The Investment Behavior of Buyout Funds: Theory and Evidence [*] [†]

Alexander Ljungqvist
Stern School of Business
New York University
and *CEPR*

Matthew Richardson
Stern School of Business
New York University
and *NBER*

Daniel Wolfenzon
Stern School of Business
New York University
and *NBER*

June 12, 2007

[*] We are grateful to an anonymous institutional investor for making data available for this study; to the Salomon Center at NYU Stern for generous financial assistance; and to Eric Green for many helpful discussions and suggestions. We thank Eric Stern for excellent research assistance. All errors are our own.

[†] Address for correspondence: Stern School of Business, New York University, Suite 9-190, 44 West Fourth Street, New York NY 10012-1126. Fax 212-995-4220. e-mail aljungqv@stern.nyu.edu (A. Ljungqvist), mrichar0@stern.nyu.edu (M. Richardson), dwolfenz@stern.nyu.edu (D. Wolfenzon).

The Investment Behavior of Buyout Funds:
Theory and Evidence

Abstract

This paper analyzes the determinants of buyout funds' investment decisions. In a model in which the supply of capital is 'sticky' in the short run, we link the timing of funds' investment decisions, their risk-taking behavior, and the returns they subsequently earn on their buyouts to changes in the demand for private equity, conditions in the credit market, and funds' ability to influence their perceived talent in the market. Using a proprietary dataset of 207 buyout funds that invested in 2,274 buyout targets over the last two decades, we then investigate the implications of the model. Our dataset contains precisely dated cash inflows and outflows in every portfolio company, links every buyout target to an identifiable buyout fund, and is free from reporting and survivor biases. Thus, we are able to characterize every buyout fund's precise investment choices. Our empirical findings are consistent with the model. First, established funds accelerate their investment flows and earn higher returns when investment opportunities improve, competition for deal flow eases, and credit market conditions loosen. Second, the investment behavior of first-time funds is less sensitive to market conditions. Third, younger funds invest in riskier buyouts, in an effort to establish a track record. Fourth, following periods of good performance, funds become more conservative, and this effect is stronger for younger funds.

JEL Classification: G23, G11.

Key words: Private equity; Buyout funds; Alternative investments; Fund management.

Over the past 25 years, private equity has grown into a sizeable asset class, with more than 9,000 funds raising in excess of $1.9 trillion from institutional and other investors (source: Venture Economics). Buyout funds account for 63% of this amount. In contrast to venture funds (which have received more academic attention), buyout funds usually purchase a controlling interest in an established corporation or one of its product lines, often involving large amounts of debt (i.e., leveraged buyouts). Despite their important role in financing firms and reallocating capital to more productive sectors of the economy, relatively little is known about the investment behavior of buyout funds. This paper provides a comprehensive analysis of the optimal investment plans of buyout funds in a setting where funds compete for target companies, the supply of capital is sticky in the short-run, and future fund-raising is sensitive to performance.

We develop a simple model of a buyout fund deciding how to invest its capital over time when faced with a choice between ‘safe’ and ‘risky’ buyout targets. In response to demand shocks, the supply of capital to buyout fund managers adjusts with a lag, which temporarily increases an existing fund manager’s bargaining power relative to target companies. Not surprisingly, funds generally make acquisitions when investment opportunities are good, their bargaining power is high, and debt is cheap. However, if fund manager skill is not observable, the optimal dynamic investment plan of a less established fund manager can involve making risky bets even if their expected returns are lower than for safe investments. This is akin to buying an option in the sense that a successful bet enables a young fund manager to raise a follow-on fund. Young fund managers may also invest at the wrong time, i.e., when competition, investment opportunities, and credit conditions are not at their most favorable. An important feature of the model is that its assumptions are chosen to be consistent with carefully documented empirical facts found in Gompers and Lerner (1998, 2000), Kaplan and Stein (1993), Lerner and Schoar (2004), and Kaplan and Schoar (2005), among others.

We test the predictions of the model with a unique and proprietary dataset made available to us by one of the largest institutional investors in private equity. It includes, among other items, precisely dated cash flows representing investments in 2,274 portfolio companies by 207 buyout funds started between 1981 and 2000. The dataset accounts for 35% of all buyout fund capital raised over the period and so affords a comprehensive view of investment behavior in the U.S. buyout industry.

The dataset has several advantages over others used in the literature. First, unlike commercial databases such as Venture Economics, VentureOne, or Asset Alternatives, it is free of self-reporting and survivor biases: We know the complete portfolio composition of every fund in the sample as well as the ultimate fate of each investment. This obviates the need to remove reporting and survivor biases through the use of structural econometric models (as in Cochrane (2005) or Hwang, Quigley, and Woodward (2005), among others). Second, we know the timing and magnitude of both cash outflows and cash inflows associated with every portfolio company, enabling us to compute not just fund-level performance measures but also returns for each portfolio company. Commercial databases generally keep fund-level performance data secret;[1] portfolio company returns are impossible to compute with any certainty from commercially available data, because the precise contractual structure of the investments (which determines the division of cash flows at exit) is not recorded. Third, we can map every buyout target to an identifiable buyout fund, which enables us to track each fund's precise investment choices. Commercial databases frequently do not know which fund in a manager's funds family made an investment and so credit many investments to 'unspecified' funds.

Our empirical results support the predictions of our model. We find that fund managers speed up their investments as investment opportunities improve, competition eases, and the cost of credit falls. More importantly, as predicted, the investment behavior of first-time funds is significantly less sensitive to market conditions. Their investment sensitivities increase relative to those of older funds following a string of early successes which obviate the need for strategic investment behavior. In terms

[1] See Kaplan and Schoar (2005), Jones and Rhodes-Kropf (2003) and Gottschalg and Phalippou (2007) for exceptions.

of the returns on invested capital that fund managers earn on their individual buyout deals, we find that performance is significantly greater in the same circumstances that favor fast investment: When investment opportunities are good, competition is low, and debt is cheap. Younger funds invest in riskier buyouts, consistent with our assumption that they seek to establish their track records. Following periods of good performance, funds become more conservative, and this reduction in risk-taking is stronger for younger funds.

Our results suggest that the return-generating process in private equity varies predictably with a small number of economic variables, such as investment opportunities, competition, and credit conditions, through their effects on the investment behavior of buyout fund managers. Importantly, they also suggest that new fund managers have strong incentives to invest inefficiently, both in terms of project choice and investment timing. The recent explosion in private equity has been accompanied by relatively loose credit conditions and a favorable investment climate, both of which our model predicts should lead to faster investment and eventually high returns. Against this, increasing competition for deal flow and entry by new fund managers predict low future returns.

1. Institutional Setting

In contrast to existing work which predominantly investigates venture capital (e.g., Gompers (1995), Gompers and Lerner (1996), Lerner (1994), and Hellmann and Puri (2002)), our model analyzing the investment behavior of private equity fund managers focuses on buyout funds. To a first approximation, the main difference is that VCs invest in young, fast growing, private companies while buyout funds invest in mature companies which they often take private, usually for structural reasons.

The competitive environment of buyout funds is easier to model than that of VC funds. First, buyouts are subject to fewer agency problems between managers and investors. The majority of buyouts involve one-off investments that result in outright or majority control. In contrast, venture investments are characterized by (i) minority stakes (Kaplan and Strömberg (2003)), (ii) a high degree of uncertainty and extreme informational asymmetries (Gompers and Lerner (1999)), and (iii) staged financing (Cornelli and Yosha (2003)). Second, the winning buyout fund is usually the highest bidder. In contrast, VC funds are often described as possessing unique skills that are not easily duplicated (Gorman and Sahlman (1989), Palepu (1990), Gompers and Lerner (1999), and Hellmann and Puri (2002)), so that the winning VC is not necessarily the one offering the highest valuation (Hsu (2004)).

Like VC funds, buyout funds are typically structured as limited partnerships with a fixed (usually ten-year) life. They are managed by the general partners (GPs) on behalf of their investors (the limited partners or LPs) who commit capital that is drawn down over the fund's life when GPs wish to buy a target company.[2] If the supply of LP capital is competitive and rational, LPs provide capital until their risk-adjusted expected returns (net of fees) equal the expected returns they could earn elsewhere.

In this setting, what type of investment behavior and returns do we expect to observe among buyout funds? This depends on how competitively funds supply capital to buyout targets. Suppose a positive shock hits either the buyout market (such as the creation of the high-yield debt market) or the market for buyout targets (such as the internet revolution). Assuming perfect, frictionless competition, capital would flow immediately into buyout funds which in turn would acquire target companies. Any NPV gains would accrue to the targets' shareholders as investors supply capital to funds until their risk-adjusted expected returns equal the opportunity cost of capital. The fees fund managers are paid would just cover their costs. Thus, LPs and GPs would break even in expectation, and no firm predictions about investment behavior could be made.

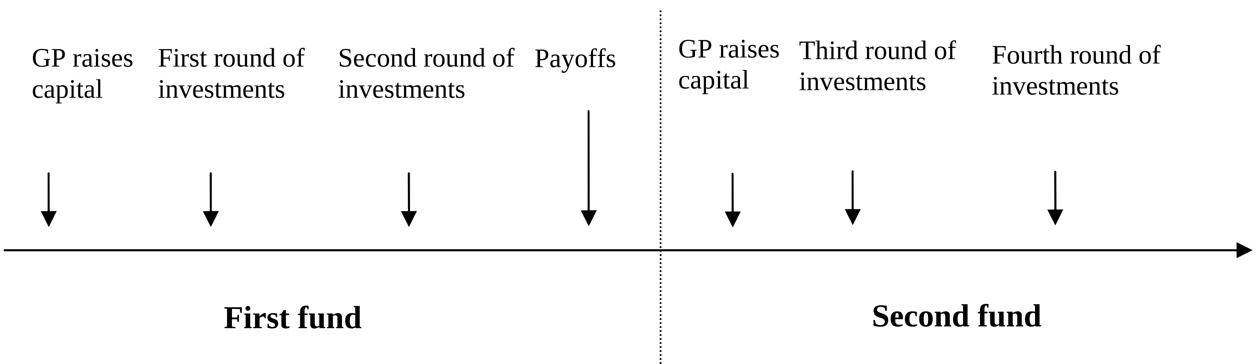
Perfect, frictionless competition does not describe the buyout market well. For institutional reasons, capital is not supplied instantaneously in response to a shock. Once raised, a fund's size cannot be increased. Thus, reacting to a demand shock requires raising a new fund which at minimum

[2] Axelson, Strömberg, and Weisbach (2007) show that these institutional features constitute an optimal response to agency problems between GPs and LPs.

takes several months. Moreover, private equity is inherently illiquid: There is no active secondary market, investors have little control over how and when their committed capital is invested, and investments take many years to pay off. A limited short-term supply of investors who put zero price on liquidity would thus slow down the supply response to a shock.[3] But if supply is fixed in the short run, a demand shock will lead to a transfer of rents from target shareholders to *existing* buyout funds (and their LPs[4]) as funds' bargaining power increases, until supply catches up (see also Sahlman (1990)).

2. A Stylized Model of Buyout Fund Investment Behavior

To capture the limited life of a fund and the decision to draw down capital over time, we assume that the GP raises capital at the beginning of the fund's life and then invests it in each of two rounds. At the end of the fund's life, investments are liquidated and the GP may raise a second fund which, if raised, would also be invested in two rounds. The following figure shows the timeline of our model.



In each investment round, the GP faces two potential buyout opportunities, each with differential NPVs and risks. The first type ('safe' buyout) generates a cash flow of $(1+g_t s)I$, where I is the amount invested, $g_t s$ denotes the productivity of the buyout, and t=1…4 denotes the round number. Productivity has two parts: A time-varying component common to all types of buyouts, g_t, and a

[3] Lerner and Schoar (2004) argue that incentive problems between GPs and LPs can be alleviated by using illiquidity to screen for investors who are less subject to liquidity shocks. For our example, funds would need to trade off the benefits of having liquid investors versus the shortage of such investors.

