The Economics of Private Equity Funds

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Abstract: This paper analyzes the economics of the private equity industry using a novel model and dataset. We obtain data from a large investor in private equity funds, with detailed records on 238 funds raised between 1992 and 2006. Fund managers earn revenue from a variety of fees and profit-sharing rules. We build a model to estimate the expected revenue to managers as a function of these rules, and we test how this estimated revenue varies across the characteristics of our sample funds. Among our sample funds, about 60 percent of expected revenue comes from fixed-revenue components which are not sensitive to performance. We find major differences between venture capital (VC) funds and buyout (BO) funds – the two main sectors of the private equity industry. In general, BO fund managers earn lower revenue per managed dollar than do managers of VC funds, but nevertheless these BO managers earn substantially higher revenue per partner and per professional than do VC managers. Furthermore, BO managers build on their prior experience by raising larger funds, which leads to significantly higher revenue per partner and per professional, despite the fact that these larger funds have lower revenue per dollar. Conversely, while prior experience by VC managers does lead to higher revenue per partner in later funds, it does not lead to higher revenue per professional. Taken together, these results suggest that the BO business is more scalable than the VC business.

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I. Introduction

Worldwide, private equity funds manage approximately $1 trillion of capital. About two-thirds of this capital is managed by buyout funds, where leverage can multiply the investment size by three or four times base capital. In the early 21st century, these buyout funds are responsible for about one-quarter of all global M&A activity. Venture capital funds – the other main type of private equity – raised nearly $160 billion of capital during the boom years of 1999 and 2000, and made early investments in recent successes like Google (in the United States), Skype (in Europe), and Baidu (in Asia). Overall, private equity funds play an increasingly important role as financial intermediaries in addition to their significant day-to-day involvement as board members and advisors. Nevertheless, relatively little is known about industrial organization of the private equity sector, mostly due to data limitations. This paper aims to fill that gap using a database of fund characteristics, past performance, and fund terms provided by one of the largest private-equity investors in the world.

Virtually all private-equity funds are organized as limited partnerships, with private equity firms serving as the general partner (GP) of the funds, and large institutional investors and wealthy individuals providing the bulk of the capital as limited partners (LPs). These limited partnerships typically last for 10 years, and partnership agreements signed at the funds' inceptions clearly define the expected payments to GPs. These payments consist of both fixed and variable components. While the fixed component resembles pricing terms of mutual-fund and hedge-fund services, the variable component has no analogue among most mutual funds and is quite different from the variable incentive fees of hedge funds.[1]

Successful private equity firms stay in business by raising a new fund every 3 to 5 years. If the current fund performs well, and LPs interpret that performance as "skill" rather than "luck", investors' demand curve for the new fund will shift out, with the equilibrium conditions requiring that LPs earn their cost-of-capital after payments to the GP. In response to this demand shift, GPs may alter the terms of the new fund so as to earn higher expected revenue for each dollar under management. Alternatively, they may increase the size of their next fund. They may also do both. Raising the size of the fund may entail additional costs, depending on the production function for the underlying private-equity activities. Do successful private equity managers earn higher revenue by setting higher prices, raising larger funds, or both? Do these strategies differ between venture capital (VC) and buyout (BO) funds? What can these strategies tell us about organizational economics of private equity funds? In this paper, we address these questions using a novel model and dataset.

We are not the first authors to investigate the revenue-based terms of private equity partnerships. The seminal paper on this topic is Gompers and Lerner (1999), who focus exclusively on venture capital funds and explore the cross-sectional and time-series variation in the fund terms. Litvak (2004) addresses similar issues from a legal perspective, and extends the Gompers and Lerner analysis to consider several additional terms from the partnership agreements. Neither of these papers addresses buyout funds –

[1] See Chordia (1996), Ferris and Chance (1987), Tufano and Sevick (1997), Christoffersen (2001), and Christoffersen and Musto (2002) for analyses of fee structures in the mutual fund industry. See Goetzmann, Ingersoll, and Ross (2003) and Agarwal, Daniel, and Naik (2006) for analyses of fee structures in the hedge fund industry.

the largest part of our sample and the part with the most variation – nor do they use an option-pricing framework to value the variable-revenue components. As we will see, many of the most important conclusions are driven by variation that can only be captured in this framework. On the modeling side, Conner (2005) uses simulation to estimate the value of various pricing terms, but he takes an ex-post perspective (which requires specific assumptions about fund returns), rather than the ex-ante perspective (based on equilibrium relations) taken in our paper.[2]

In Section II, we discuss our data sources, define the key revenue variables used in the paper, and summarize these variables for our sample funds. Our main data set is provided by one of the largest LPs in the world, which we refer to as "the Investor". In the course of making investment decisions in private equity funds, the Investor requires potential GPs to provide information about internal fund organization in addition to providing standard documentation of fund terms. The Investor provided us access to these data for 238 funds raised between 1992 and 2006, of which 94 are VC funds and 144 are BO funds.

In Section III, we develop an expected-revenue model for private equity firms. Section III.A discusses the model for management fees, Section III.B discusses the model for the largest component of variable revenue ("carried interest"), and Section III.C discusses two other components of revenues that are specific to BO funds: "transaction fees" and "monitoring fees". (All of these terms will be defined in Section II.) As compared to previous models in the literature, our main contributions here are to adopt an

[2] There is also a related and growing literature that examines the performance of private equity funds. See Woodward (2004), Cochrane (2005), Kaplan and Schoar (2005), Phalippou and Gottschalg (2006), Groh and Gottschalg (2007), and Cao and Lerner (2007). We abstract from all performance issues by positing an equilibrium condition where, in expectation, LPs receive exactly their cost of capital. This equilibrium condition is discussed in Section III.B.1.

option-pricing framework for the valuation of carried interest, and to anchor all of our key model inputs to industry data. Section III.D summarizes the outputs of the model. This framework allows us to identify several important determinants of fund revenue that have not previously been measured.

Section IV provides the main empirical results of the paper. Using the revenue estimates from the models of Section III, we empirically test for the relationship of various revenue measures with fund characteristics and past performance. Among our sample funds, about 60 percent of the expected revenue comes from fixed revenue components. We find striking differences between VC and BO funds. In general, BO funds earn lower revenue per managed dollar than do venture capital funds, but nevertheless these BO funds earn substantially higher revenue per partner and per professional than do VC funds. Furthermore, BO funds build on past success by raising larger funds, which leads to significantly higher revenue per partner and per professional, despite the fact that these larger funds have lower revenue per dollar. Conversely, while past success by VC funds does lead to higher revenue per partner, it does not lead to higher revenue per professional. Section V concludes the paper.

II. Data and Summary Statistics

In this section, we describe the dataset and define some key terms.

A. Data sources

We construct our dataset from several sources. Our main data source is the Investor, from whom we obtained detailed information on terms and conditions for 238 private equity funds raised between 1992 and 2006. In addition to terms and conditions, we also obtained information on the fund management firms' past investment experience, returns, investment focus, and team composition. We use this data to construct expected-revenue measures for each fund manager. In addition, we use several other sources to supplement and verify information from the Investor. One is *Galante's Venture Capital and Private Equity Directory* (Asset Alternatives, 2006), which provides a nearly comprehensive reference of publicly available information about private equity funds. This publication enables us to cross-check some of the information provided by the Investor and fill in occasional omissions, but does not provide any information about fund terms or past returns. In recent years, some fund-level return data has become publicly available. This data is summarized in the *Private Equity Performance Monitor* 2006 (Private Equity Intelligence, 2006), which we use to benchmark the performance of our sample funds. This benchmarking is aided by industry-level returns data from the *Investment Benchmarks Reports* published by Venture Economics (2006a and 2006b).

B. Definitions and Summary Statistics

Table I presents summary statistics for our sample. The sample consists of 238 funds, of which 94 are VC funds and 144 are BO funds. Overall, about three-quarters of these funds focus on investments in the United States, and the majority of the remaining funds are focused on investments in Europe. Unlike mutual funds, private equity funds do not have a well-defined level of assets under management. Instead, GPs receive commitments from LPs to provide funds when needed for new investments. The total amount of such LP commitments for any given fund is defined as the *committed capital* of the fund. The median VC fund in our sample has $225M in committed capital, and the median BO fund has $600M. Note that the interquartile range for the size of BO funds is from $297M to $1500M, versus a much smaller range of $100M to $394M for VC funds.

