger than the \$0.00325 estimated by Jensen and Murphy (1990) for public company CEOs.

B.2. Estimates accounting for sequence effects

The estimates presented in Tables III and IV suggest that the implicit incentives calculated in Table V could potetially be affected by the declining sensitivity of future fundraising to current performance in the sequence of a partnership's funds. This implication comes directly from the learning framework presented in Section II, and the estimates presented in Table IV suggest that the magnitude of this effect is likely to be substantial.

In Table VI we consider the quantitative importance of this effect by estimating the implicit pay-performance relation facing private equity GPs, calculated using the approach described in Section V. B. above, and coefficients from Table IV (which take sequence effects into account) rather than those from Table III (which do not).

There are 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 funds, 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), current performance will have less of an impact on the market's assessment of ability, and so future fundraising will be less sensitive to it.

The pay-for-performance relations presented in Table VI strongly support these ideas. In Panel A, 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 ($0.25 undiscounted, $0.216 discounted), 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 implicit pay for performance, holding $k()$ fixed at its median values from Table V (as before all estimates are linear in $k())$. Two patterns are evident. The estimates are smaller than their counterparts in Table V, and decline rapidly with the sequence number of the current fund. The decline is fairly effects weak for buyout funds and very strong for venture capital funds. Figure 1 depicts these patterns graphically. For all funds taken together and for venture capital funds, implicit pay for performance declines to virtually zero by the time the partnership is managing its fourth fund, leaving only the explicit component.

While smaller than the estimates in Table V, the estimates for first-time current funds in particular are still quite large and of the same order of magnitude as direct effects from the current fund, with ratios of implicit to explicit pay for performance ranging from a low of 0.484 for venture capital funds with $N = 3$ to a high of 3.015 for buyout funds with $N = 5$. The estimates for second and third "current" funds are smaller but still substantial, and for buyout funds implicit pay for performance remains important well into a partnership's sequence of funds.

The rapid decline for venture capital funds in particular helps understand the findings in Gompers and Lerner (1999) that successful venture capital partnerships sometimes raise their carry percentages in future funds (typically to 25% or 30% from 20%). Gibbons and Murphy (1992) argue that optimal explicit pay for performance should increase when implicit, market-driven pay for performance decreases (e.g., as a person ages). However, the magnitude of the decline in implicit pay for performance is much too large to be offset by an increase in carry to 25% or even 30%, and so our estimates imply that total pay for performance declines over a partnership's life. The extent to which this compensation system is efficient is an interesting question for future research.

VI. Discussion and Conclusion

In the private equity industry, the possibility of future fundraising can provide substantial incentives to general partners above and beyond the much-discussed incentives from the explicit compensation system. Partnerships establish a reputation for being able to generate returns early in their careers, which can be lucrative later on as it allows partners to earn fees on larger funds subsequently. We present a learning framework that characterizes this process. We then provide estimates of the relation between current fund performance and future fundraising that allow us to estimate the size of the implicit pay for performance relation facing private equity general partners. Our estimates suggest that the implicit component of pay for performance is of the same order of magnitude as the explicit component from carried interest that has been commonly credited with much of the value creation in private equity. Implicit pay for performance, and the resulting incentives, are particularly important for newer partnerships who have yet to establish a reputation, and for younger partnerships who have the potential to reap the benefits of the reputation for a longer period of time.

Clearly there are a number of measurement issues that affect the interpretation of the results. Throughout the paper, our assumptions are intended to be realistic, and wherever possible, conservative. If anything, our conclusion that the implicit component of total pay for performance is approximately the same size as the explicit component likely understates its true importance. The calculation of the direct effect is likely an overestimate, as it assumes that general partners keep 20% of each incremental dollar while in fact they get less than that in expectation. In contrast, the calculation of the indirect effect ignores the possibility that individual partners can use their personal reputations to raise new funds on their own, or join other existing firms for lucrative salaries. These possibilities, which do occur fairly regularly, are examples of valuable reputational capital acquired by general partners through earning high returns that the formal analysis in this paper does not consider.

This paper contributes to the debate about the incentives of private equity managers and their effect on value creation. Metrick and Yasuda (2010) find that roughly two-thirds of the compensation in private equity partnerships comes from fixed rather than variable components of compensation. Our results suggest that their calculations understate the total incentive compensation that general partners have, and that performance-based compensation in private equity partnerships is larger than previously thought.

The analysis in this paper could be applied to other forms of organization. Perhaps the most straighforward would be to other asset management settings, because the explicit fee structures in this industry allow for straightforward calculation of the returns to managing a larger quantity of funds. Hedge funds have a somewhat different institutional structure than private equity funds with their infinite lives and their compensation system based on the "high-water mark". Nonetheless, it should be possible to adapt our framework to perform similar calculations for hedge funds as we do for private equity funds. In addition, mutual funds, pension funds, and private management of institutional capital, although with a different fee structure, similarly exhibit a relation between current performance and subsequent inflows of new investment. Calculating the incentives implicit in the flow-performance relations in these settings would be an important addition to our understanding of these industries.