[4] Who ultimately earns the excess rents depends on the contractual arrangements between the fund and its investors.

buyout-type specific component, s. The second type ('risky' buyout) generates a cash flow of $(1+g_t h)I$ with probability p and $(1+g_t l)I$ with probability $(1\text{-}p)$.

We assume that 1) $h > s$ and 2) $r \equiv ph + (1\text{-}p)l < s$. Assumption 1 implies that, with probability p, the risky buyout has higher cash flows than the safe one. Assumption 2 implies that the risky buyout has a lower expected return than the safe buyout. Thus, ex ante, the safe buyout is strictly preferred.

The GP raises K^1 dollars in his first fund and K^2 in the second fund. (Superscripts denote fund numbers whereas subscripts denote rounds.) Consistent with the fund flow results of Kaplan and Schoar (2005), we let K^2 depend on the performance of the first fund as the market infers the GP's ability from the value he generates: $K^2 = K^1\left[b + a \cdot 1(P^1 \geq RK^1)\right]$. For simplicity, we do not endogenize investors' beliefs. When the value created in the first fund, P^1, exceeds $R\,K^1$, the GP receives additional capital of aK^1. The parameter a measures the sensitivity of capital to performance in the preceding fund and depends on the GP's characteristics. For example, the market has access to a long history of outcomes for well-established GPs, and therefore one more observation does not affect the market's beliefs much. However, for younger GPs with no track record, the first outcome significantly influences the market's beliefs. Therefore, it is likely that a is larger for younger funds.

Our notion of imperfect competition relates to the degree that the supply of capital is sticky. As in Inderst and Mueller (2004), the stickier the supply of capital, the greater the GP's bargaining power in his negotiations with the buyout target. The parameter α_t (t =1, 2, 3, and 4) measures the fraction of the NPV that the buyout fund captures in round t.

In addition to using fund capital, the GP can raise debt to finance the buyout. Following industry practice, we assume the debt is raised by the target firm and not by the fund. We also assume that the target can borrow c_t times the amount of equity the GP invests. The parameter c_t is a measure of how loose credit is. We consider the case in which c_t is sufficiently low so that the debt is risk free. Assuming the credit market is competitive, the GP always borrows the maximum possible, regardless of whether he invests in the risky or safe buyout.[5] The reason is that every dollar invested generates value that accrues entirely to the fund (debt holders simply break even), so the effect of borrowing is to increase the value created per dollar of equity capital invested by a factor of (1+c_t).

Finally, we assume that the discount rate is zero and that the GP learns all the parameters in the model before investing in the first round.

2.1 Solution

Let I_1^S and I_1^R be the fund's *own* capital invested in the first round in the safe and risky buyouts, respectively. We use similar notation for the second-round investments, $I_2^S(x)$ and $I_2^R(x)$, which depend on the outcome x_1 (with $x_1 = h$ or l) of the first-round investment in the risky buyout.

The GP's payoff in the first fund is given by

$$P^1 = \alpha_1 g_1 r(1+c_1)I_1^R + \alpha_1 g_1 s(1+c_1)I_1^S + p\left[\alpha_2 g_2 r(1+c_2)I_2^R(h) + \alpha_2 g_2 s(1+c_2)I_2^S(l)\right] \\ + (1-p)\left[\alpha_2 g_2 r(1+c_2)I_2^R(l) + \alpha_2 g_2 s(1+c_2)I_2^S(l)\right]$$

This expression is maximized by investing in the safe buyout only (because $s>r$) and in the round in which $\alpha_t g_t(1+c_t)$ (t=1,2) is higher. However, because the size of the second fund is a function of the value created in the first one, the GP might optimally allocate capital to the risky buyout if that increased the probability of reaching the threshold return.

Because the second fund is the last one, the GP does not gain by investing in the risky buyout. Thus, the GP's payoff in the second fund is given by

$$P^2 = \max\{\alpha_3 g_3(1+c_3), \alpha_4 g_4(1+c_4)\}sbK^1 + 1(P^1 \geq RK^1)BK^1$$

where $B = a\max\{\alpha_3 g_3(1+c_3), \alpha_4 g_4(1+c_4)\}s$. The expression BK^1 represents the additional payoff from reaching the threshold in the first fund.

---

[5] The results continue to hold if debt holders capture part of the value created, as long as they do not capture a greater fraction per dollar invested than does the GP.

The GP chooses an investment plan for the first fund to maximize his payoff, $P^1 + P^2$, solving:

$$\max_{I_1^S, I_1^R, I_2^S(h), I_2^R(h), I_2^S(l), I_2^R(l)} \quad P^1 + \Pr[P^1 \geq RK^1]BK^1$$
$$\text{subject to } I_1^S + I_1^R + I_2^S(h) + I_2^R(h) \leq K^1, \text{ and} \qquad (1)$$
$$I_1^S + I_1^R + I_2^S(l) + I_2^R(l) \leq K^1,$$

where we drop the constant $\max\{\alpha_3 g_3(1+c_3), \alpha_4 g_4(1+c_4)\}sbK^1$ from the objective function.

The following proposition characterizes the solution to this problem. Recall that the GP always borrows the maximum possible. In the proposition we refer only to the amount the GP invests from his own capital. It should be understood that, in addition, he also invests the amount borrowed.

Proposition 1: *The GP always borrows the maximum possible. Let $\hat{t}$ be the round (1 or 2) in which $\alpha_t g_t(1+c_t)$ is maximized. The solution to the GP's problem is as follows:*

1) *When either $\alpha_{\hat{t}} g_{\hat{t}}(1+c_{\hat{t}})s \geq R$ or $\alpha_{\hat{t}} g_{\hat{t}}(1+c_{\hat{t}})h < R$, the GP invests the entire capital K^1 in the safe buyout in round $\hat{t}$.*
2) *When $\alpha_{\hat{t}} g_{\hat{t}}(1+c_{\hat{t}})s < R \leq \alpha_{\hat{t}} g_{\hat{t}}(1+c_{\hat{t}})h$ and*
   a. *$B < \overline{B}$, the GP invests the entire K^1 in the safe buyout in round $\hat{t}$.*
   b. *$\overline{B} \leq B \leq \overline{\overline{B}}$, the GP invests the entire K^1 in round $\hat{t}$, by allocating $\tilde{I}$ to the risky buyout and $K^1 - \tilde{I}$ to the safe one. $\tilde{I}$ is defined such that the GP's payoff is exactly RK^1 in case of a high outcome.*
   c. *$B > \overline{\overline{B}}$, the GP invests $K^1 - \widehat{I}_1 - \widehat{I}_2$ in the safe buyout in round $\hat{t}$. In addition, in the first round, he invests $\widehat{I}_1$ in the risky buyout. He invests the remaining capital, $\widehat{I}_2$, in the second round. He allocates it to the risky buyout following a low outcome in the first round or to the safe buyout following a high outcome. $\widehat{I}_1$ and $\widehat{I}_2$ are set such that the GP's payoff is exactly RK^1 when either the first risky buyout is successful or the first risky buyout fails but the second one succeeds.*

Proof. See the Appendix.

When condition 1) holds, the GP can either reach the threshold return by investing in the safe buyout or he cannot reach such threshold even by investing his entire capital in the risky buyout. In either case, there is no benefit of investing in the risky buyout.

When condition 2) holds, the GP can reach the threshold return but only by investing some capital in the risky buyout. Clearly, when the benefits of reaching the threshold are low (case 2a), the GP forgoes the possibility of reaching the threshold and instead invests all his capital in the safe buyout.

When the benefits of reaching the threshold are higher, the GP allocates capital to the risky buyout (cases 2b and 2c). In the investment plan in 2b), the GP invests in the risky buyout in only one round, whereas in plan 2c) he invests in the risky buyout in the first round and, in case the risky buyout fails, he invests in another risky buyout in the second round.

The benefit of these investment plans is that they allow the GP to reach the threshold return, with the probability of doing so being greater for the plan with the option to invest in a risky buyout a second time (plan 2c). However, the cost associated with this investment plan is larger not only because more capital is potentially allocated to the risky buyout, but also because it calls for investment in a round in which returns to the GP are not maximized. This implies that the plan with the option to invest in a risky buyout a second time is only chosen when the benefits of reaching the threshold are sufficiently high.

2.2 Testable Implications

The model has the following testable implications.

1) *The GP is more likely to invest in rounds in which the overall quality of buyouts is high.*
2) *The GP is more likely to invest in rounds in which his bargaining power is high.*
3) *The GP is more likely to invest in rounds in which credit is looser.*
4) *The GP's investment returns are in turn higher when the overall quality of buyouts is high, bargaining power is high, and credit is looser.*

As Proposition 1 shows, almost all plans involve investing only in the round in which the product of the index of the overall quality of buyouts, g_t, the bargaining power, α_t, and the ease of credit, $1+c_t$, is maximized, as this maximizes the GP's return.[6] This result has implications both for how investment decisions are made and for their relative success. Consider a fund manager's investment behavior following a positive economic shock (a high g_t) in a world where the supply of capital is sticky in the short run (i.e., when α_t is large) and credit market conditions (c_t) do not change. Ceteris paribus, the manager of a fund that is already in place should invest his capital as fast as possible, before new funds are created to invest in the same opportunities. Thus, the existing fund's investment rate should increase as more promising investment opportunities arise. These investments should also yield higher returns.

On the other hand, holding the quality of buyouts constant, an increase in competition for deal flow (i.e., low α_t) makes it harder for the GP to find 'diamonds in the rough.' A manager trying to maximize the return on the fund's investments will then take longer to invest his capital, to avoid overpaying.

Similarly, keeping the quality of the buyouts and the GP's bargaining power constant, an easing of credit implies that the GP can attain a more leveraged position. This increases his return per dollar invested and makes it more likely that he will invest fast.

5) *Younger GPs are more likely to invest in risky buyouts*.

Assuming younger GPs have greater fund flow-performance sensitivities, a, they derive greater benefits from reaching the threshold and thus are more willing to bear the cost of investing in risky buyouts. As Proposition 1 shows, the greater the benefits, the more risks the GP takes. (Note that the investment plan in 2a) is less risky than in 2b), which in turn is less risky than that in 2c).)

6) *Investment by younger GPs should be less sensitive to market conditions.*

Because younger GPs derive greater benefit from reaching the threshold, they are more likely to invest in a risky buyout early on, regardless of market conditions, so that they have the option of

[6] The exception is part 2c of Proposition 1. However, even in this case, the capital not invested in the risky buyout is invested in the round that maximizes $\alpha_t g_t(1+ c_t)$. This case only obtains when the difference between $\alpha_1 g_1(1+ c_1)$ and $\alpha_2 g_2(1+ c_2)$ is small. Thus, increasing α_t, g_t, or c_t makes case 2c less likely so that the GP invests all the capital in round $\hat{t}$.

investing in another risky buyout in case the first one fails. (In terms of Proposition 1, younger GPs have higher *B*'s and thus are more likely to follow investment plan 2c.) Older GPs who benefit less from reaching the threshold forgo this option and invest when market conditions are optimal.

7) *Following periods of good performance, GPs should become conservative. This effect is stronger for younger GPs.*

For a GP who invests in the risky buyout, it is not optimal to rely on two consecutive successes in risky buyouts since this reduces the probability of reaching the threshold compared to an investment plan that requires only one success (this feature is present in investment plans 2b and 2c). The effect is stronger for younger GPs because younger GPs are more likely to invest in risky buyouts.