Table I also shows that the median GP of a VC fund has raised one fund prior to the sample fund, has been in business for three years, and has four partners; the median GP of a BO fund has raised one fund prior to the sample fund, has been in business for six years and has five partners. Overall, these are small organizations, with the median VC fund having only nine professionals (= partners + non-partners) and the median BO fund having 13 professionals. The largest VC fund in our example is staffed by less than 50 professionals; the largest buyout fund is staffed by less than 100.[3] Outside of our sample, Asset Alternatives (2006) reports only a few private equity organizations with more than 100 investment professionals.

In materials provided to the Investor, GPs must provide information about typical investment size, which then implies an expected number of investments for each fund. We summarize this expected number in the last row of Panels A and B. The median VC fund expects to make 20 investments, which yields five investments per partner at that fund. Since each investment typically requires significant work from a venture capitalist, it is difficult for this ratio to grow much higher, and few VC funds expect to make more than ten investments per partner. BO funds tend to make larger investments and require even more intense involvement on each one, with the median fund making only 12 investments, or 2.4 per partner. In the revenue model of Section III.B, the expected

[3] Note that the number of professionals dedicated to a fund is not necessarily the same as the number of professionals employed at the GP firm. The GP firm may engage in more than one type of private equity and raise different types of funds; in such cases, the number of professionals employed at the firm level may exceed the number of professionals dedicated to a fund. Our data allows us to distinguish between these two measures.

number of investments plays an important role in driving the overall volatility of the fund portfolio, which in turn has a significant effect on the expected present value of revenue.

GPs earn the bulk of fixed revenue – which is not based on the performance of the fund – through *management fees*[4]. To see how management fees are calculated, we need to define several terms. Over the lifetime of the fund, some of the committed capital is used for these fees, with the remainder used to make investments. We refer to these components of committed capital as *lifetime fees* and *investment capital*, respectively. At any point in time, we define the *invested capital* of the fund as the portion of investment capital that has already been invested into portfolio companies. *Net invested capital* is defined as invested capital, minus the cost basis of any exited investments. Similarly, *contributed capital* is defined as invested capital plus the portion of lifetime fees that has already been paid to the fund, and *net contributed capital* is equal to contributed capital minus the cost basis of any exited investments. The typical fund has a lifetime of ten years, with general partners allowed to make investments in new companies only during the first five years (the *investment period*), with the final five years reserved for follow-on investments and the exiting of existing portfolio companies.

Most funds use one of four methods for the assessment of management fees. Historically, the most common method was to assess fees as a constant percentage of committed capital. For example, if a fund charges 2 percent annual management fees on committed capital for ten years, then the lifetime fees of the ten-year fund would be 20 percent of committed capital, with investment capital comprising the other 80 percent. In recent years, many funds have adopted a decreasing fee schedule, with the percentage

[4] In addition to management fees, BO funds frequently earn another type of fixed revenue called *entry transaction fees* at the time of investments. This is discussed later in this section.

falling after the investment period. For example, a fund might have a 2 percent fee during five-year investment period, with this annual fee falling by 25 basis points per year for the next five years.

The third type of fee schedule uses a constant rate, but changes the basis for this rate from committed capital (first five years) to net invested capital (last five years). Finally, the fourth type of fee schedule uses both a decreasing percentage and a change from committed capital to net invested capital after the investment period. For any fee schedule that uses net invested capital, the estimation of lifetime fees requires additional assumptions about the investment and exit rates. In Section III.A, we discuss the assumptions used in our model, and the data behind these assumptions.

The top half of Table II presents summary statistics on management-fee terms for the sample funds. The most common initial fee level is 2 percent, though the majority of funds give some concessions to LPs after the investment period is over; e.g., switching to invested capital basis (43.0 percent of VC funds and 84.0 percent of BO funds), lowering the fee level (54.8 percent of VC funds and 45.1 percent of BO funds), or both (16.1 percent of VC funds and 38.9 percent of BO funds). Based on these facts, we should expect lifetime fees to be less than 20 percent of committed capital for most funds. Consistent with this expectation, in untabulated results we find that median level of lifetime fees is 12 (17.75) percent of committed capital for BO (VC) funds in our sample, with an interquartile range between 10 (14) and 13.5 (21.25) percent, respectively.

GPs earn variable (performance based) revenue from several sources: *carried interest, transaction fees*, and *monitoring fees*. Of these three sources, carried interest tends to receive the most attention from all parties and provides the largest portion of expected variable revenue for most funds. In our discussion of carried interest, it is helpful to distinguish among four different concepts: *carry level, carry basis, carry hurdle,* and *carry timing*. The carry level refers to the percentage of "profits" claimed by the general partner. The carry basis refers to the standard by which profits are measured. The carry hurdle refers to whether a GP must provide a preset return to LPs before collecting any carried interest and, if so, the rules about this preset return. Finally, carry timing, not surprisingly, refers to the set of rules that govern the timing of carried interest distributions. To see how these terms work in practice, consider a simple case with a carry level of 20 percent, a carry basis of committed capital, no hurdle rate, and carry timing that requires the repayment of the full basis before GPs receive any carry. Under these terms, LPs would receive every dollar of exit proceeds until they had received back their entire committed capital, and then the GPs would receive 20 cents of every dollar after that. Below, we discuss the typical types of variations in these terms, with summary statistics shown in the bottom half of Table II.

The overwhelming majority of funds – including all 144 BO funds – use 20 percent as their carry level. Among the 94 VC funds, one fund has a carry level of 17.5 percent, three funds have 25 percent, and one fund has a carry level of 30 percent. The exact origin of the 20 percent focal point is unknown, but previous authors have pointed to Venetian merchants in the middle ages, speculative sea voyages in the age of exploration, and even the book of Genesis as the source.[5] Notwithstanding this tiny variation in the carry level, other fund terms in the model will give rise to significant variation in expected carried interest.

[5] See Kaplan (1999) and Metrick (2007) for references and discussion.

There are two main alternatives for the carry basis. The first alternative – carry basis equal to committed capital – is used by 92.1 percent of the VC funds and 83.2 percent of the BO funds in our sample. The second alternative – carry basis equal to investment capital – is used by the remaining funds in the sample. The use of investment capital as the carry basis can have a large effect on the amount of carried interest earned by the fund. As a first approximation, for a successful fund that earns positive profits – ignoring the effect of risk and discounting – a change in basis from committed capital to investment capital would be worth the carry level multiplied by lifetime fees.

The effect of a hurdle return on expected revenue is greatly affected by the existence of a *catch-up* return for the GP. As an illustration of hurdle returns with a catch-up, consider a $100M fund with a carry percentage of 20 percent, a carry basis of all committed capital, a hurdle return of 8 percent, and a 100 percent catch-up. We keep things simple and imagine that all committed capital is drawn down on the first day of the fund, and that there are total exit proceeds of $120M, with $108M of these proceeds coming exactly one year after the first investment, $2M coming one year later, and $10M coming the year after that. Under these rules, all $108M of the original proceeds would go to the LPs. This distribution satisfies the 8 percent hurdle rate requirement for the $100M in committed capital. One year later, the catch-up provision implies that the whole $2M would go to the GPs; after that distribution they would have received 20 percent ($2M) out of the total $10M in profits. For the final distribution, the $10M would be split $8M for the LPs and $2M for the GPs.

Beyond this simple example, the calculations quickly become unwieldy to handle without a spreadsheet. The key idea is that, even with a hurdle return, the GPs with a catch-up still receive the same fraction of the profits as long as the fund is sufficiently profitable. In this example, the fund made $20M of profits ($120M of proceeds on $100M of committed capital), and the GPs received 20 percent ($4M) of these profits. A fund with a catch-up percentage below 100 percent would still (eventually) receive 20 percent of the profits, albeit at a slower pace than the fund in the above example. If, however, the fund had only earned $8M or less of profits over this time period, then all these profits would have gone to the LPs.

Table II shows that hurdle returns are much more prevalent among buyout funds than among VC funds (93.1% versus 47.6%). Among funds with a hurdle rate, the modal rate of 8 percent is used by about two-thirds of the VC funds and three-quarters of the BO funds. Virtually all funds with a hurdle use a rate between six and ten percent. The majority of funds with a hurdle have a catch-up rate of 100 percent (not shown in the table), and most of the remaining funds have a catch-up rate of 80 percent. Only two funds have a hurdle return without having any catch-up provision.

The final element of carried interest to be discussed is *carry timing*. In the discussion so far, we have proceeded under the assumption that GPs must return the entire carry basis to LPs before collecting any carried interest. The reality can be quite different, with funds using a variety of rules to allow for an early collection of carried interest upon a profitable exit. When such early carry is taken, the LPs typically have the ability to “clawback” these distributions if later performance is insufficient to return the full carry basis. In the present version of the model, we have not incorporated any of these variations – we assume that all funds are using the base-case terms with a return of the full basis before any carry is collected.