Most generally, our analysis provides some empirical content to the idea started by Fama (1980) and Holmstrom (1982, 1999) that implicit pay for performance can be an important source of incentives inside firms. Holmstrom in particular argues that in an intertemporal setting, agents will take actions to maximize people's perception of their abilities, which can but do not necessarily coincide with increasing a firm's profitability. The advantage of focusing on the private equity setting as we do here is that it is possible to quantify the long-term pecuniary benefits to agents from these perceptions. Private equity is nonetheless 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 regressions predicting future fundraising as a function of a fund's interim, as opposed to final, IRR (see the discussion in Section IV. A.). 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. A.), 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 approximate the cash flow distribution that gives rise to the IRR as 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. We discount the incremental GP revenue at 5% for 3 years because the cashflow out is 3 years in the future. The discounted direct effect per extra undiscounted dollar of return to LPs is therefore $0.216.

Panel B presents estimates of the indirect effect of a one percentage point or one dollar improvement in net return to LPs in the current fund on the present value (using a 5% discount rate) 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. δTR/δIRR and δTR/δD are the incremental indirect effect from an extra percentage point and extra dollar of return, respectively.

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)		2.659	4.340	1.220	2.991
Discounted	5%	2.297	3.749	1.054	2.584

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%	1.347	0.128	3.215	0.305
20%	1.797	0.170	4.287	0.407
25%	2.246	0.213	5.359	0.508

Buyout

	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
15.75%	4.667	0.271	12.391	0.720
17.72%	5.250	0.305	13.940	0.810
19.60%	5.807	0.337	15.419	0.896

Venture

	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
20.24%	0.593	0.123	1.073	0.222
22.84%	0.670	0.138	1.211	0.250
26.11%	0.765	0.158	1.385	0.286

Real Estate

	N=3		N=5	
k	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
15%	2.311	0.195	4.447	0.375
20%	3.081	0.260	5.929	0.500
25%	3.851	0.325	7.412	0.625

Ratio of indirect to direct effect

All Funds

k	N=3	N=5
15%	0.587	1.400
20%	0.782	1.867
25%	0.978	2.333

Buyout

k	N=3	N=5
15.75%	1.245	3.305
17.72%	1.400	3.718
19.60%	1.549	4.113

Venture

k	N=3	N=5
20.24%	0.563	1.018
22.84%	0.635	1.149
26.11%	0.726	1.314

Real Estate

k	N=3	N=5
15%	0.894	1.721
20%	1.193	2.295
25%	1.491	2.869

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. Throughout, the discount rate is 5%. 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 approximate the cash flow distribution that gives rise to the IRR as 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. We discount the incremental GP revenue at 5% for 3 years because the cashflow out is 3 years in the future. The discounted direct effect per extra undiscounted dollar of return to LPs is therefore $0.216.

Panel B presents estimates of the indirect effect of an improvement in net return to LPs in the current fund on 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. δTR/δIRR and δTR/δD are the incremental indirect effect from an extra percentage point and extra dollar of return, respectively.

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)		2.659	4.340	1.220	2.991
Discounted	5%	2.297	3.749	1.054	2.584
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)		3.534	6.069	1.572	4.349
Discounted	5%	3.053	5.243	1.358	3.757
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)		4.668	8.216	1.985	4.994
Discounted	5%	4.033	7.097	1.715	4.314

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	1.508	0.143	2.200	0.209
2	1.683	0.120	2.045	0.146
3	1.510	0.082	1.150	0.062

Buyout

k=17.72%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	5.418	0.315	11.303	0.657
2	7.685	0.319	13.722	0.570
3	10.497	0.322	15.118	0.464

Venture

k=22.84%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	0.510	0.105	0.643	0.133
2	0.530	0.085	0.596	0.096
3	0.388	0.049	0.307	0.039

Real Estate

k=20%	N=3		N=5	
Current fund sequence	δTR/δIRR	δTR/δD	δTR/δIRR	δTR/δD
1	3.908	0.329	6.119	0.516
2	3.921	0.227	6.388	0.370
3	3.436	0.174	5.906	0.298

Ratio of indirect to direct effect

All Funds

Current fund sequence	N=3	N=5
1	0.657	0.958
2	0.551	0.670
3	0.374	0.285

Buyout

Current fund sequence	N=3	N=5
1	1.445	3.015
2	1.466	2.617
3	1.479	2.130

Venture

Current fund sequence	N=3	N=5
1	0.484	0.610
2	0.390	0.439
3	0.226	0.179

Real Estate

Current fund sequence	N=3	N=5
1	1.513	2.368
2	1.044	1.700
3	0.796	1.369

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

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.