3. Sample and Data

3.1 Overview of Dataset

We obtain complete and detailed cash flow and investment data for 207 private equity funds raised between 1981 and 2000 from one of the earliest and largest institutional investors in private equity in the U.S. ('the LP').[7,8] We have data for every private equity fund the LP invested in through 2000, representing close to $5 billion in committed capital, as well as data for these funds' investments in 2,274 portfolio companies through 2003.[9]

Table 1 presents summary statistics for the sample as a whole and for funds raised in 1981-1993 (the 'mature funds') which are ten or more years old and have completed their investment activity and capital distributions. The 207 funds had average, median, and aggregate capital commitments of $829.7 million, $453.5 million, and $171 billion in nominal terms, respectively. More than 80% of this

[7] We have agreed not to identify the LP, the funds, or the portfolio companies in the dataset.

[8] The institutionalization of the private equity industry is commonly dated to three events: The 1978 Employee Retirement Income Security Act (ERISA) whose 'Prudent Man' rule allowed pension funds to invest in higher-risk asset classes; the 1980 Small Business Investment Act which redefined private equity firms as business development companies rather than investment advisers, so lowering their regulatory burdens; and the 1980 ERISA 'Safe Harbor' regulation which sanctioned limited partnerships, now the dominant organizational form in the industry.

[9] Buyout funds account for around 85% of the LP's private equity portfolio. Given our focus, we exclude VC funds.

was committed to funds raised after 1993, some of which are still actively investing. The average mature sample fund raised $604.8 million.

Based on the LP's internal classification, 48.4% of sample funds specialize in small and medium-sized buyouts, 22.6% in large buyouts, 16.1% are general buyout funds, 6.5% provide mezzanine finance, and the remainder are growth equity, private equity, late-stage VC/buyout, and distressed buyout funds. Venture Economics, a commercial database vendor, classifies most of our sample funds as 'buyout funds' (87.4%); the remainder are flagged as 'mezzanine' (4.8%), 'generalist private equity' (2.4%), and 'other private equity' (0.5%). Note that 10 sample funds (4.8%) are incorrectly flagged as 'venture capital' in Venture Economics.

As Table 2 shows, the number of funds the LP invested in increases throughout the 1990s, peaking in 1998-2000. This is similar to the pattern in the sample of buyout funds tracked by Venture Economics. There are two years (1982 and 1991) when the LP made no investments in new buyout funds; in the other years, the LP invested in between 2.8% and 22% of new funds raised, according to Venture Economics. Overall, the LP has invested in funds accounting for 35% of total buyout capital raised over the period, with somewhat greater coverage in the 1990s. The LP's exposure to such a large fraction of buyout activity means that our sample gives us a comprehensive view of buyout fund behavior over the sample period. While Table 2 also shows that larger funds are overrepresented in our sample, this is not because we oversample established fund managers. According to Table 1, first-time funds account for 30% of the 1981-2000 sample and 39.6% of the mature funds – a rate that is not significantly lower than the 42% reported by Kaplan and Schoar (2005) for the VE database (p=0.735).

3.2 Sample Selection Issues

Apart from being skewed toward larger buyout funds, how representative is our funds sample?

1) There is no survivorship bias: All investments the LP has made since 1981 are included.

2) There is no problem of selective reporting: Fund managers have a contractual obligation to

periodically report their activities, valuation, and performance to their investors, including the LP. This is in contrast to the performance and portfolio holdings data available through Venture Economics, which are based on voluntary disclosure by fund managers or limited partners.

3) The sample covers a large fraction (35%) of the private equity fund 'universe' over the 1981-2000 period, according to Venture Economics.

4) Prior to a reorganization that post-dates our sample, the aims of the LP's private equity program were strategic as much as financial. As a consequence, the LP did not engage in 'fund-picking' (e.g., investing in follow-on funds by successful managers) and actively sought to establish relationships with emerging fund managers. We therefore have good variation in fund manager experience, in view of the large number of first-time funds in the sample.

There is one sense in which our data may not be representative. The LP may be exceptional in that it 'survived' for more than 20 years, so that we observe its data more by virtue of its luck in investing in winner funds than because private equity funds were good investments on average. While this point is probably not particularly relevant (as investing in private equity accounts for only a small part of the LP's business), we can shed more light on it directly by comparing the performance of our funds to the performance of the wider Venture Economics sample. Kaplan and Schoar (2005) report that cash flow IRRs averaged 18% among the 169 mature buyout funds raised in 1980-1995 covered by VE. For our sample of mature (albeit larger) buyout funds, Ljungqvist and Richardson (2003) report average IRRs of 21.8%; these estimates are not statistically different from each other (t-statistic = 0.99).

3.3 Cash Flow Data

We have the complete cash flow records for all sample funds through September 2003. A typical record consists of the date and amount of the cash flow, the fund and portfolio company to which it relates, and the type of transaction. Transaction types include 'disbursements' (investments in portfolio companies) and 'exits' (receipt of cash inflows from IPOs or trade sales); dividends or interest paid by portfolio companies; annual management fees (typically 1-2% of committed capital); and (occasional) interest payments on cash held by GPs prior to making an investment. The data do not separately record the GPs' share in a fund's capital gains (usually 20%), as GPs transmit capital gains to investors net of their 'carried interest'.

The cash flows involve three investment scenarios: Cancelled transactions (a cash call followed by the return of the cash, along with bank interest); write-offs (cash outflow(s) without subsequent cash inflow, or with a subsequent accounting entry flagging a 'capital loss'); and cash or stock distributions following successful exits (in the form of an IPO or a trade sale) or management buybacks.[10] In the case of stock distributions, we observe a non-cash entry reflecting receipt of common stock (that of the portfolio company's in the case of an IPO or the buyer's in the case of a sale to a publicly traded firm). The LP either sells the stock or holds it in inventory. Sales are recorded as cash inflows. Positions that are held in inventory are marked to market periodically (usually monthly), but they are obviously not cash. The LP virtually always liquidates distributed stock positions.

3.4 Draw-down Rates And Capital Return Schedules

Table 3 shows that the average sample fund draws down only two-thirds of committed capital. However, this understates draw downs as more recent funds are too young to be fully invested; the 53 funds raised between 1981 and 1993 invested on average 94.2% of committed capital. Average draw downs are around 90% or above for funds raised up to 1996, with later vintages still actively investing.

It is arguable when a fund is fully invested. Among 1981-1993 vintage funds that have subsequently been liquidated, some never invested more than 60% to 70% of committed capital. In the overall 1981-2000 dataset, 54.1% of funds have invested at least 70% of committed capital, and 48.8% have invested 80% or more as of the end of our sample period. These might reasonably be thought of as fully, or close to fully, invested. They include a few recent funds that invested their committed

[10] Private equity funds typically have covenants restricting reinvestment of capital gains; see Gompers and Lerner (1996).

capital very rapidly: 37.9% of the 1998 vintage funds and 6.5% of the 1999 vintage funds had already invested at least 70% of committed capital by May 2001. There is wide variation in the speed with which funds draw down committed capital. For instance, some funds draw it down by year 2, while others take as long as ten years to invest 80% or more of their commitments. Adjusting for the fact that many of the more recent funds are right-censored, in that they drop out of our sample before they are fully invested, the average (median) fund takes 13.5 (13) quarters to invest 80% or more of its commitments.

Table 3 also shows how much of the invested and committed capital was returned to investors by the earlier of the end of our sample period or a fund's liquidation date. The average fund distributed 100.8% of drawn-down capital and 88.3% of committed capital. Again, this understates cash flows as recent funds have yet to exit many of their portfolio holdings. The 53 funds raised between 1981 and 1993 returned 2.57 times invested capital and 2.43 times committed capital, on average.

3.5 Portfolio Compositions and Industry Specializations

Following the literature, we use the six broad Venture Economics industry groups to control for industry effects. On this basis, 46.3% of the 2,274 portfolio companies are assigned to 'Non-High-Technology', 15.2% to 'Communications and Media', 11.6% to 'Computer Related', 4.4% to 'Medical/Health/Life Science', 2.6% to 'Semiconductors/Other Electronics', and 0.4% to 'Biotechnology'. Companies not in VE are assigned to these groups using Dun & Bradstreet's *Million Dollar Database*, SIC codes taken from standard sources for companies that have gone public, fund reports received by our LP, and web searches. We add a 'Miscellaneous' group for companies that cannot be assigned unambiguously to a VE group; this accounts for 19.6% of portfolio companies.

Funds rarely invest in only one industry. We take a sample fund's industry specialization to be the broad Venture Economics industry group that accounts for most of its invested capital. On this basis, 66.2% of funds specialize in 'Non-High-Technology', 12.1% in 'Communications and Media', 9.7%

in ‘Miscellaneous industries’, 6.3% in ‘Computer Related’ companies, 3.4% in ‘Medical/Health/Life Science’, and 2.4% in ‘Semiconductors/Other Electronics’.

4. The Investment Behavior of Buyout Funds

4.1 The Effect of Investment Opportunities, Competition, and Credit Conditions on Investment

We test Predictions 1, 2, and 3 by relating the timing of a fund’s draw downs to proxies for the quality of buyout targets, the fund manager’s bargaining power relative to target shareholders, and credit market conditions, each of which is predicted to accelerate investment. To test Prediction 6 that young GPs have smoother investment plans, we allow for potential differences between first-time and more established GPs in their sensitivity of investment to market conditions.

Since we are interested in the *time* it takes a fund to be fully invested, the appropriate econometric specification is a duration (or hazard) model, commonly used in labor economics to estimate the duration of unemployment spells. The dataset is structured as an unbalanced panel of t_i quarterly observations for each fund i where the dependent variable equals one in the quarter T_i in which cumulative draw downs exceed K% of committed capital, and zero for quarters $t_i < T_i$. Similar to Table 3, we report results for three alternative cut-offs, K=70, 80, or 90. To aid interpretation, we report coefficients from accelerated-time-to-failure models, which are isomorphic to duration models, rather than survival odds ratios. The coefficients measure the effect of a covariate on the log of the time (in quarters) between a fund being raised and it having drawn down at least K% of committed capital.

Duration models have four desirable features compared to OLS. First, they can easily deal with the problem of right-censoring (Kalbfleisch and Prentice (1980)), which clearly affects our sample: Some funds draw down their capital at some unknown time after the end of our sample period, September 2003. We can thus use the draw down patterns of all 207 sample funds in a duration model.[11,12]

[11] In the absence of right-censoring, the likelihood of the data is simply the product of the conditional densities $f(t_i|\beta,x_i)$ for all observations i. For a censored observation, the time at which ‘failure’ occurs is unknown, as failure occurs after the end of the observation period, T. All that is known is that failure hasn’t yet occurred as of time T. The appropriate contribution

Second, because of the quasi-panel set-up, duration models can easily accommodate time-varying covariates. For instance, changes over time in a GP's bargaining power can be allowed to affect the fund's draw down rate. Third, because of this dynamic structure, endogeneity and reverse causality concerns are reduced. And fourth, duration models make more appropriate assumptions about the distribution of time to an event than does OLS (which assumes normality). We use the Weibull distribution, which ensures that the hazard of being fully invested increases monotonically with time since the fund was raised, as it logically must. Our results are robust to reasonable alternatives.

To proxy for the unobserved quality of investment opportunities faced by a sample fund (Prediction 1), we follow Gompers and Lerner (2000) and Hochberg, Ljungqvist, and Lu (2007) who use public-market pricing multiples as indirect measures of the investment climate in the private markets. There is a long tradition in corporate finance, based on Tobin (1969), that views low book-to-market ratios in an industry as an indication of favorable investment opportunities. By definition, private companies lack market value data, so we construct multiples for publicly traded Compustat companies which we map into the six Venture Economics industries. The specific measure we use is the value-weighted average multiple of all Compustat companies in a given industry.[13] It is estimated at an annual frequency and so varies over the life of a fund. This captures the notion, outlined in Section 2, that investment behavior responds to *changes* in investment opportunities when the supply of private equity is sticky in the short run.

To test Prediction 6, we interact the investment opportunity proxy with an indicator identifying first-time funds. A negative coefficient on the interaction term would suggest that the investment

---

to the likelihood function of a censored observation is therefore the probability of not having failed prior to *T*.