Aside from carried interest, the other two components of variable revenue are transaction fees and monitoring fees. Both of these fees are common features for BO funds, and are rare for VC funds. When a BO fund buys or sells a company, they effectively charge a transaction fee, similar to the M&A advisory fees charged by investment banks. While this fee is rolled into the purchase price, the GP can still benefit if they own less than 100 percent of the company and if they share less than 100 percent of these transaction fees with their LPs. About 80 percent of BO fund agreements require that GPs share at least some portion of these transactions fees with their LPs, with one-third of all funds required to return all transaction fees to LPs. Another third of funds use a 50/50 sharing rule between GPs and LPs, with most of the remaining funds allocating between 50 and 100 percent for the LPs. While VC funds often have these sharing rules written into their partnership agreements, transaction fees are nevertheless rare in VC transactions and thus are not covered in our analysis. In terms of performance sensitivity, entry transaction fees (assessed at the time of asset purchase) are largely determined as a fixed % of investment capital[6], whereas exit transaction fees (assessed at the time of asset sale) are realized only at exits and are based on realization values. Thus we treat entry transaction fees as a fixed revenue component and exit transaction fees as a variable revenue component.

In addition to transaction fees, BO funds often charge a monitoring fee to their portfolio companies. In most cases, these fees are shared with LPs receiving 80 percent and GPs receiving 20 percent. We did not consistently code for the differences in the sharing rule for monitoring fees, so in our model we assume all BO funds use the same

[6] Leverage is another important determinant of entry transaction fees. In the present version of the model we assume a fixed leverage ratio of 2:1.

80/20 rule. While there is no set schedule for these fees, industry practitioners have told us that these fees range between one and five percent of EBITDA each year, with smaller companies falling on the higher side of that range. In Section III.C, we discuss our method for modeling these fees. As with transaction fees, monitoring fees are rare for VC funds, so we do not include them in our estimates of VC fund revenue. Since monitoring fees are based on operating performance of portfolio companies under BO fund ownership, we treat monitoring fees as a variable revenue component.

III. A Model of Expected Revenue for Private Equity Funds

In this section, we discuss our models for the present value of GP revenue. Section III.A presents a model of management fees that takes account of differences observed in our sample. Section III.B presents a model for carry revenue, based on a risk-neutral option-pricing approach. Section III.C appends a model for transaction fees and monitoring fees onto the model of Section III.B. Section III.D summarizes the model outputs for some benchmark cases.

Why is it necessary to build these models at all? Instead, why not just use the data to estimate the actual revenue earned by the funds? We use the models because we want to measure the *ex ante* revenue as a function of fund terms. We are attempting to measure whether fund terms vary with fund characteristics, not whether fund terms predict performance. In a very large sample, one would expect these two approaches to be the same, but in our small sample they could be quite different. Furthermore, the cash-flow data available for our sample funds is limited, and does not separate LP payments into the necessary components. Overall, the *ex post* analysis would not be feasible with our data.

A. Management Fees

In our model, we assume that funds are fully invested at the end of investment period. Using quarterly cash-flow data drawn from over 500 completed funds[7], we construct size-weighted average investment pace of VC and BO funds, respectively, and use annualized versions of the empirically-derived investment pace as inputs in our model. For example, a 10-year VC fund that has a 5-year investment period invests 30%, 24%, 31%, 12%, and 3% of its investment capital in years one through five, respectively. For BO funds, the pace is 26%, 23%, 25%, 18%, and 8%.

For exits, we take the investment pace above as given, and use simulations to draw random time to exit according to the same exponential distribution as used in the carry model of Section III.B. For the benchmark case, we assume that VC funds make 25 investments per fund and that each investment is equal in size. For buyout funds, the benchmark case uses 11 investments. Panel A of Table III reports an example calculation for a BO fund with a five-year investment period. In this example, the net invested capital grows for the first 3 years as the bulk of new investments are made and relatively few exits occur, but starts declining before the end of investment period as the investment pace slows down and the exit pace increases.

[7] We thank Private Equity Intelligence for providing us with this data.

The amount of management fees is a function of fee level, fee basis, committed capital, net invested capital, and the establishment cost of the fund.[8] For each fund in our sample, we solve for the exact investment capital and lifetime fees such that

Committed capital = investment capital + lifetime fees + establishment cost (1)

Since fees are a contractual obligation of the limited partners, we treat these fees as a riskfree revenue stream to the GP with a five percent discount rate.[9] Using this discount rate, we obtain the PV of management fees for each fund. Panel B of Table III shows an example for a $100M BO fund that charges 2 percent fees on committed capital for the first 5 years, 2 percent fees on net invested capital for the next 5 years, and has 1 percent establishment cost; the lifetime fees and PV of management fees are $12.77M and $11.07M, respectively.

B. Carried Interest

For GPs, carried interest is like a fractional call option on the total proceeds of all investments, with this fraction equal to the carry level and the strike price of the call equal to the carry basis. In our model, we use simulation to obtain the exit dates and returns for each of the underlying investments, and then we use risk-neutral valuation to estimate the carried-interest option on these investments. For a portfolio of publicly

[8] General establishment cost for the fund is charged to the fund. Funds set a maximum amount that GPs are allowed to charge either as dollar amounts or % of fund size. We assume that the GPs charge the maximum amount allowed in the partnership agreement. A common maximum is $1 million.
[9] If LPs default on their fee obligations, then they forfeit all current fund holdings to the partnership. Since these holdings typically exceed the future fee obligations, the fee stream is effectively collateralized and can be treated as being close to riskfree for the GPs.

traded assets with known volatilities and expiration dates, this process would be conceptually straightforward. In the private-equity environment, however, we have to deal with several complications.

1) Private equity investors provide valuable services (time, contacts, reputation) in addition to their cash investments. How do these services get incorporated into the option-pricing problem?
2) How can we estimate the volatility and correlation of the underlying (untraded) investments?
3) Each investment in a private-equity portfolio has an unknown exit date. How can this be incorporated into an option-pricing framework?
4) Standard option-pricing methods require strong no-arbitrage assumptions. How can we reconcile these assumptions with the reality of illiquid private markets?

We discuss our approach for handling each of these complications in Sections B.1, B.2, B.3, and B.4, respectively. In Section B.5, we present our model of carried interest and discuss the outputs of this model for several typical structures.

B.1 – The Value of Private–Equity Services

In every transaction, a GP invests dollars, but also invests time, energy, and a share of their reputation. Thus, following a transaction, the "market valuation" of the fund's stake should include not only the dollars invested, but also some expected value of these non-pecuniary components. To capture these components, we posit a partial-equilibrium framework where GPs invest if and only if the value of their investment is equal to the cost of the investment, where this equality is net of any revenue paid to GPs.

To model this decision, we start with the cost side. Consider first a simple case where all investments and fee payments are made on the same day. Then, suppose that a fund invests $\$I_i$ in company i, with this $\$I_i$ investment comprising some fraction f of the investment capital of the fund. From the perspective of a limited partner, if we assign a pro rata share of the lifetime fees to this investment, the full cost (= *LP cost*) of the investment could be written as

$$\text{LP cost}_i = f * \text{ committed capital} = I_i * (\text{committed capital / investment capital}) \quad (2)$$

In a more realistic scenario, investments are spread out over the investment period of the fund, and fees are spread over the full lifetime. To handle this case, we express all outlays in present value terms, as of the inception date of the fund. Equation (3) gives the present value analogue for Equation (2):

$$\text{PV(LP cost}_i) = \text{PV}(I_i) + f * \text{PV(lifetime fees)}. \quad (3)$$

In the remainder of this discussion, we suppress the present value notation and simply use “LP Cost” to refer to both sides of Equation (3). Now, on the benefit side, the present value of the investment, V_i, that belongs to the fund can be divided into two components. The *GP value*$_i$ represents the present value of all variable revenue from this investment: carried interest plus transactions fees plus monitoring fees. The *LP* $value_i$ represents the present value of everything else: LP $value_i = V_i$ – GP $value_i$. In the absence of principal-agent conflicts, a GP would invest if and only if LP $value_i \geq$ LP $cost_i$. To pin down the LP value, we assume a competitive market for private equity investment, where fund managers capture all the rents for the scarce skills, so that LP $value_i$ = LP $cost_i$. Thus, the value of the underlying asset is

$$V_i = \text{LP value}_i + \text{GP value}_i = \text{LP cost}_i + \text{GP value}_i. \quad (4)$$