[12] Our results are qualitatively unaffected if we restrict the sample to mature funds, which are not subject to right-censoring.

[13] We define the book/market ratio as the ratio of book equity to market equity, where book equity is total assets (#6) minus liabilities (#181) minus preferred stock (#10, #56, or #130, in order of availability) plus deferred tax and investment tax credit (#35), and market equity is stock price (#199) times shares outstanding (#25). To control for outliers, we winsorize at the 5th and 95th percentiles. To calculate a value-weighted average, we consider as weights the firm's market value (market value of equity plus liabilities minus deferred tax and investment tax credit plus preferred stock).

decisions of first-time funds are less sensitive to the investment climate than those of older funds.

To proxy for the degree of competition faced by a sample fund (Prediction 2), we construct two variables. The first measures how much financial 'fire power' the fund's most direct competitors have access to, and is defined as the amount of capital committed to buyout funds *in the year the sample fund was raised*, in log dollars of 1996 purchasing power. This definition assumes that (say) a 1990 vintage fund competes primarily with other funds of that vintage.[14] This variable does not vary over time and is similar to the competition proxy used by Gompers and Lerner (2000) and Hochberg, Ljungqvist, and Lu (2007).

The second proxy for competition is a Herfindahl index of the concentration of uninvested capital held by buyout funds specializing in a given Venture Economics industry in quarter t (where uninvested capital equals the sum of committed capital less cumulative draw downs for still-active buyout funds at t). The index equals one if a single fund controls all the capital and tends to zero the less concentrated is capital. A fund's bargaining power increases in the Herfindahl.

To estimate the effect of credit market conditions, we include the yield spread on corporate bonds (using Moody's BAA bond index, estimated quarterly in March, June, September, and December) over the CRSP riskfree rate. We assume that a low yield spread implies loose credit conditions. Obviously, many factors drive yield spreads other than the supply of credit, including most prominently asset volatility and the degree of leverage. Nevertheless, our measure alleviates these other factors by conditioning on credit rating and is often cited as a proxy for the tightness of credit.

We also control for two fund characteristics that may affect investment decisions. Funds managed by more established GPs likely have easier access to investment opportunities; for instance, they often invest in the existing portfolio companies of their GP's earlier funds. We therefore include the log age of the fund management partnership, using data from Venture Economics which we correct using

---

[14] Results are qualitatively unchanged if we widen the window to include the year before and after the fund's vintage year.

information taken from GPs' websites. We also control for the size of the fund (in log real dollars).

Finally, we proxy for market conditions using the quarterly return on the Nasdaq Composite Index.

Table 4 reports the MLE results for the three cut-offs, i.e., drawing down more than 70%, 80%, or 90% of committed capital.[15] The results are qualitatively similar in each case. The pseudo R^2 show that our models capture between 21.4% and 33.9% of the variation in draw down rates. The model χ^2 statistics are large and highly significant in all three models, indicating good overall fit.

The positive coefficients estimated for the industry book-to-market ratio suggest that funds accelerate their investments in response to improvements in investment opportunities, consistent with Prediction 1. This effect is statistically significant and economically sizeable. To illustrate, at the means of the other covariates, decreasing the book-to-market ratio by one standard deviation (an improvement in investment opportunities) is associated with a 2.3 quarter decrease in the time it takes a fund to invest 90% of its capital, from 14.9 to 12.6 quarters.

When we interact the book-to-market variable with a dummy identifying first-time funds, we find a negative coefficient (statistically significant in two of the three specifications), which confirms Prediction 6 that young funds are less sensitive to investment opportunities than are old funds.

Funds also seem to invest more when their bargaining power is high, as Prediction 2 suggests. Specifically, when their vintage-year peers have raised more money, draw downs are slower (though this is statistically significant only for the 70% cut-off). Conversely, the more concentrated among a small number of funds is investable capital, the faster do funds invest (significant in all three models).

The effect of changes in credit market conditions supports Prediction 3: Dearer debt is associated with a slow-down in investment (statistically significant in two of the three specifications).

Among fund characteristics, we find no evidence that the age of the GP partnership or fund size

[15] As mentioned previously, a small number of the mature funds never invested more than 60-70% of their capital. For these, we measure time-to-fully invested as the number of quarters until they reached their maximum draw down.

affects the investment rate. Similarly, conditions in the public equity markets also do not influence investment behavior, in view of the insignificant coefficient estimated for the return on the Nasdaq Composite Index. Of course, these conditions are above and beyond those already captured by our proxies for investment opportunities and competition in the buyout market.

In conclusion, the results shown in Table 4 are consistent with Predictions 1, 2, 3, and 6.

4.2 Further Evidence Regarding the Investment Sensitivity to Market Conditions

An alternative way to test Prediction 6 is to note that the only reason not to concentrate investment when conditions are optimal is to keep the option to 'double up' in case the first risky investment goes awry. Therefore, funds that want to keep this option alive show a lower sensitivity of investment to market conditions since they are willing to invest in periods in which the environment is not optimal. Because the option to double up is costly, GPs who have already had a string of successes should abandon it. Therefore, we expect that the sensitivity of investment to market conditions should increase after a string of successes and that this result should be stronger for younger funds.[16] Because investment sensitivity might depend on individual GP characteristics as well as on the age of the fund, we test this prediction by implementing a difference-in-difference analysis.

We compare the change in the investment sensitivity to market conditions before and after a string of successes for both young and experienced GPs. The first difference (over time) controls for observed and unobserved fixed GP characteristics. The second difference (the change in a young GP's sensitivity minus the change in an experienced GP's sensitivity) controls for changes in investment sensitivity that are related to the age of the fund. We expect the investment sensitivity for the young GP to increase relative to that of an experienced GP after a series of early successes.

Implementing this test requires a proxy for early success. An obvious summary measure of success

[16] This result would obtain if we extended our model to three periods. In the current version of the model, we cannot meaningfully define investment sensitivity after an early success. In a two-period model, GPs invest all their capital in the second period (because it is the last one) regardless of the outcome of the first period investment.

is the IRR a GP has generated since starting the fund. A fund that breaks even sooner, in present value terms, presumably had a string of early successes. For most funds, the IRR turns positive some time *after* most of the capital has already been invested; private equity professionals call this the 'J curve effect.' To test Prediction 6, we therefore focus on funds whose IRR turns positive while they still have a meaningful amount of capital left to invest. We report results using a cut-off of at least 50% of committed capital available for investment; results are not sensitive to reasonable alternatives.

Duration models of the kind shown in Table 4 above are ideally suited to estimating changes in investment sensitivities over the life of a fund, for they can accommodate time-varying covariates. As before, our estimate of a fund's investment sensitivity is the coefficient for investment opportunities in the duration model, except that we now interact investment opportunities with four indicator variables to identify the investment sensitivities of first-time and older funds before and after early successes. We include all other covariates shown in Table 4, but to conserve space we only report the four investment sensitivities along with *p*-values for standard errors clustered at the fund level. We also report estimates of the differences in investment sensitivities across time, across funds, and across both, along with *p*-values for Wald tests of their significance. As in Table 4, we estimate three different models of the time to drawing down 70%, 80%, or 90% of committed capital, respectively.

Table 5 reports the results. As before, first-time funds are less sensitive to changes in investment opportunities than are older funds, and this is statistically significant for the 80% and 90% cut-offs. Once they have broken even, first-time funds with at least 50% of capital yet to invest become significantly more sensitive to investment opportunities, as predicted. Older funds become significantly more sensitive, an effect our model did not predict. Crucially, the difference between older and first-time funds' change in investment sensitivities is statistically significant in all three specifications, which supports Prediction 6.

4.3 The Effect of Investment Opportunities, Competition, and Credit Conditions on Returns

A fund's payoffs should be a function of its investment decisions. According to Prediction 4, the same factors that determine a fund manager's optimal investment plan should affect the performance of his buyouts. That is, investing when investment opportunities are good, his bargaining power is high, and credit is cheap should lead to better returns. This allows us to test the robustness of our empirical proxies, because a poorly specified proxy should not be able to explain both faster drawdown rates and higher returns.

Uniquely, our data allow us to compute annualized geometric returns on invested capital at the level of individual portfolio companies.[17] We measure returns as $|\text{cash inflows/invested capital}|^{1/\text{holding period}} - 1$.[18] Among the 53 mature funds, equal-weighted returns average 12.7% across portfolio holdings, though the distribution is highly skewed; the median return is 4.9%.[19] To reduce the impact of skewness, we analyze log returns.

Write-off dates are not generally known, so it is impossible to calculate excess returns: Without further information or assumptions, we do not know over what period to measure benchmark returns. The analysis that follows therefore focuses on raw returns.[20] For the same reason, we do not include variables that are dated as of the time of exit (such as conditions in the IPO or M&A markets).[21]

We estimate OLS regressions[22] of log returns on our proxies for investment opportunities, competition, and credit market conditions, each measured as of the date the fund bought the target

---

[17] Prior literature focuses on *fund*-level returns. See Kaplan and Schoar (2005), Jones and Rhodes-Kropf (2003), Ljungqvist and Richardson (2003), and Gottschalg and Phalippou (2007).

[18] This requires that a fund's accounts identify a portfolio position by name both at the time of the buyout and at the time of the exit. Some investments are originally booked under code names and later exited under their real names, or change their names, preventing us from unambiguously linking some cash outflows and inflows by name.

[19] The mean arithmetic return is 34.0%, which is a little lower than the 59% mean arithmetic return Cochrane (2005) reports for a sample of venture-backed investments. Note that arithmetic returns are generally higher than geometric returns. Neither is directly comparable to the fund-level IRR of 21.8% for our mature funds, as IRRs take duration into account.

[20] The correlation between investment returns and contemporaneous Nasdaq returns *conditional on success* is negative in eight of the twenty vintage years 1981-2000, especially among the 1980s vintages. Controlling for Nasdaq returns in the regressions reported below (which restricts the sample to exited investments only) does not change our results.

[21] Such variables can only be measured for exited investments, reducing the sample size substantially. Conditional upon exit, we find that conditions in the IPO market have a significantly positive effect on returns (results not reported).

[22] We obtain qualitatively identical results in probits of the likelihood of 'success' vs. 'failure', where 'success' is alternately defined as an investment multiple that exceeds 1, 2, or 3.

company. We also control for fund characteristics (fund age and size), as well as investment characteristics (size of investment and fund year in which it was undertaken) and the Nasdaq return in the quarter of the buyout.

In contrast to the duration models in Table 4, OLS provides no easy way to correct for right-censoring: Funds raised more recently are less likely to have reached the point where investments can be exited, so their portfolio companies are more likely to show returns of –100%.[23] Therefore, we estimate the model over different samples, beginning with the investments held by funds raised in 1981-1993 (the mature funds in our dataset) and adding later vintage years one by one. As more vintages are added, sample size grows but the risk of right-censoring bias increases.

Table 6 reports the estimation results. The adjusted R^2 ranges from 3.9% to 39.8%. Improvements in investment opportunities have the predicted positive effect on returns. This effect is highly significant and large across all regressions, regardless of the sample period we consider. Among mature funds, for example, a one-standard deviation increase in the book-to-market ratio at the time of the investment (a worsening of investment opportunities) reduces the subsequent log return by more than 0.3 of a standard deviation, holding all other covariates at their sample means. Tougher competition for deal flow, on the other hand, reduces returns significantly as predicted, whether we use fund inflows or the Herfindahl proxy. Investments undertaken when debt was expensive have lower returns. Taken together, these three findings support both Prediction 4 and thereby our choice of proxies for investment opportunities, competition, and credit conditions.

4.4 Risk-taking Behavior

According to Prediction 5, younger GPs are more likely to invest in risky buyouts than are older

[23] Alternatively, one might consider estimating censored regressions (such as a Tobit). This is problematic for two reasons. First, we face the practical problem of which investments in our data have zero multiples (-100% returns) because they have been written off (so their true multiple is indeed zero), and which have zero multiples because we don't observe them long enough for them to pay off (right-censoring). Second, censored regressions (unlike OLS) are not robust to departures from the assumption that the underlying distribution is normal (see Goldberger (1983)). Normality is not a good description of the distribution of investment returns.

GPs. To test this cross-sectional prediction, we make use of the second moment of the return distributions analyzed in the previous section. We proceed as follows. For each year in the life of a fund, we compute the standard deviation of the ex post log returns of the investments it undertook in that year (returns are computed as in the previous section). This results in a panel tracking the standard deviation of investment returns across fund-years. Holding investment opportunities, bargaining power, and credit market conditions in a given year constant, and controlling for fund size and conditions in the stock market, we expect first-time funds to make riskier investment choices.

To get meaningful estimates of the dependent variable, we discard fund-years with fewer than five investments. We also take into account that the precision with which we estimate investment risk varies with the number of investments a fund undertakes in a given year by estimating weighted least squares. As in the previous section, we face a trade-off between sample size and the risk of right-censoring bias, so we again estimate the model over different samples, beginning with funds raised in 1981-1993 (the mature funds in our dataset) and adding later vintages one by one.

The resulting estimates are reported in Table 7. Adjusted R^2 is highest (at 21.2%) when we focus on mature funds and decreases monotonically as more vintage years are added. Across all specifications, first-time funds and smaller funds are associated with significantly greater investment risk. For funds raised in 1981-1993, for instance, risk is nearly one standard deviation higher among first-time funds. This is consistent with Prediction 5.

Better investment opportunities are associated with riskier investments (i.e., more volatile realized returns), and this effect is especially strong among first-time funds. This suggests that funds play it safe when the investment climate is tough (or that all the investments they undertake then fare equally poorly). Greater competition for deal flow, using either of our proxies, correlates with more volatile returns. The effect of credit market conditions changes sign as we add more recent vintages.

Prediction 7 concerns the time-series of risks a fund takes. Following periods of good performance, GPs should become conservative, and this effect should be stronger for younger GPs because, as we have seen, younger GPs invest in riskier buyouts to begin with. To test this prediction, we compute the change in the risk of a fund's investments in the first and second half of its life, proxied using the standard deviations of log returns on investments made in the first five years and the last five years of the fund's life.[24] To get meaningful estimates of the dependent variable, we require a minimum of five investments in each period. The estimation sample contains one observation per fund.

We relate the change in portfolio risk to two proxies for interim performance, each computed using data for the first five years of a fund's life: a) The number of exits, and b) the fraction of committed capital distributed to investors (defined as the difference between capital returns and draw downs, divided by fund size).[25] Among mature funds raised in 1981-1993, exits during the first five years range between zero and 20 (average: 1.76). The average fund remains cash flow negative after five years (its average capital return is -1.9% of committed capital), with a range from -10.5% to +23.0%. We interact each performance proxy with a dummy variable for first-time funds. We also control for log real fund size as larger funds may have larger portfolios and so more exits, all else equal. As in Table 7, we estimate weighted least squares regressions (because the precision with which we estimate investment risk varies with the number of investments a fund undertakes) over different sample periods, beginning with funds raised in 1981-1993.

Table 8 reports the results. The explanatory power is good in view of the high adjusted R^2, which vary from 26.7% to 35.2%. Controlling for the fact that larger funds increase their portfolio risk by more over time than do smaller funds, we find that funds reduce their risk in the second half of their lives when they have achieved more exits or returned more capital to their investors in the first half.

[24] Results are robust to increasing the length of the first period (e.g., splitting fund life 6-4). The shorter we make the first period, the less responsive is the change in portfolio risk to our measures of good performance.

[25] We obtain qualitatively similar results if we instead use the minimum, maximum, or mean log return the fund has generated on its investments in the first five years (defined as in the previous section). Because of the J-curve effect, IRRs after five years are usually highly negative (mean: –42.3%) and vary little across funds.

These effects, which are significant across all specifications, support Prediction 7.

The interaction terms crossing the first-time fund dummy with the number of exits are negative and significant in all specifications, indicating that relative to more established funds, younger funds buy more (less) risky targets the poorer (stronger) the performance of their existing investments. This too supports Prediction 7. A similar interaction involving the fraction of committed capital returned to investors is generally negative as well but at best marginally significant (namely in the sample of mature funds). This could indicate that the occurrence of an IPO is considered a more potent signal of the performance of a young fund than the speed with which it returns capital to investors. Or else it could indicate that our second proxy for interim performance is a noisy one.

5. Concluding Remarks

What factors explain the investment behavior of buyout funds? This paper proposes a framework based on an imperfectly competitive market for private equity in which demand varies over time and supply is sticky in the short run. Increases in demand can, in the short run, only be met by existing funds which accelerate their investment flows and earn excess returns. Increases in supply lead to tougher competition for deal flow, and fund managers respond by cutting their investment spending. Also, as buyout funds have access to positive NPV projects, they benefit by availability of credit and thus invest more of their own capital when credit is loose.

An important element of the model is that fund managers can affect the market's perception of their talent by generating high returns in their current funds. A higher perceived talent enables fund managers to raise more capital in their subsequent funds. As a result, fund managers might be tempted to invest in lower-value but riskier buyouts in the hope of impressing the market in case the risky buyout succeeds. We show that young GPs are particularly susceptible to engaging in this risky behavior and, as a consequence, their investment behavior is less responsive to market conditions.

Using a unique dataset of buyout funds active over the last two decades, we document evidence consistent with this framework. Controlling for fund characteristics and market conditions, we show that the competitive environment facing fund managers plays an important role in how they manage their investments. During periods in which investment opportunities are good, existing funds invest their capital faster, taking advantage of the favorable business climate. This tends to lead to significantly better returns on their investments. In contrast, when facing greater competition from other private equity funds, fund managers invest their capital more slowly. Returns on acquisitions made when competition was tougher are ultimately significantly lower. Consistent with the model, looser credit leads to more investment and higher subsequent returns.

We also find that the ability of a fund manager to affect the perception of his talent affects his investment behavior. In particular, we find that young fund managers' investments are less responsive to market conditions and that such managers invest in riskier targets. Following good performance, they then take some of their chips of the table and reduce risk.

These results have important implications for the literature on fund performance. Assuming managers' fees are homogenous across funds, investors who have access to funds that are in a position to take advantage of the stickiness of private equity capital should earn excess expected returns. Other investors earn normal risk-adjusted rates of return. The fact that younger funds take larger risks can help explain the negative expected returns Kaplan and Schoar (2005) find for first-time funds. Why then would anyone invest in first-time funds? One possible explanation is that investments in first-time funds provide investors with an option to invest in the GP's later funds if its first-time fund has been successful. Thus, investors may actually earn normal expected returns on first-time funds due to the embedded option. This hypothesis of course cannot explain why the successful, mature funds allow their LPs to achieve excess returns by not raising management fees.

References

Axelson, Ulf, Per Strömberg, and Michael Weisbach, 2007, Why are buyouts leveraged? The financial structure of private equity funds, Unpublished working paper, Swedish Institute for Financial Research.

Cochrane, John, 2005, The risk and return of venture capital, Journal of Financial Economics 75, 3-52.

Cornelli, Francesca, and Oved Yosha, 2003, Stage financing and the role of convertible securities, Review of Economic Studies 70, 1-32.

Goldberger, A.S., 1983, Abnormal selection bias, in: S. Karlin, T. Amemiya, and L.A. Goodman (eds.), Studies in Econometrics, Time Series and Multivariate Statistics, 67-84. Academic Press.

Gompers, Paul A., 1995, Optimal investment, monitoring, and the staging of venture capital, Journal of Finance 50, 1461-1490.

Gompers, Paul A., and Josh Lerner, 1996, The use of covenants: An analysis of venture partnership agreements, Journal of Law and Economics 39, 463-498.

Gompers, Paul A., and Josh Lerner, 1998, What drives fundraising? Brookings Papers on Economic Activity: Microeconomics, 149-92.

Gompers, Paul A., and Josh Lerner, 1999, The Venture Capital Cycle, MIT Press.

Gompers, Paul A., and Josh Lerner, 2000, Money chasing deals? The impact of fund inflows on private equity valuations, Journal of Financial Economics 55, 281-325.

Gorman, Michael, and William A. Sahlman, 1989, What do venture capitalists do? Journal of Business Venturing 4, 231-248.

Hellmann, Thomas J., and Manju Puri, 2002, Venture capital and the professionalization of start-up firms: Empirical evidence, Journal of Finance 57, 169-197.

Hochberg, Yael V., Alexander Ljungqvist, and Yang Lu, 2007, Whom you know matters: Venture capital networks and investment performance, Journal of Finance 62, 251-301.

Hsu, David, 2004, What do entrepreneurs pay for venture capital affiliation? Journal of Finance 59, 1805-1844.

Hwang, Min, John M. Quigley, and Susan E. Woodward, 2005, An index for venture capital, 1987-2003, Contributions to Economic Analysis and Policy 4, 1-43.

Inderst, Roman, and Holger Mueller, 2004, The effect of capital market characteristics on the value of start-up firms, Journal of Financial Economics 72, 319-356.

Jones, Charles M., and Matthew Rhodes-Kropf, 2003, The price of diversifiable risk in venture capital and private equity, Unpublished working paper, Columbia University.

Kalbfleisch, J.D., and R.L. Prentice, 1980, The Statistical Analysis of Failure Time Data, John Wiley & Sons, New York.

Kaplan, Steven N., and Antoinette Schoar, 2005, Private equity returns: Persistence and capital flows, Journal of Finance 60, 1791-1823.

Kaplan, Steven N., and Jeremy Stein, 1993, The evolution of buyout pricing and financial structure in the 1980s, Quarterly Journal of Economics 108, 313-358.

Kaplan, Steven N., and Per Strömberg, 2003, Financial contracting theory meets the real world: Evidence from venture capital contracts, Review of Economic Studies 70, 281-315.

Lerner, Josh, 1994, Venture capitalists and the decision to go public, Journal of Financial Economics 35, 293-316.

Lerner, Josh, and Antoinette Schoar, 2004, The illiquidity puzzle: Theory and evidence from private equity, Journal of Financial Economics 72, 3-40.

Ljungqvist, Alexander, and Matthew Richardson, 2003, The cash flow, return and risk characteristics of private equity, NBER Working Paper no. 9454.

Palepu, Krishna, 1990, Consequences of leveraged buyouts, Journal of Financial Economics 27, 247-262.

Phalippou, Ludovic, and Oliver Gottschalg, 2007, Performance of private equity funds, Review of Financial Studies, forthcoming.

Sahlman, William A., 1990, The structure and governance of venture-capital organizations, Journal of Financial Economics 27, 473-521.

Tobin, James, 1969, A general equilibrium approach to monetary theory, Journal of Money, Credit, and Banking 1, 15-19.

Appendix

Proof of Proposition 1.

To simplify notation we drop the term (1 + c) from the calculations. The only effect of this is to change the expressions that should be $\alpha g(1 + c)$ to simply αg.

We solve the maximization problem in Equation (1). We define $I_1 = I_1^S + I_1^R$ and $I_2 = I_2^S(x_1) + I_2^R(x_1)$ for $x_1 = h$ or l as the total capital invested in rounds one and two, respectively. An optimal investment plan is then given by $\left(I_1, I_1^R, I_2, I_2^R(h), I_2^R(l)\right)$. The restrictions on these parameter are that $I_1^R \le I_1$, $I_2^R(x) \le I_2$, and $I_1 + I_2 \le K^1$.

We define the *realized* value created in round t as:

$$N_t(I_t, I_t^R, x_t) = \alpha_t g_t s I_t + \alpha_t g_t (x_t - s) I_t^R \tag{A1}$$

We also use $N_t(I_t, I_t^R, r) = \alpha_t g_t s I_t + \alpha_t g_t (r - s) I_t^R$ to denote the *expected* value created in round t.