Let GP value be the sum of the GP $value_i$, $i = 1, \ldots, N$, where N is the number of investments in a fund. Similarly, let V be the sum of V_i. Let *GP%* represent the expected percentage of each investment that belongs to the GP: GP% = GP value / *V*. Then, summing over $i = 1, \ldots, N$, dividing both sides of (4) by *V,* and rearranging terms we have

$$1 = \text{LP Cost} / V + \text{GP Value} / V = \text{LP cost} / V + \text{GP\%}$$

$$\rightarrow \quad V = \text{LP Cost} / (1 - \text{GP\%}) \quad (5)$$

Equation (5) is our key equilibrium condition. The logic here is similar to Berk and Green (2004): the managers are in possession of scarce skills, and they adjust prices and quantities to capture all of the rents from these skills. A graphical illustration of this condition is given in Figure 1. Consider an investment that would be worth $1 to a passive investor. In equilibrium, the price of this asset to passive investors would also be

\$1. For an active investor, however, the value of the asset may be greater than \$1. Let \$b represent the increased value over some unknown holding period, as shown on the left-axis of Figure 1. Such increased value could come from many sources: one simple case would be that the investor provides below-cost management services to the company.[10] (If \$b is zero or negative, then presumably the active investor would need to find another line of work.) If these value-added services are bundled with an ownership stake, then the investor should be able to demand a discount from the \$1 price, since the present owners will see the value of their remaining stake increase with the value add. In Figure 1, this discount is shown on the left-axis as \$a. After his discount, the fund pays $\$I_i = \$(1\text{-}a)$ for each \$(1+b) value of the asset, so that \$(a + b) represents the excess value to the fund.[11]

On the right-hand axis, we show one example of how this value is allocated. In expectation, the GP value is equal to GP% * (1+b), where GP% is a function of the variable revenue terms in the partnership agreement. Furthermore, if the fund pays \$1-a for an investment, then the LP cost can be represented as \$(1-a) plus the (present value of) the pro-rata share of management fees. (In the figure, the management fees are shown as larger than \$a, but this does not have to be true.) Our equilibrium condition of Equation (4) requires that this LP cost be exactly equal to the LP value: to achieve this equilibrium, the fund adjusts the terms of its partnership agreement so that GP% and

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[10] Hellmann and Puri (2002) find that VC-backing is related to a variety of professionalization measures, such as human resource policies, the adoption of stock option plans and the hiring of a marketing VP. Hellmann and Puri (2000) also report that VC-backing is associated with a significant reduction in the time to bring a product to market, especially for innovation firms. Hochberg, Ljungqvist, and Lu (2007) find that portfolio companies of better-networked VC firms are significantly more likely to survive to subsequent financing and eventual exit.

[11] Hsu (2004) finds that experienced VCs actually do receive price breaks as compared to less-experienced VCs. One could also interpret \$a as representing selection skill of the manager, who may be able to find investments at "below-market" prices. Sorensen (2007) builds a model of venture capital to disentangle such selection ability (= \$a in our framework) from value-adding activities (= \$b in our framework).

management fees completely consume any surplus. In this equilibrium, LPs receive exactly their cost of capital.

B.2 – Volatility and Correlation

To estimate volatility for investments by VC funds, we rely on Cochrane (2005). In this paper, Cochrane begins with a CAPM model of expected (log) returns for venture capital investments. He then uses a relatively comprehensive database of venture capital investments to estimate the parameters of the model. In general, this data suffers from sample-selection problems: we only observe returns for a company upon some financing or liquidation event. To solve this problem, Cochrane simultaneously estimates thresholds for IPOs and bankruptcy liquidations. With these thresholds in place, the parameters of the CAPM equation can be estimated, and these parameters then imply means and standard deviations for returns. For the whole sample, Cochrane estimated a volatility of 89 percent. We round this estimate up to 90 percent in our simulations.

For BO funds, we do not have access to a database of investments that would allow a replication of the Cochrane analysis. Instead, we rely on the fact that BO funds sometimes invest in public companies (and take them private) or in private companies that are comparable in size to small public companies. Woodward (2004) finds that the average beta of all buyout funds is approximately equal to one. In general, funds achieve this beta by purchasing low-beta companies and levering them up. Since this levering would also affect the idiosyncratic risk of these companies, we will estimate the volatility of BO investments as being the same as a unit beta public stock of similar size. For a median BO fund of $600M making 12 investments, the average equity investment would be \$50M and typical leverage of 2:1 would imply a \$150M company.[12] For a company of this size we use a small-stock volatility estimate of 60 percent from Campbell et al. (2001).

Our simulation model will also require an assumption about the correlation of any pair of investments. For BO funds, this pairwise correlation is chosen to match the high end of the correlation between small-company investments in the same industry as reported in Campbell et al. (2001), which is 20 percent. For VC funds, there is no analogous empirical evidence. In the absence of such evidence, we adopt an estimate of 50 percent. As compared to the BO correlation of 20 percent, the VC correlation will tend to increase the variance of VC portfolios and, thus, increase the estimate for the "option-like" carried interest. In Section IV, we discuss the implications of using different estimates for this pairwise correlation.

B.3 – Unknown Exit Dates

Carried interest is an option on a private equity portfolio, but the underlying investments in this portfolio have unknown exit dates. Metrick (2007) shows that the median first-round VC investment has an expected holding period of five years, with annual probability of exit close to 20 percent. We use this estimate for all VC and BO investments, and assume that exits follow an exponential distribution, with an exit rate of $q = 0.20$ per year. We also assume that exits are uncorrelated with underlying returns. While this assumption is certainly false, it is computationally expensive to handle these

[12] See Kaplan and Stein (1993), among others, for discussions of the financial structure of leveraged buyouts. See Axelson, Stromberg, and Weisbach (2007) for a theoretical analysis of the relation between the financial structure of buyout transactions and that of private equity partnerships as equilibrium outcomes.

correlations on large portfolios, and in robustness checks using small portfolios we have not found any clear pattern between correlation structure and expected carried interest.

B.4 – No-Arbitrage Assumptions

Our model uses a risk-neutral approach, which is based on strong no-arbitrage conditions. Since private securities are illiquid, the reality is far from this perfect-markets ideal. Nevertheless, this is the same assumption used in all real-option models on untraded assets, and conceptually does not require any more of a leap than does any other discounted-cash-flow analysis on such assets. It is important to note, however, that the valuation is only applicable for an investor that can diversify the non-systematic risks. The GPs cannot do this, as in general they will be unable to diversify the risk in their portfolio companies. Hence, the option-based valuation of carried interest should be interpreted as proportional to the expected value to an outside "large" investor that holds some small claim on GP revenue. It should not be interpreted as expected compensation to the GPs.

B.5 – A Model for Carried Interest

Figure 2 gives a flowchart for the simulation model. In STEP 1, we set the fund terms for each set of trials. These terms then determine the lifetime fees and LP cost for the fund (as in Section III.A and Figure 1). Consider first the benchmark VC case, with a 20 percent carry on committed capital basis with no hurdle rate. In this benchmark case, the fund makes 25 investments, distributed temporally as discussed in Section III.A. The goal of the simulation is to solve for expected value of carried interest at the "equilibrium condition" of LP value equal to LP cost. To find this equilibrium condition, we adjust the starting value for the fund. Recall from Figure 1 that the starting value for each investment is a function of the (present value of) dollars invested, value added, selection ability, and price discounts for the fund. In STEP 2, we set this starting value to be V_0.

STEP 3 contains the main work of the simulation: 100,000 trials for all investments. Figure 3 gives a more detailed flowchart for a single trial. In STEP 3A, we draw an exit time for each investment. As in the management-fee model, we draw these exit times from an exponential distribution with a constant 20 percent annual rate. Exits are independent across investments and are uncorrelated with investment value. Since funds typically last for 10 years, with up to 2 years of extension subject to LPs' approval, we truncate the maximum exit time at 12 years from the fund inception date. In STEP 3B, we simulate a valuation path for each investment. Each firm follows a geometric Brownian motion with a volatility of 90 percent. As discussed in Section III.B.2, this volatility is divided into common and idiosyncratic components to imply a 50 percent cross-correlation between any pair of existing investments. In STEP 3C, we use the carried-interest rules for the fund (as defined in STEP 1) to divide the value at each exit into components for the GP (carried interest) and the LP. In STEP 3D, we use the riskfree discount rate to take the present value of these components as of day 0. These present values are the GP value (=present value of carried interest) and the LP value.

Returning now to Figure 2, we move to STEP 4, where we compute the average LP value across all 100,000 trials. In STEP 5, we compare this estimated LP value with the LP cost computed in STEP 1. If this LP value is greater than the LP cost for the fund, then we return to STEP 2 and choose a lower value for V_0, and if LP value is less than LP cost, then we return to STEP 2 and choose a higher value for V_0. In either case, we then repeat the calculations of STEP 3 using the same random draws. We continue to iterate this process until the LP value converges to the LP cost. When this has been achieved, we label the average carried interest for those trials as the expected carried interest for that set of fund terms. In the language of Figure 1, this whole procedure is trying to find the level of "a + b" such that LP value is equated to LP cost. Once that value is found, then carried interest can be observed from the simulation results.

Once the benchmark case has been solved, we change each of these assumptions: carry level (20, 25, or 30), basis (committed capital, 90% of committed capital, 85% of committed capital, and 80% of committed capital), hurdle (none, 8% with catchup, 8% without catchup), and number of investments (5, 15, 25, and 35). Overall, we solve for 144 sets (3 x 4 x 3 x 4) of VC fund terms and 108 sets (3 x 4 x 3 x 3) of BO fund terms. For funds with terms that are not directly covered by these combinations, we interpolate or extrapolate from these results.

For BO funds the volatility and cross-correlation of BO investments is 60% and 20%, respectively. (The reasons for these assumptions are discussed in Section III.B.2). The only other difference for BO funds is that it becomes necessary to keep track of transactions fees and monitoring fees. These issues are discussed in the next section.

C. Transaction Fees and Monitoring Fees

For BO funds, we append transaction and monitoring fees to the carry model of Section III.B.[13] For a transaction fee schedule, we consulted with industry practitioners and adopted a simplified schedule of two percent on the first $100 million, one percent on

[13] We thank Josh Lerner for suggesting this part of our analysis.

the next $900 million, and 50 basis points on any amount over $1 billion. In practice, fee schedules are more nuanced and also drop off further at high levels. Since these high levels are rarely reached in our simulations, we keep this simplified schedule. Fees are assessed both for the initial investment time (asset purchase) and at the random exit time (asset sale). We assume 2:1 leverage at the time of entry, with total debt (but not the leverage ratio) remaining constant until exit. The LP share of these fees is treated the same as any other distribution. The present value of transaction fees to the GPs is calculated along with carried interest in STEP 5 of Figure 2.[14]

While transaction fees have an analogue in M&A advisory fees, the monitoring fees are more difficult to benchmark. In informal discussions with practitioners, we were told that these annual fees can vary between one and five percent of EBITDA, with smaller companies at the high end of this scale and larger companies at the low end. Typically, a BO fund signs a contract with its portfolio company to provide monitoring services over a fixed time period. If the company has an exit before this period expires, then the fund usually receives a lump sum payment at exit for the remaining present value of the contract. For computational convenience, we assess all monitoring fees at exit, assuming a five-year contract with annual fees at two percent of EBITDA. Assuming a constant valuation multiple to EBITDA, the value of the monitoring contract would be proportional to firm value. Using an EBITDA multiple of five, this proportion would be 40 basis points of firm value per year, which we assess all at once as 0.40 * 5 years = 2 percent of firm value at exit. In all versions of the model, we use the typical sharing rule and allocate 80 percent of this value to the LPs and 20 percent to the GPs.

[14] For computational ease we assume that GPs share 50% of transaction fees with LPs for all BO funds, reflecting the median fund characteristics.

As with transaction fees, the expected value of monitoring fees can be computed in STEP 5 of Figure 2.

D. Model Outputs

Table IV summarizes outputs for the fee model of Section III.A. Panel A gives the results for lifetime fees; Panel B presents the results for the PV of fees. In the following discussion, we will focus on the lifetime fee results reported in Panel A, as the PV fee results are qualitatively similar. The middle cell of Panel A.1 shows the results of the base case fund: 2 percent initial fee level, no fee level change, no fee basis change, and 10-year fund. This means that a constant management fee of 2 percent was charged on $100 of committed capital every year for 10 years. The lifetime fees are $20. (These values are expressed in dollars per $100 of committed capital.) A shift to a constant fee level of 1.5 percent per year decreases the lifetime fees to $15. Panel A.2 shows the results for a 10-year fund with investment period of 5 years that changes its fee basis to net invested capital after the investment period. Continuing to focus on the base case fund that charges a constant fee level of 2 percent, this basis change reduces the lifetime fees to $12.80, a reduction of $7.20. Thus, a shift in the fee basis from committed capital to net invested capital (in the post-investment period) has a greater effect on the lifetime fees than a 50 basis point shift in the fee level.

Panel A.3 presents the results for a 10-year fund that changes its fee level after the 5-year investment period. The middle cell in the panel shows the results of a fund that charges an initial fee level of 2 percent, which goes down to 1.5 percent after the investment period. The fee basis is committed capital throughout the lifetime of the fund.

For this fund, the lifetime fees are \$17.50, a reduction of \$2.50 from the base case fund (the middle cell in Panel A.1).

Finally, Panel A.4 shows the results of changing both the fee basis and fee level after the investment period. The middle cell shows the results of a fund that changes the fee basis to net invested capital *and* reducing the fee level to 1.5 percent (from the initial level of 2 percent) after the investment period. For this fund, the lifetime fees are \$12.12, a reduction of \$7.88 from the base case fund. Obviously, changing both fee basis and fee level results in the greatest concessions for GPs.

Table V summarizes the results of simulating present values of the carry model. The top left cell of Panel A.1 shows the results for the base case VC fund: 20 percent carry level, carry basis = committed capital, no hurdle return, and 25 investments in the fund. The PV of carried interest for this base case is \$8.63. (As with all numbers in Table V, these values are expressed in dollars per \$100 of committed capital.) A shift to a hurdle rate of 8 percent (with 100 percent catch-up rate) leads to a reduction of \$0.34 in the PV of carry, while a shift to a carry level of 25 percent would increase the PV of carry by \$2.63. Panel A.2 shows the results for a VC fund that makes only 15 investments. With this smaller number of investments, the overall fund portfolio is less well-diversified, so the volatility of the portfolio is higher and the option value (carried interest) is higher. As compared to the results in Panel A.1, the PV of carried interest increases by between \$0.39 and \$0.57.

Panels A.3 and A.4 show the results using an investment-capital basis, where invested capital is set to 85 percent of committed capital. In comparing the cells in these panels to their analogues in Panels A.1 and A.2, we can see that the decrease in carry basis leads to increases in the PV of carry that are typically around $1.00 for a 20 percent carry and $1.40 for a 25 percent carry. Thus, a shift in the carry basis from committed capital to investment capital has approximately half the impact as a 5 percent shift in the carry level.

Panel B of Table V summarizes the results for BO funds. The base case, in the top-left cell of in Panel B-1, has 11 investments, 20 percent carry level, no hurdle, and a carry basis of committed capital. The PV of carried interest in this base case is $5.88 per $100 of committed capital. This is $2.75 lower than the base case for VC funds (top-left cell of Panel A-1). The drivers of this difference are the higher volatility for VC investments (90 percent vs. 60 percent for BO investments) and the higher pairwise correlation between VC investments (50 percent vs. 20 percent for BO investments). Even though there are fewer BO investments – which tends to increase option value on the portfolio of such investments – the volatility and correlation effects dominate and VC earns a higher PV of carried interest. The remaining cells of Panel B-1 show how the PV of carry is affected by changing one input at a time. A move to an 8 percent hurdle – the most common case – results in a loss of $0.71 in PV of carry. Conversely, an increase of the carry level to 25 percent -- a level not used by any of the BO funds in our sample – would increase PV of carry by $1.79.

Panel B-2 shows how the PV of carry is affected by a switch to 5 investments per fund from the base case of 11. This change is worth between $1.32 and $1.88 per $100 of committed capital. Panels B-3 and B-4 provide analogues to Panels B-1 and B-2 using an investment-capital basis, with investment capital set to 85 percent of committed capital. This change is even more important for BO funds than it is for VC funds, with increases in PV of carried interest ranging from $1.49 in the base case (11 investments, no hurdle, and 20 percent carry) to $2.12 for a carry level of 25 percent, 5 investments, and an 8 percent hurdle.