The GP's total payoff, P, is given by:

$$\begin{aligned} P = P^1 + P^2 &= N_1(I_1, I_1^R, r) + N_2(I_2, pI_2^R(h) + (1-p)I_2^R(l), r) \\ &\quad + \Pr\left[N_1(I_1, I_1^R, x_1) + N_2(I_2, I_2^R(x_1), x_2) \ge RK^1\right]BK^1 \end{aligned} \tag{A2}$$

Case 1: $\alpha_{\hat{t}} g_{\hat{t}} s \ge R$ or $\alpha_{\hat{t}} g_{\hat{t}} h < R$

Because $r - s < 0$ and $\alpha_{\hat{t}} g_{\hat{t}} \ge \alpha_{t \ne \hat{t}} g_{t \ne \hat{t}}$, investing K^1 in the safe buyout in round $\hat{t}$ maximizes the payoff from the first fund, $N_1(I_1, I_1^R, r) + N_2(I_2, pI_2^R(h) + (1-p)I_2^R(l), r)$. We show that this investment plan also maximizes the payoffs in the second fund. When $\alpha_{\hat{t}} g_{\hat{t}} s \ge R$, the GP always reaches the threshold when he follows this investment plan and so his payoff in the second fund is BK^1, which is the maximum value it can take. When $\alpha_{\hat{t}} g_{\hat{t}} h < R$, $\Pr\left[N_1(I_1, I_1^R, x_1) + N_2(I_2, I_2^R(x_1), x_2) \ge RK^1\right]BK^1 = 0$ for all investment plans, so maximizing the total payoff is equivalent to maximizing the payoff in the first fund.

Case 2: $\alpha_{\hat{t}} g_{\hat{t}} s < R \le \alpha_{\hat{t}} g_{\hat{t}} h$.

We divide the proof into a number of steps.

Step 1: *The amount invested in the risky buyout in the* ***second*** *round is either zero or, if positive, it is* $I^* = \dfrac{RK^1 - N_1 - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h - s)}$*, where* N_1 *is the value created in round one. This amount is such that the GP exactly reaches the threshold in case of success. The GP chooses to invest* I^* *(as opposed to zero) in the risky buyout if and only if* $N_1 + N_2(I_2, 0, r) < RK^1 \le N_1 + N_2(I_2, I_2, h)$*, and* $pB > \alpha_2 g_2 (s - r) I^*$.

Proof. First, we show that the GP chooses to invest either 0 or I^* in the risky project. We write the GP's final payoff, $P = P^1 + P^2$, as:

$$P = N_1 + N_2(I_2, I_2^R, r) + 1(I_2^R \ge I^*) pBK^1$$

The derivative of this expression with respect to I_2^R is $\alpha_2 g_2 (r - s)$ everywhere except at $I_2^R = I^*$, where the function jumps up. Because $r < s$, this expression is negative. This implies that for a plan with $I_2^R \neq 0, I^*$ generates a lower payoff than a plan with a slightly lower I_2^R. Note that this alternative plan is feasible as the condition $I_2^R \leq I_2$ is not violated.

Second, we characterize the condition under which one option is better than the other. The first condition in Step 1 guarantees that the threshold cannot be achieved by using only the safe project, but can achieved by investing in the risky one. The second condition states that the GP receives a higher payoff by investing I^* in the risky buyout than by investing 0. It is obtained by simplifying the following expression:

$$N_1 + N_2(I_2, I^*, r) + pB > N_1 + N_2(I_2, 0, r)$$

Finally, I^* is defined as the investment amount such that the GP exactly reaches the threshold in case of a high outcome. That is, the expression for I^* can be found by solving:

$$N_1 + N_2(I_2, I^*, h) = RK^1.$$

Step 2: *The amount invested in the risky buyout in the* ***first*** *round is either zero or, if positive, it is such that the GP exactly reaches the threshold in case of success without the need to invest in the risky buyout in the second round.*

Proof. First, consider an investment plan such that success in the first round is more than strictly necessary to reach the threshold even if the GP does not invest in the risky buyout again. That is, $N_1(I_1, I_1^R, h) + N_2(I_2, 0, r) > RK^1$. Step 1 implies that $I_2^R(h) = 0$ and $I_2^R(l) = 0$ or $I_2^R(l) = \dfrac{RK^1 - N_1(I_1, I_1^R, l) - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h-s)}$. Suppose that $I_2^R(l) = 0$. Because $\alpha_{\hat{i}} g_{\hat{i}} s < R$ and $l < s$, when the outcome of the first risky buyout is low, the plan with $I_2^R(l) = 0$ does not reach the threshold. Thus, the GP's payoff is then

$$N_1(I_1, I_1^R, r) + N_1(I_2, 0, r) + pB,$$

which is decreasing in I_1^R. If $I_2^R(l) = \dfrac{RK^1 - N_1(I_1, I_1^R, l) - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h-s)}$, the GP's payoff becomes:

$$N_1(I_1, I_1^R, r) + N_2(I_2, I_2^R(l), r) + (p + (1-p)p)B.$$

The derivative of the payoff with respect to I_1^R is given by $\dfrac{\partial N_1}{\partial I_1^R} + \dfrac{\partial N_2}{\partial I_2^R(l)} \dfrac{\partial I_2^R(l)}{\partial N_1} \dfrac{\partial N_1}{\partial I_1^R} < 0$ because $\dfrac{\partial N_1}{\partial I_1^R} < 0$, $\dfrac{\partial N_2}{\partial I_2^R(l)} < 0$, and $\dfrac{\partial I_2^R(l)}{\partial N_1} < 0$. In both cases the GP's payoff is decreasing in I_1^R. Thus, an investment plan with a slightly lower I_1^R generates a higher payoff and is feasible as the condition $I_1^R \leq I_1$ is not violated.

Next, we show it is never optimal to invest in the risky buyout an amount that requires investing in another risky buyout to achieve the threshold. That is, an investment plan $\left(I_1, I_1^R, I_2, I_2^R(h), I_2^R(l)\right)$ such that $N_1(I_1, I_1^R, h) + N_2(I_2, 0, r) < RK^1$ is never optimal. From step 1, we know that second-round investment can be either 1) $I_2^R(h) = I_2^R(l) = 0$, 2) $I_2^R(h) = \dfrac{RK^1 - N_1(I_1, I_1^R, h) - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h-s)}$ and $I_2^R(l) = \dfrac{RK^1 - N_1(I_1, I_1^R, l) - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h-s)}$, or 3) $I_2^R(h) = \dfrac{RK^1 - N_1(I_1, I_1^R, h) - \alpha_2 g_2 s I_2}{\alpha_2 g_2 (h-s)}$ and $I_2^R(l) = 0$. The reason why we do not have $I_2^R(l) > 0$ and $I_2^R(h) = 0$ is that it can be easily shown that whenever $N_1(I_1, I_1^R, h) + N_2(I_2, 0, r) < RK^1$ holds, if the conditions for investing in the risky buyout in step 1 are satisfied following a low outcome in the first round, they should be satisfied following a good outcome. We proceed to rule out options 1, 2 and 3.

First we rule out option 1. Because $N_1(I_1, I_1^R, h) + N_2(I_2, 0, r) < RK^1$ and the GP never invests in the risky buyout in the second round then he never reaches the threshold. But if the GP does not reach the threshold, he is better off investing only in the safe project.

Next we rule out option 2. Note that under the proposed plan the probability of reaching the threshold is $p^2 + (1-p)p = p$. Consider the alternative investment plan: invest all the capital in round $\hat{t}$ by allocating $\tilde{I} = \dfrac{RK^1 - \alpha_{\hat{t}} g_{\hat{t}} K^1 s}{\alpha_{\hat{t}} g_{\hat{t}} (h-s)}$ to the risky buyout and $K^1 - \tilde{I}$ to the safe one. $\tilde{I}$ is defined such that the GP exactly reaches the threshold in case of a good outcome. Thus, the probability of reaching the threshold under this alternative plan is also p. We show that the alternative investment plan dominates the proposed one. The payoff from following the proposed plan minus the payoff from following the alternative one is:

$$P^{proposed} - P^{alt} = N_1(I_1, I_1^R, r) + N_2(I_2, pI_2^R(h) + (1-p)I_2^R(l), r) - \left(\alpha_{\hat{t}} g_{\hat{t}} sK^1 + \alpha_{\hat{t}} g_{\hat{t}} (r-s)\tilde{I}\right)$$

$$= -\left(\alpha_{\hat{t}} g_{\hat{t}} sK^1 - \alpha_1 g_1 sI_1 - \alpha_2 g_2 sI_2\right) + \frac{r-s}{h-s}\left(\alpha_1 g_1 I_1^R (h-r) + \alpha_{\hat{t}} g_{\hat{t}} sK^1 - \alpha_1 g_1 sI_1 - \alpha_2 g_2 sI_2\right) < 0,$$

where equality in the second line is derived by plugging in the expressions for $I_2^R(h)$, $I_2^R(l)$, and $\tilde{I}$ and simplifying. The inequality follows from the fact that

$$\alpha_{\hat{t}} g_{\hat{t}} sK^1 - \alpha_1 g_1 sI_1 - \alpha_2 g_2 sI_2 = \left(\alpha_{\hat{t}} g_{\hat{t}} - \alpha_1 g_1\right) sI_1 + \left(\alpha_{\hat{t}} g_{\hat{t}} - \alpha_2 g_2\right) sI_2 > 0,$$

and $r - s < 0$. Thus, the proposed plan is always dominated.

Finally we rule out option 3. Under this plan the GP needs two successes in the risky buyout to reach the threshold. That is, the probability of reaching the threshold is p^2. We consider two cases.

Sub-case a). The first case is when $\dfrac{r-s}{h-s}(RK^1 - \alpha_{\hat{t}} g_{\hat{t}} K^1 s) + pBK^1 < 0$. In this case, consider the difference in payoffs between the proposed plan and an alternative investment plan in which the entire K^1 is invested in round $\hat{t}$ in the safe project:

$$P^{proposed} - P^{alt} = N_1(I_1, I_1^R, r) + p\left(N_2(I_2, I_2^R(h), r) + pBK^1\right) + (1-p)N_2(I_2, 0, r) - \alpha_{\hat{t}} g_{\hat{t}} sK^1$$

$$= -\left(\alpha_{\hat{t}} g_{\hat{t}} sK^1 - \alpha_1 g_1 sI_1 - \alpha_2 g_2 sI_2\right) + (1-p)\alpha_1 g_1 (r-s) I_1^R + \left(\frac{r-s}{h-s}(RK^1 - \alpha_{\hat{t}} g_{\hat{t}} sK^1) + pBK^1\right) +$$

$$+ \frac{r-s}{h-s}\left(RK^1 - \alpha_{\hat{t}} g_{\hat{t}} sK^1\right) < 0$$

where the first term is negative as shown above, the second term is negative because $r < s$, the third term is negative by the definition of sub-case a), and the last term is negative because $r < s$ and $R > \alpha_{\hat{t}} g_{\hat{t}} s$ by definition of case 2. Thus, in this case the proposed plan is not optimal.