IV. Empirical Results

Using the models from Section III, we estimate the present values of all revenue components for all sample firms. Table VI presents the summary statistics of these components. Panel A presents the results for the VC fund sample; Panel B presents the results for the buyout fund sample. The first few rows of both panels summarize the distributions of revenue per $100 of committed capital. The largest two components of total revenue are management fees and carried interest. For both of these components, VC funds have higher PV per $100 of committed capital. Overall, the PV of total revenue has a median (mean) of $23.50 ($23.78) per $100 among VC funds and $19.36 ($19.76) per $100 for BO funds.

Although the median PV of carried interest is much lower for BO funds ($5.35) than for VC funds ($8.86), BO funds can make up much of this difference in other variable revenue sources, namely monitoring fees and exit transaction fees. In total, the median BO fund receives $2.11 per $100 of committed capital in PV of monitoring fees and exit transaction fees, thus raising the total variable revenue per $100 to $7.46. Similarly, the median BO fund receives $1.44 per $100 in entry transaction fees, thus raising the total fixed revenue per $100 to $11.78. Since we did not code any variation in the sharing of monitoring fees across our sample firms – restricting all firms to return 80 percent of these fees to LPs – the only variation in expected monitoring fees comes from second-order adjustments induced by other terms. For example, as compared to the benchmark case, a fund with a carry level of 25 percent will require higher V in order to return the full LP cost to their investors. This higher V then implies higher exit values and higher monitoring fees than in the benchmark case. Overall, this induced variation is relatively small, and most funds have expected monitoring costs that are very close to the sample mean of $0.82 per $100 of committed capital.

Although VC funds have a higher unit PV of revenue, BO managers make up for this by raising larger funds than VC managers. As seen in Section II, the median BO fund has $600M in committed capital versus $225M for VC funds. BO managers achieve this larger size without a significant increase in the number of partners and other professionals, so that the measures of revenue per partner and revenue per professional are much higher for BO funds than for VC funds. The bottom rows in Panels A and B demonstrate these differences. The median (mean) level of total revenue per partner is $24.07M ($35.93M) for BO funds versus $11.21M ($17.61M) for VC funds. The analogous figures for total revenue per professional are $8.56M ($12.58M) for BO funds versus $5.68M ($6.87M) for VC funds. At the top of the scale, BO funds enjoy an even greater advantage over VC funds.

To further explore these differences we estimate a series of regressions of the form

$$Revenue\_Measure_i = \alpha + \beta_1\, sequence_i + \beta_2\, TopQ_i + year\ dummies + e_i \quad (6)$$

The dependent variable, *Revenue_Measure*, refers to any of the measures in Table VI, with each of these measures normalized in turn by the number of partners, number of professionals, and committed capital. *Sequence* is the natural logarithm of the number of previous funds (plus one) by the same firm. *TopQ* is the number of "top quartile" funds in the most recent four funds raised by the same firm. To benchmark these funds, we combine data from the Investor with industry benchmarks drawn from Private Equity Intelligence (2006) and Venture Economics (2006a and 2006b). We also include year fixed effects to control for any unobserved year-specific factors.

Table VII summarizes the results of these regressions. In each case, we estimate the regressions for the full sample, with separate coefficients on each variable for VC and BO funds. Panel A gives results for revenue measures normalized by the number of partners, Panel B gives results for measures normalized by the number of professionals, and Panel C gives results for measures normalized by committed capital. The coefficient on *TopQ* is not significant in any of the specifications. The coefficient on *sequence* – a measure of firm experience – is significant in many of the specifications. In Panel A, the sequence coefficient is positive and significant for both VC and BO funds in all specifications. In none of the regressions in Panel A are the sequence coefficients significantly different between VC and BO funds.

Panel B summarizes results for revenue measures normalized by the number of professionals. In these regressions, there are many significant differences between BO and VC funds. In all revenue-component specifications, the sequence coefficient is positive and significant for BO funds but not for VC funds, and the difference between the BO and VC coefficients is significant at the five percent level. Given these results, it is not surprising that we also find the same pattern in the regression for total revenue per professional. Taken together with the results in Panel A, it appears that BO firms are able to increase their revenue per partner without significantly increasing their non-partner staff, whereas VC firms cannot.

The results of Panel C allow us to gain further insight into these relationships. Here, the revenue measures are normalized by committed capital. While the sequence coefficients are never significant for VC funds, these coefficients are negative and significant for BO funds in all specifications. Also, in all cases, the BO sequence coefficient is significantly lower than the VC sequence coefficient. Thus, this cross-sectional evidence suggests that BO funds actually *decrease* their revenue per unit of committed capital as they grow more experienced.

BO funds make up for this lower unit revenue by raising ever larger funds, as demonstrated in Panel D. In this panel, we use measures of size (rather than revenue) as the dependent variable, with the same regressors as in the previous panels. The first column shows results using the log of committed capital as the dependent variable. While the sequence coefficients are positive and significant for both BO and VC funds, the BO coefficients are more than twice as large as the VC coefficients, a difference that is significant at the one percent level. As might be expected from the previous results, the ratio of these key coefficients is even larger when we use the log of committed capital per professional as the dependent variable, with the sequence coefficient for BO funds more than four times the size of its VC counterpart.

Our simulation model required many assumptions, but only one of these assumptions – the pairwise correlation of 50 percent for VC investments, as discussed in Section

III.B.2 – did not have any supporting empirical evidence. This assumption may seem to be high, especially in comparison to the 20 percent correlation used for BO funds. Nevertheless, a lower assumption for this correlation would only make our main results *stronger*: with a lower pairwise correlation, the overall volatility of the VC funds would be lower. Thus, the carried interest – which is like a call option on the VC portfolio – would also be lower. This change would effectively reduce the coefficients on the log(sequence) variables for VC funds in Table VII, as the overall dispersion in carried interest would be smaller.

Overall, these results suggest that the BO and VC businesses are quite different. The LP community is apparently willing to let BO funds grow significantly larger with experience. While this increased size leads to downward pressure on expected revenue per unit of committed capital, the BO managers can more than make up for this loss by increasing fund size without requiring much additional staff. In contrast, VC managers, while able to increase their fund size somewhat, also need to add staff at nearly the same rate. In untabulated tests, we find that VC firms add an additional professional for each additional $100M under management; BO funds add an additional professional for each additional $200M under management.

Our results support the view that BO managers with managerial ability increase fund size to maximize their revenue as in Berk and Green (2004), subject to (1) diminishing expected returns to scale, (2) investors earn zero expected excess returns, and (3) investors update their assessment of managerial ability from past performance. Thus, performance persistence may not be observed in equilibrium in the BO industry. Consistent with this interpretation, Kaplan and Schoar (2005) report that BO fund performance is less persistent than VC fund performance. In contrast, our results suggest that VC fund managers with managerial ability are not able to maximize their revenue per professional by increasing their fund size. Thus positive-alpha VC funds remain relatively small or grow slowly. Consistent with this interpretation, Lerner, Schoar and Wong (2007) find that slow-growth VC funds perform better than fast-growth VC funds.

V. Conclusions

This paper analyzes the economics of the private equity industry using a novel model and dataset. We obtain data from a large investor in private equity funds, with detailed records on 238 funds raised between 1992 and 2006. Fund managers earn revenue from a variety of fees and profit-sharing rules. We build a model to estimate the expected revenue to managers as a function of these rules, and we test how this estimated revenue varies across the characteristics of our sample funds. We find major differences between venture capital (VC) funds and buyout (BO) funds – the two main sectors of the private equity industry. In general, BO fund managers earn lower revenue per managed dollar than do managers of VC funds, but nevertheless these BO managers have substantially higher present values for revenue per partner and revenue per professional than do VC managers. Furthermore, BO managers build on their prior experience by raising larger funds, which leads to significantly higher revenue per partner and per professional, despite the fact that these larger funds have lower revenue per dollar. Conversely, while prior experience by VC managers does lead to higher revenue per partner in later funds, it does not lead to higher revenue per professional. Taken together, these results suggest that the BO business is more scalable than the VC business.

What emerges from our analysis is a picture of a labor-intensive, high value-added, and high-rent industry that nonetheless has significant heterogeneity. Recall from Table I that the median BO fund in our sample makes 2.4 investments per partner. Moreover, this range of 2-3 firms per partner appears to be fairly stable across the inter-quartile range. The numbers are consistent with Heel and Kehoe (2005) which report that successful BO deal partners devote around 50 percent of his/her time on the company during the first several months after the transaction, and spend around 5-15 percent of his/her time per company after the first several months. The rest of her time may be split between screening for new investments, arranging for exits, and fundraising for new funds.