Sub-case b). In this case, $\dfrac{r-s}{h-s}(RK^1 - \alpha_{\hat{t}} g_{\hat{t}} K^1 s) + pBK^1 \geq 0$. Consider the alternative plan that calls for investing the entire K^1 in round $\hat{t}$ in the following way: an amount $\tilde{I}$ (as defined above) in the risky buyout and the rest in the safe project. Note that:

$$P^{proposed}-P^{alt}=N_1(I_1,I_1^R,r)+p\left(N_2(I_2,I_2^R(h),r)+pBK^1\right)+(1-p)N_2(I_2,0,r)$$
$$-\alpha_{\hat{t}}g_{\hat{t}}sK^1-\alpha_{\hat{t}}g_{\hat{t}}(r-s)\tilde{I}-pBK^1$$
$$=-\left(\alpha_{\hat{t}}g_{\hat{t}}sK^1-\alpha_1g_1sI_1-\alpha_2g_2sI_2\right)-\left(\frac{r-s}{h-s}(RK^1-\alpha_{\hat{t}}g_{\hat{t}}sK^1)+pBK^1\right)+$$
$$+\frac{r-s}{h-s}p\left(\alpha_{\hat{t}}g_{\hat{t}}sK^1-\alpha_1g_1sI_1-\alpha_2g_2sI_2\right)+\frac{r-s}{h-s}\alpha_1g_1I_1^R\left(h-\left(pr+(1-p)s\right)\right)<0$$

where the inequality follows because 1) the expression in parentheses in the first term is positive, 2) the expression in parentheses in the second term is positive (by definition of case b), 3) the expression in parentheses in the third term is positive (as seen before) and $r<s$, and 4) the expression $h-(pr+(1-p)s)$ is positive because h is greater than either r or s. Thus, the proposed plan is not optimal.

Step 3. The only candidates for optimal plans are then: 1) A plan that calls for investing all the capital in the safe buyout in round $\hat{t}$; 2) a plan that calls for investing all the capital in round $\hat{t}$ in the following way: an amount $\tilde{I}$ (as defined above) in the risky buyout and the rest in the safe project; and 3) a plan that calls for investing $K^1-\widehat{I}_1-\widehat{I}_2$ in the safe buyout in round $\hat{t}$, investing $\widehat{I}_1$ in the risky buyout in the first round, and investing the remaining capital $\widehat{I}_2$ in the second round. The plan specifies that $\widehat{I}_2$ be allocated to the risky buyout following a low outcome in the first round and to the safe buyout following a high outcome.

Proof. Steps 1 and 2 rule out other patterns of investment in risky projects. The rest of the capital is always allocated to the safe buyout in round $\hat{t}$ since this maximizes the GP's payoff.

Step 4: There are $\overline{B}$ and $\overline{\overline{B}}$ such that plan 1 is chosen when $B<\overline{B}$, plan 2 is chosen when $\overline{B}\le B\le\overline{\overline{B}}$ and plan 3 is chosen when $B>\overline{\overline{B}}$.

Proof. Let $P^{\text{plan i}}(B)$ be the GP's payoff from plan i with a level of B. First note that $P^{\text{plan i}}(0)$ is the payoff the GP obtains in the first fund. Because this payoff is decreasing in the amount of capital invested in the risky project, we have

$$P^{\text{plan 1}}(0)>P^{\text{plan 2}}(0)>P^{\text{plan 3}}(0) \tag{A3}$$

Also, we have that plan 1 never reaches the threshold, plan 2 reaches the threshold with probability p, and plan 3 reaches the threshold with probability $p + (1 - p)p$. Thus, we have:

$$\frac{\partial P^{\text{plan 1}}}{\partial B}=0<\frac{\partial P^{\text{plan 2}}}{\partial B}=p<\frac{\partial P^{\text{plan 3}}}{\partial B}=p+(1-p)p \tag{A4}$$

The proof of this step follows immediately from Equations (A3) and (A4).

Table 1. Summary Statistics

The sample consists of 207 private equity (buyout) funds raised between 1981 and 2000 (the 'vintage years'). We refer to the 53 buyout funds raised before 1993 as 'mature' funds. Fund size is the capital committed by investors to a fund in all closings, as reported by Venture Economics and corrected by us where needed using partnership reports prepared by the fund managers. Total fund size is the aggregate amount raised by all sample funds. The 'VE universe' refers to all funds raised in the relevant sample period according to Venture Economics. All monetary numbers are in nominal U.S. dollars.

	1981 to 2000	1981 to 1993
Number of funds	207	53
Fund size (committed capital, $m)		
Total	170,917	32,055
Mean	829.7	604.8
Median	423.5	265.0
Type of fund (according to LP's internal classification, in % of total)		
Small/Mid-Sized Buyout	48.4	36.4
Large Buyout	22.6	30.3
Buyout	16.1	27.3
Mezzanine	6.5	6.1
Growth Equity	2.6	
Private Equity	1.9	
Late Stage VC/Buyout	1.3	
Distressed Buyout	0.6	
Type of fund (according to Venture Economics, in % of total)		
Buyout	87.4	94.3
Generalist Private Equity	2.4	5.7
Mezzanine	4.8	
Venture Capital	4.8	
Other Private Equity	0.5	
% of VE universe covered (by capital)	35.0	31.4
First-time funds (as % of funds by number)	30.0	39.6
Age of partnership in fund vintage year		
Mean	9.4	7.1
Median	7.0	6.0

Table 2. Sample Breakdown by Vintage Year

Vintage year is the year a fund had its first closing. Aggregate proceeds is the aggregate amount raised by all funds of a certain vintage. Fund size is the capital committed by investors to a fund in all closings, as reported by Venture Economics and corrected by us where needed using partnership reports prepared by the fund managers. 'VE' refers to all buyout funds raised in the relevant period according to Venture Economics. All monetary numbers are in nominal million U.S. dollars.

	Number of funds			Aggregate proceeds			Mean fund size			Median fund size		
Vintage year	Sample [1]	VE [2]	[1]/[2] in %	Sample [3]	VE [4]	[3]/[4] in %	Sample [5]	VE [6]	[5]/[6]	Sample [7]	VE [8]	[7]/[8]
1981-2000	207	1,502	13.8	170,917	488,893	35.0	829.7	325.5	2.5	423.5	150.0	2.8
1981-1993	53	554	9.6	32,055	101,971	31.4	604.8	184.1	3.3	265.0	100.0	2.7
1981	1	7	14.3	75	391	19.2	75.0	55.8	1.3	75.0	39.0	1.9
1982	0	13	0.0	0	567	0.0		43.6	0.0		34.7	0.0
1983	1	19	5.3	114	1,887	6.0	113.6	99.3	1.1	113.6	62.7	1.8
1984	3	24	12.5	206	3,444	6.0	68.5	143.5	0.5	59.0	87.5	0.7
1985	3	29	10.3	688	3,984	17.3	229.3	137.4	1.7	160.2	94.6	1.7
1986	5	32	15.6	1,091	4,559	23.9	218.1	142.5	1.5	125.0	105.0	1.2
1987	5	44	11.4	6,313	15,239	41.4	1,262.6	346.4	3.6	235.0	100.0	2.4
1988	11	61	18.0	9,348	14,024	66.7	849.8	229.9	3.7	465.8	100.0	4.7
1989	8	84	9.5	3,560	11,207	31.8	445.0	133.4	3.3	257.5	97.5	2.6
1990	2	71	2.8	1,108	9,371	11.8	553.8	132.0	4.2	553.8	70.0	7.9
1991	0	32	0.0	0	5,127	0.0		160.2	0.0		100.0	0.0
1992	4	63	6.3	2,842	14,298	19.9	710.5	226.9	3.1	653.4	115.0	5.7
1993	10	75	13.3	6,711	17,873	37.5	671.1	238.3	2.8	420.0	135.1	3.1
1994	15	102	14.7	8,546	24,828	34.4	569.7	243.4	2.3	350.0	124.0	2.8
1995	12	100	12.0	7,034	33,325	21.1	586.2	333.2	1.8	400.0	150.0	2.7
1996	13	104	12.5	13,674	26,374	51.8	1,051.8	253.6	4.1	415.0	150.0	2.8
1997	22	133	16.5	15,611	62,659	24.9	709.6	471.1	1.5	380.0	225.5	1.7
1998	29	181	16.0	29,283	84,522	34.6	1,009.8	467.0	2.2	515.0	200.0	2.6
1999	31	141	22.0	27,417	60,148	45.6	884.4	426.6	2.1	476.0	238.9	2.0
2000	32	187	17.1	37,298	95,066	39.2	1,165.6	508.4	2.3	699.1	276.0	2.5

Table 3. Draw Downs and Capital Distributions by Vintage Year

Fund managers typically draw down the limited partners' capital commitment not when the fund is raised but when they wish to invest in a portfolio company. The average fund in our sample has drawn down 66.3% of committed capital. However, this understates draw downs as the more recent funds in the sample are not yet fully invested. Therefore, we also report draw down schedules for the 53 funds raised between 1981 and 1993. Funds are typically ten-year limited partnerships, with possible extensions by a few years subject to the limited partners' approval. Following liquidity events (such as an IPO), capital is returned to the limited partners in the form of cash or stock distributions. In the latter case, the LP may either sell the stock directly or hold it as a public market investment. At the end of the fund's life, the general partner 'liquidates' the fund by selling all remaining assets and distributing the cash to the limited partners. The liquidation phase can potentially take a few years. We report average cumulative distributions divided by invested and by committed capital for all funds raised between 1981 and 2000, between 1981 and 1993, and by vintage year.

		Draw downs			Capital distributions	
Vintage Year	No. of funds	Average draw downs / committed capital (%)	Fraction of funds that are 70% invested (%)	Fraction of funds that are 80% invested (%)	Average distributions / capital invested	Average distributions / committed capital
1981-2000	207	66.3	54.1	48.8	1.008	0.883
1981-1993	53	94.2	96.2	88.7	2.571	2.430
1981	1	99.9	100.0	100.0	3.278	3.275
1983	1	100.0	100.0	100.0	3.590	3.590
1984	3	100.9	100.0	100.0	3.505	3.547
1985	3	101.5	100.0	100.0	5.711	5.719
1986	5	100.0	100.0	100.0	3.798	3.799
1987	5	85.6	80.0	60.0	2.890	2.616
1988	11	97.6	100.0	100.0	2.000	1.935
1989	8	92.2	100.0	87.5	2.437	2.172
1990	2	86.5	100.0	50.0	1.697	1.398
1992	4	85.9	75.0	75.0	2.163	1.803
1993	10	93.2	100.0	90.0	1.475	1.339
1994	15	92.6	93.3	86.7	1.270	1.141
1995	12	89.5	100.0	91.7	0.989	0.875
1996	13	88.8	92.3	84.6	0.722	0.674
1997	22	69.6	45.5	36.4	0.389	0.292
1998	29	63.4	37.9	34.5	0.437	0.284
1999	31	36.4	6.5	3.2	0.213	0.096
2000	32	19.0	0.0	0.0	0.042	0.002

Table 4. The Determinants of Draw Down Rates

The table reports the determinants of the time a fund takes to be fully invested. The dataset is structured as an unbalanced panel of quarterly observations where the dependent variable equals one in the quarter T in which cumulative draw downs exceed K% of committed capital for the first time; it equals zero until that quarter and is missing afterwards. We report three alternative cut-offs, K=70, 80, or 90. The explanatory variables are listed in the table and discussed more fully in the text. Given the data structure, covariates can be allowed to vary over time for a given fund, so that changes over time in a covariate can affect a fund's draw down rate. For convenience, we report coefficients from accelerated-time-to-failure models, estimated using MLE; these are isomorphic to proportional-hazard duration models, and the reported coefficients can easily be converted into hazard ratios. In the accelerated-time-to-failure model, the dependent variable can be thought of as the log of the time (in quarters) between a fund being raised and drawing down at least K%. We use all sample funds and correct for the right-censoring caused by funds leaving our sample before they are fully invested. The error is assumed to follow a Weibull distribution. Intercepts and vintage-year fixed effects are included but not reported. Standard errors are shown in italics; they are clustered on fund ID and so the various quarterly observations between a fund being raised and it being fully invested are not required to be independent for a given fund. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