The key feature of the BO business is that once a BO manager is successful in handling $100M-size companies this way, the same skill can be applied to manage $1B companies without a complete elimination of excess performance. (At least, the market believes this to be the case, or else investors would not allow these terms for BO funds.) This scalability allows BO funds to sharply increase the size of the fund (and more crucially the size of the capital managed per partner or professional) while keeping the number of companies per partner and per professional fairly constant.

This is in sharp contrast to the VC business. VC funds invest by definition in a small firm, with valuation of no more than $25-50M in case of early-stage VC. Their goal is to hold these firms until they are mature enough to have an exit value of $150-$200M or more. The median VC fund in our sample makes 5 investments per partner (see Table I). Again, this ratio appears to be very stable across the range. In other words, even the most successful VC partner is not capable of supervising 50 ventures successfully. The value-added of a venture capitalist includes screening firms based on technology, business model, and management team, helping the founder team to hire key personnel, introduce them to potential customers, suppliers, etc., as well as advising them generally on growth and exit strategy as board member. Unfortunately, these skills are critical in helping firms that are in their developmental infancy and poised for high growth, but not applicable to more mature firms that are 10 times larger and already in possession of core management skills. In other words, the ideal firm size for VC business is bounded above. So when successful VC firms increase the size of their fund, which they do to some extent, they cannot just scale up the size of each firm they invest in without dissipating their source of rent. The best they can do is to back more companies of the same size as before. Doing this, however, requires hiring more partners and non-partners, so even as the aggregate fund size grows, capital managed per investment professional cannot grow as fast.

Both types of private equity are inherently labor-intensive, skill-based business. The crucial difference between BO and VC derives from the fact that a BO manager's skill can add value to extremely large companies, whereas a VC manager's skill can only add value to generally small companies. Our analysis shows that this difference has significant implications for organizational economics of the two segments of private equity industry and the relation between fund characteristics and future fund terms.

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Table I

Sample Summary Statistics

This table presents sample summary statistics for the 238 VC and BO funds in our sample. Panel A gives the data on the 94 VC funds and Panel B gives the data on the 144 BO funds. "Size" is the amount of committed capital in $ millions. "First fund dummy" is 1 if the fund is the first fund for which the management firm is raising public money (not captive money), and 0 otherwise. "# of past funds" is the number of funds that the management firm has raised prior to the current fund. "Firm age" is the difference between the vintage year of the firm's first fund and the vintage year of the current fund. "# of partners" is the number of partners in the management firm. "# of professionals" is the sum of the number of partners and the number of non-partner investment professionals in the management firm. "# of investments" is fund size divided by the expected size of investments.

Panel A: Venture capital fund characteristics (94 funds)

	mean	25%	median	75%
Size	$322	$100	$225	$394
First fund dummy	0.44			
# of past funds	1.78	0	1	3
Firm age (years)	4.69	0	3	8
# of partners	4.81	3	4	6
# of professionals	11.49	7	9	13
# of investments	24.24	15	20	30

Panel B: Buyout firm characteristics (144 funds)

	mean	25%	median	75%
Size	$1,238	$297	$600	$1,500
First fund dummy	0.27			
# of past funds	1.80	0	1	3
Firm age (years)	6.44	0	6	11
# of partners	6.10	3	5	7
# of professionals	20.33	9	13	24
# of investments	14.76	9.75	12	16.67

Table II

Fund Terms

This table presents summary statistics on fund terms for the VC and buyout funds raised in the 1992-2006 period. "Initial fee level" is the level of annual management fees as the percentage of the fund's committed capital at the beginning of the fund's life. "% of funds changing fee basis after investment period" is the proportion of funds that changes its fee basis from committed capital to (net) invested capital after the completion of the investment period (which is typically 5 years for a 10-year fund). "% of funds changing fee level after investment period" is the proportion of funds that changes its fee level from its initial fee level after the completion of the investment period. "% of funds changing both basis and level" is the proportion of funds that changes both its fee basis and fee level after the investment period. "Carry level" is the level of carried interest as the percentage of the fund's net profit. "% of funds requiring return of fees before carry" is the proportion of funds that uses committed capital as its carry basis (as opposed to investment capital). "% of funds with hurdle return" is the proportion of funds that entitles LPs to a pre-specified level of hurdle return before carried interest is paid to GPs. "Hurdle level" is the level of annual hurdle return for those funds which have hurdle returns.

	Panel A: VC	Panel B: Buyout
# of funds with initial fee level		
greater than 2%	39	11
equal to 2%	42	59
less than 2%	9	74
% of funds changing fee basis after investment period	43.0%	84.0%
% of funds changing fee level after investment period	54.8%	45.1%
% of funds changing both basis and level	16.1%	38.9%
# of funds with carry level		
greater than 20%	4	0
equal to 20%	87	142
less than 20%	1	0
% of funds requiring return of fees before carry	92.1%	83.2%
% of funds with hurdle return	47.6%	93.1%
# of funds with hurdle level		
greater than 8%	5	18
equal to 8%	28	105
less than 8%	7	11

Table III

Management-Fee Model: Inputs and Example

This table presents the key inputs to and an example of the management-fee model. Panel A presents the simulation results of net invested capital as % of investment capital in a 10-year buyout fund with 5-year investment capital. The simulations use the empirically-derived investment pace as inputs and draws random time to exit for each investment from the exponential distribution with exit rate of 0.2 per year. Panel B presents an example of the fee model calculation for a $100M buyout fund that charges 2% of committed capital for years 1-5, 2% of net invested capital for years 6-10, and has the establishment cost of 1% of fund size. The management fees calculated in Panel B uses the net invested capital figures in Panel A as inputs for years 6-10. For example, in year 6, the management fees charges is 2%*46.0%*$86.23M = $0.79M. The model is solved such that investment capital + lifetime fees + establishment cost sum up to the committed capital of the fund ($100M).

Panel A: investment and exit pace

Fund year	net invested capital as % of investment capital
1	24.7%
2	45.0%
3	61.5%
4	58.6%
5	56.2%
6	46.0%
7	37.7%
8	30.9%
9	25.3%
10	20.7%
11	16.9%
12	13.9%

Panel B: Fee model example

Fund year	fee basis	fee level (%)	management fees ($M)	PV of fees ($M)
1	committed	2%	$2.00	$2.00
2	committed	2%	$2.00	$1.90
3	committed	2%	$2.00	$1.81
4	committed	2%	$2.00	$1.72
5	committed	2%	$2.00	$1.64
6	net invested	2%	$0.79	$0.62
7	net invested	2%	$0.65	$0.48
8	net invested	2%	$0.53	$0.38
9	net invested	2%	$0.44	$0.29
10	net invested	2%	$0.36	$0.23
	Total fees		**$12.77**	**$11.07**
	Establishment cost		$1.00	
	Investment capital		$86.23	
	Committed capital		$100.00	

Table IV
Management-Fee Model: Outputs

This table smmarizes outputs of the management-fee model for the base case (neither fee basis nor fee level change) and three alternative cases (fee basis change, fee level change in the post-investment-period, and both basis and level change). Panel A presents the lifetime fees expressed as a percentage of committed capital; Panel B presents the PV of fees expressed as a percentage of committed capital. Lifetime fees are the sum of management fees paid to GP over the lifetime of the fund. A Riskfree rate of 5% is used to discount the fees. Fund term and investment period are assumed to be 10 years and 5 years, respectively.

Panel A: Lifetime fees				
No fee basis / level change				
		Initial fee level		
		1.50%	2.00%	2.50%
duration	10	**15.0%**	**20.0%**	25.0%
Fee basis changes to invested				
		Initial fee level		
		1.50%	2.00%	2.50%
duration	10	9.7%	**12.8%**	15.9%
Fee level goes down				
		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	12.5%	15.0%	17.5%
fee	1.50%	NA	**17.5%**	20.0%
level	2.00%	NA	NA	22.5%
Both basis and level change				
		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	9.0%	11.4%	13.9%
fee	1.50%	NA	**12.1%**	14.6%
level	2.00%	NA	NA	15.2%

Panel B: PV of fees				
No fee basis / level change				
		Initial fee level		
		1.50%	2.00%	2.50%
duration	10	**12.1%**	**16.1%**	20.2%
Fee basis changes to invested				
		Initial fee level		
		1.50%	2.00%	2.50%
duration	10	8.4%	**11.1%**	13.8%
Fee level goes down				
		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	10.3%	12.6%	14.9%
fee	1.50%	NA	**14.4%**	16.6%
level	2.00%	NA	NA	18.4%
Both basis and level change				
		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	7.9%	10.1%	12.3%
fee	1.50%	NA	**10.6%**	12.8%
level	2.00%	NA	NA	13.3%

Table V
Carried Interest Model: Outputs

This table presents the simulation results for the PV of carried interest. Panel A summarizes results for VC funds with either 25 or 15 investments, and Panel B summarizes the results for BO funds with either 11 or 5 investments. "Investment capital basis" is set to 85 percent of the committed capital basis. "8% hurdle rate" includes a 100 percent catch-up.