	Time-varying?	Draw-down: 70% (1)	Draw-down: 80% (2)	Draw-down: 90% (3)
Investment opportunities				
value-weighted mean industry book/market ratio	yes	0.702^{**}	0.852^{***}	1.035^{***}
		0.291	*0.300*	*0.343*
… X (dummy=1 if first-time fund)	yes	-0.160	-0.255^{*}	-0.362^{**}
		0.147	*0.145*	*0.161*
Competition for deal flow				
log real fund inflows, same vintage year	no	0.342^{***}	0.187	0.080
		0.121	*0.131*	*0.119*
Herfindahl industry concentration index	yes	-0.384^{*}	-0.532^{**}	-0.806^{**}
		0.213	*0.227*	*0.370*
Cost of capital				
BAA corporate bond premium over riskfree rate (in %)	yes	0.292^{**}	0.255^{**}	0.081
		0.120	*0.130*	*0.156*
Fund characteristics				
log age of GP partnership in vintage year	no	-0.010	-0.025	-0.074
		0.043	*0.042*	*0.052*
log real fund size	no	-0.002	-0.008	0.001
		0.029	*0.034*	*0.038*
Market conditions				
quarterly return on Nasdaq Composite Index (in %)	yes	-0.002	-0.003	0.000
		0.002	*0.002*	*0.003*
Diagnostics				
Pseudo-R^2		33.9 %	30.1 %	21.4 %
Likelihood ratio test: all coeff. = 0 (χ^2)		427.4^{***}	191.4^{***}	193.3^{***}
Number of funds		206	206	206
Number of right-censored observations		86	94	109
Number of observations (time at risk)		2,550	2,776	3,080

Table 5. Change in Investment Sensitivities by Fund Age

The table reports difference-in-difference tests of Prediction 6. We compare the change in a fund's investment sensitivity to market conditions before and after a string of successes for both young and experienced GPs. The first difference (over time) controls for observed and unobserved fixed GP characteristics. The second difference (the change in a young GP's sensitivity minus the change in an experienced GP's sensitivity) controls for changes in investment sensitivity that are related to the age of the fund. We expect the investment sensitivity for the young GP to increase relative to that of an experienced GP after a series of early successes. We define early success as breaking even in present value terms (i.e., IRR>0) while still having at least 50% of committed capital available for investment. As in Table 4, our estimate of a fund's investment sensitivity is the coefficient for investment opportunities in a duration model of time to investing at least *K*% of committed capital. We report three alternative cut-offs, *K*=70, 80, or 90. We interact investment opportunities with four indicator variables to identify the investment sensitivities of first-time and older funds before and after early successes. Funds without early successes remain in the "before" category throughout their investment life. We include all other covariates shown in Table 4 but to conserve space only report the four investment sensitivities along with *p*-values for standard errors (clustered on fund ID). We also report estimates of the differences in investment sensitivities across time, across funds, and across both (the difference-in-differences test, shown in bold face), along with *p*-values for Wald tests of their significance.

	Draw-down: 70%			Draw-down: 80%			Draw-down: 90%		
	before	after	difference	before	after	difference	before	after	difference
first-time funds	0.494	0.981	0.487	0.572	0.914	0.342	0.664	0.995	0.331
	0.031	*0.000*	*0.018*	*0.047*	*0.006*	*0.147*	*0.000*	*0.000*	*0.013*
older funds	0.713	-0.247	-0.960	0.870	-0.324	-1.195	1.107	0.222	-0.885
	0.000	*0.223*	*0.000*	*0.003*	*0.327*	*0.000*	*0.000*	*0.287*	*0.000*
difference	-0.219	1.228	**1.447**	-0.298	1.239	**1.537**	-0.442	0.774	**1.216**
	0.254	*0.000*	***0.000***	*0.054*	*0.000*	***0.000***	*0.000*	*0.000*	***0.000***

Table 6. Determinants of investment returns

The dependent variable is the log of one plus the annualized (geometric) return on investment for each portfolio company. The annualized return is defined as *abs*(cash inflows/invested capital) raised to the power (1/holding period), minus 1. The explanatory variables are listed in the table. We estimate ordinary least-squares regressions over different sample periods, beginning with all funds raised between 1981 and 1993 (the mature funds in our dataset) and adding later vintage years one by one. Funds raised more recently are less likely to have reached the point where investments can be exited, so their portfolio companies are more likely to have –100% returns. Heteroskedasticity-consistent standard errors are shown in italics. Intercepts and industry fixed effects are included but not reported. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

Vintage years:	1981 to 1993	1981 to 1994	1981 to 1995	1981 to 1996	1981 to 1997	1981 to 1998
Investment opportunities at time of investment						
value-weighted mean industry book/market ratio	-3.634**	-5.665***	-6.068**	-7.191**	-9.824***	-7.693**
	1.709	*1.315*	*1.896*	*1.965*	*1.310*	*2.506*
… X (dummy=1 if first-time fund)	0.168	-0.599	-1.329	-1.368	-1.468	-1.490
	0.613	*0.901*	*1.120*	*1.017*	*0.912*	*1.187*
Competition for deal flow at time of investment						
log real fund inflows	0.067	-3.198***	-4.035***	-4.622***	-4.896***	-4.695***
	0.863	*0.285*	*0.521*	*0.422*	*0.371*	*0.303*
Herfindahl industry concentration index	-0.009	0.034***	0.040***	0.049***	0.057***	0.056***
	0.014	*0.003*	*0.003*	*0.004*	*0.004*	*0.006*
Cost of capital at time of investment						
BAA corporate bond premium over riskfree rate	0.591	-1.902***	-2.716***	-3.793***	-3.667***	-3.693***
	1.209	*0.469*	*0.506*	*0.618*	*0.522*	*0.448*
Fund characteristics						
log age of GP partnership in vintage year	0.615	0.837*	0.418	0.356	0.198	0.253
	0.459	*0.404*	*0.468*	*0.368*	*0.294*	*0.268*
log real fund size	0.194	0.060	0.555***	0.336*	0.256	0.113
	0.323	*0.205*	*0.139*	*0.153*	*0.213*	*0.216*
log real investment cost	0.522**	0.224	0.118	0.046	0.019	0.069
	0.210	*0.120*	*0.183*	*0.165*	*0.138*	*0.071*
fund year in which investment was made (1 to 10)	-0.158	-0.110	0.053	0.235***	0.315***	0.385***
	0.186	*0.059*	*0.075*	*0.044*	*0.050*	*0.045*
Market conditions at time of investment						
quarterly return on Nasdaq Composite Index (in %)	2.111	0.082	-1.699	-0.506	-0.725	-0.134
	3.862	*2.027*	*0.886*	*1.668*	*1.246*	*1.142*
Adjusted R^2	3.9 %	13.3 %	18.6 %	26.1 %	35.9 %	39.8 %
Wald test: all coeff. = 0 (F)	6.4***	17.8***	14.6***	29.5***	59.5***	79.9***
No. of portfolio companies	426	571	655	807	1,011	1,273

Table 7. Determinants of portfolio risk

The dependent variable is the standard deviation of the log returns of investments undertaken by fund *i* in fund-year *t*. Returns are defined as in Table 6. To get meaningful estimates of the dependent variable, we discard fund-years with fewer than five investments. The panel runs till the last year a fund makes new investments. We estimate weighted least-squares regressions, to account for the fact that the precision with which we measure investment risk varies with the number of investments a fund undertakes in a given year. The regressions are estimated over different sample periods, beginning with all funds raised between 1981 and 1993 (the mature funds in our dataset) and adding later vintage years one by one. The explanatory variables are listed in the table. Heteroskedasticity-consistent standard errors are shown in italics. Intercepts and fund-year fixed effects are included but not reported. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

Vintage years:	1981 to 1993	1981 to 1994	1981 to 1995	1981 to 1996	1981 to 1997	1981 to 1998
Fund characteristics						
dummy=1 if first-time fund	2.120**	1.715***	1.142*	1.239**	0.025	1.023***
	0.918	*0.663*	*0.636*	*0.633*	*0.401*	*0.374*
log real fund size	-0.444***	-0.377***	-0.413***	-0.382***	-0.378***	-0.361***
	0.082	*0.070*	*0.064*	*0.049*	*0.044*	*0.044*
Investment opportunities in fund-year						
value-weighted mean industry book/market ratio	-4.645***	-1.733**	-1.846***	-1.844***	-2.174***	-1.646***
	0.734	*0.711*	*0.628*	*0.473*	*0.433*	*0.374*
… X (dummy=1 if first-time fund)	-2.751**	-2.218**	-1.704*	-1.801*	-0.224	-1.599**
	1.324	*1.047*	*1.022*	*1.020*	*0.687*	*0.653*
Competition for deal flow in fund-year						
log real fund inflows	1.068***	0.807***	0.537***	0.522***	0.304***	0.083
	0.126	*0.112*	*0.104*	*0.085*	*0.078*	*0.074*
Herfindahl industry concentration index	-6.671***	-7.807***	-6.933***	-5.610***	-5.704***	-3.993***
	1.085	*1.167*	*1.157*	*0.985*	*0.981*	*1.090*
Cost of capital in fund-year						
BAA corporate bond premium over riskfree rate	1.671***	0.757***	0.160	-0.008	-0.232**	-0.677***
	0.252	*0.233*	*0.213*	*0.142*	*0.118*	*0.107*
Market conditions in fund-year						
quarterly return on Nasdaq Composite Index (in %)	-1.809**	-1.696**	-0.512	-0.307	-0.143	0.520
	0.754	*0.682*	*0.661*	*0.511*	*0.472*	*0.429*
Adjusted R^2	21.2 %	15.5 %	12.8 %	12.8 %	11.1 %	9.9 %
Wald test: all coeff. = 0 (F)	63.0***	52.6***	42.2***	32.7***	28.0***	26.2***
No. of fund-years	266	344	393	439	511	588

Table 8. Changes in portfolio risk

The dependent variable is the difference in the standard deviation of log returns on investments undertaken in the last five years versus the first five years of a fund's life. There is one observation per fund. To get meaningful estimates of the dependent variable, we require a minimum of five investments in each period, which reduces the sample size somewhat compared to Table 2. The number of exits equals the number of portfolio companies that have been sold via an IPO or an M&A transaction during the fund's first five years. The fraction of committed capital distributed to LPs is computed as the difference between capital returns and investments during the first five years, divided by fund size. It is negative for funds that have drawn down more capital than they have distributed. We estimate weighted least-squares regressions, to account for the fact that the precision with which we measure investment risk varies with the number of investments a fund has undertaken. The regressions are estimated over different sample periods, beginning with all funds raised between 1981 and 1993 (the mature funds in our dataset) and adding later vintage years one by one. Heteroskedasticity-consistent standard errors are shown in italics. Intercepts and vintage-year fixed effects are included but not reported. We use ***, **, and * to denote significance at the 1%, 5%, and 10% level (two-sided), respectively.

Vintage years:	1981 to 1993	1981 to 1994	1981 to 1995	1981 to 1996	1981 to 1997	1981 to 1998
Fund characteristics						
log real fund size	1.107***	1.014***	0.841***	0.573***	0.351***	0.286***
	0.108	*0.104*	*0.092*	*0.068*	*0.048*	*0.039*
Performance in first-half of fund life						
number of exits	-0.052***	-0.102***	-0.083***	-0.059***	-0.041***	-0.026**
	0.011	*0.019*	*0.017*	*0.014*	*0.013*	*0.010*
… X (dummy=1 if first-time fund)	-0.529***	-0.319***	-0.261***	-0.205***	-0.108***	-0.122***
	0.074	*0.051*	*0.048*	*0.044*	*0.035*	*0.035*
fraction of committed capital distributed to LPs	-1.950***	-2.535**	-2.825**	-2.398**	-2.658**	-2.505**
	1.122	*1.208*	*1.244*	*1.210*	*1.160*	*1.134*
… X (dummy=1 if first-time fund)	-15.725*	-4.857	-2.165	1.107	-0.587	-0.394
	6.669	*3.111*	*2.571*	*2.408*	*2.316*	*2.244*
Adjusted R^2	35.2 %	31.3 %	30.0 %	28.9 %	26.7 %	26.8 %
Wald test: all coeff. = 0 (*F*)	24.5***	24.8***	25.1***	26.7***	27.2***	31.1***
No. of funds	50	65	77	89	111	139