Panel A: Venture Capital Funds

Panel A-1: VC: 25 Investments
Committed Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$8.63	$11.26
8% Hurdle	$8.29	$10.77

Panel A-2: VC: 15 Investments
Committed Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$9.02	$11.78
8% Hurdle	$8.71	$11.34

Panel A-3: VC: 25 Investments
Investment Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$9.69	$12.70
8% Hurdle	$9.39	$12.26

Panel A-4: VC: 15 Investments
Investment Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$10.07	$13.21
8% Hurdle	$9.77	$12.78

Panel B: Buyout Funds

Panel B-1: BO: 11 Investments
Committed Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$5.88	$7.67
8% Hurdle	$5.17	$6.68

Panel B-2: BO: 5 Investments
Committed Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$7.20	$9.44
8% Hurdle	$6.58	$8.56

Panel B-3: BO: 11 Investments
Investment Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$7.37	$9.68
8% Hurdle	$6.72	$8.76

Panel B-4: BO: 5 Investments
Investment Capital Basis

	Carry Level	
	20%	25%
No Hurdle	$8.73	$11.51
8% Hurdle	$8.14	$10.68

Table VI

Summary Statistics: Revenue Estimates

This table presents sample summary statistics for revenue estimates. Panel A gives the data on the 94 VC funds and Panel B gives the data on the 144 BO funds. Carry per $100 is the present value of carried interest per hundred dollars under management. Carry per partner is the present value of carried interest per partner in $millions. Carry per professional (partners plus non-partners) is the present value of carried interest per professional in $millions. Other measures are defined similarly. Variable revenue is the sum of carried interest, monitoring fees, and exit transaction fees. Fixed revenue is the sum of management fees and entry transaction fees. Each measure was constructed using the model described in Section III and reflecting the relevant terms for each fund.

Panel A: Venture capital fund characteristics (94 funds)

Present Value of	mean	25%	median	75%
Carry per $100	$8.98	$8.40	$8.86	$9.32
Management fees per $100	$14.80	$12.04	$14.61	$17.61
Total revenue per $100	$23.78	$20.92	$23.50	$26.69
Carry per partner	$7.04	$2.14	$4.45	$7.68
Management fees per partner	$10.57	$3.69	$7.13	$12.67
Total revenue per partner	$17.61	$5.74	$11.21	$19.99
Carry per professional	$2.69	$1.09	$1.95	$3.43
Management fees per professional	$4.19	$1.73	$3.43	$5.20
Total revenue per professional	$6.87	$2.76	$5.68	$8.56

Panel B: Buyout firm characteristics (144 funds)

Present Value of	mean	25%	median	75%
Carry per $100	$5.41	$4.98	$5.35	$5.93
Variable revenue per $100	$7.54	$6.29	$7.46	$8.46
Management fees per $100	$10.35	$8.77	$10.34	$11.65
Fixed revenue per $100	$12.22	$10.11	$11.78	$14.02
Total revenue per $100	$19.76	$16.49	$19.36	$22.56
Carry per partner	$10.27	$3.38	$6.27	$12.73
Variable revenue per partner	$14.21	$4.25	$8.94	$17.94
Management fees per partner	$18.47	$6.85	$12.93	$24.33
Fixed revenue per partner	$21.70	$7.15	$14.63	$27.35
Total revenue per partner	$35.93	$11.38	$24.07	$46.57
Carry per professional	$3.54	$1.27	$2.32	$3.80
Variable revenue per professional	$4.92	$1.94	$3.31	$5.69
Management fees per professional	$6.52	$2.74	$4.67	$7.41
Fixed revenue per professional	$7.66	$3.39	$5.25	$8.77
Total revenue per professional	$12.58	$5.21	$8.56	$14.72

Table VII
Regression Results

Panels A, B, and C of this table summarize the results of multivariate regressions of various revenue measures on proxies of managers' past success. (Equation (6) in the text.) The revenue measures are the present values of carried interest, total variable revenue (carry + exit transaction fees + monitoring fees), management fees, total fixed revenue (management fees + entry transaction fees), and total revenue (carry + (entry & exit) transaction fees + monitoring fees + management fees), with each of these measures normalized in turn by the number of partners (Panel A), number of professionals (Panel B), and committed capital (Panel C). Log(sequence) is the natural logarithm of the number or previous funds (including the current fund) by the same firm. Log (# of top quartile funds) is the natural logarithm of the number of top-quartile performing funds out of the most recent four funds raised by the same firm plus one. To benchmark these funds, we combine our data from the Investor with industry benchmarks drawn from Private Equity Intelligence (2006) and Venture Economics (2006a and 2006b). Panel D summarizes results of estimating Eq. (6) using measures of fund size as the dependent variable. These measures are the log of committed capital, and the log of committed capital normalized by the number of partners and by the number of professionals. All regressions also include constant terms and year fixed effects separately for VC and BO funds. *, **, and *** indicate statistical significance at the ten percent, five percent, and one percent levels, respectively.

	Panel A: Per-Partner Revenue Measure				
Dependent variable	carry per partner	variable revenue per partner	fee per partner	fixed revenue per partner	total revenue per partner
log(sequence)					
***VC dummy (β_{VC})**	4.8470	4.8470	7.0303	7.0303	11.8774
	(1.7160)***	(2.1427)**	(2.5987)***	(2.9509)**	(5.0654)**
***BO dummy (β_{BO})**	5.2610	6.3611	9.0387	9.2687	15.6298
	(1.7819)***	(2.2251)***	(2.6986)***	(3.0643)***	(5.2601)***
log(# of top-quartile funds)					
*VC dummy	-2.6248	-2.6248	-4.4013	-4.4013	-7.0260
	(-3.5108)	(4.3840)	(-5.3169)	-6.0374	-10.3638
*BO dummy	-0.5478	-0.7072	0.5211	0.5308	-0.1764
	(-2.6053)	(3.2532)	(3.9456)	(4.4802)	-7.6907
Year F.E.	Yes	Yes	Yes	Yes	Yes
constant term	Yes	Yes	Yes	Yes	Yes
p -values for H_0: β_{BO}-β_{VC}=0	0.87	0.63	0.74	0.60	0.65
R^2	0.51	0.51	0.52	0.55	0.54
N of observations	234	234	234	234	234

Panel B: Per-Professional Revenue Measure

Dependent variable	carry per professional	variable revenue per professional	fee per professional	fixed revenue per professional	total revenue per professional
log(sequence)					
***VC dummy (β_{VC})**	0.5443	0.5443	0.8991	0.8991	1.4434
	(0.5231)	(0.6932)	(0.9540)	(1.0793)	(1.7616)
***BO dummy (β_{BO})**	2.5792	3.3238	4.7567	5.1531	8.4769
	(0.5251)***	(0.6959)***	(0.9577)***	(1.0835)***	(1.7685)***
log(# of top-quartile funds)					
*VC dummy	-0.2491	-0.2491	-1.1591	-1.1591	-1.4082
	-1.0330	(1.3689)	(-1.8839)	-2.1314	-3.4788
*BO dummy	-0.3428	-0.5114	-0.0387	-0.1290	-0.6404
	-0.7986	-1.0582	(-1.4564)	-1.6477	-2.6893
Year F.E.	Yes	Yes	Yes	Yes	Yes
constant term	Yes	Yes	Yes	Yes	Yes
p -values for H_0: β_{BO}-β_{VC}=0	0.01	0.01	0.01	0.01	0.01
R^2	0.61	0.60	0.61	0.60	0.60
N of observations	221	221	221	221	221

Panel C: Per-dollar Revenue Measure

Dependent variable	carry per $	variable revenue per $	fee per $	fixed revenue per $	Total revenue per $
log(sequence)					
***VC dummy (β_{VC})**	-0.0003	-0.0003	0.0051	0.0051	0.0049
	(-0.0012)	(0.0018)	(0.0038)	(0.0044)	(0.0055)
***BO dummy (β_{BO})**	-0.0034	-0.0063	-0.0104	-0.0144	-0.0206
	(-0.0013)***	(0.0019)***	(-0.0041)**	(0.0046)***	(0.0058)***
log(# of top-quartile funds)					
*VC dummy	0.0031	0.0031	-0.0088	-0.0088	-0.0058
	(0.0025)	(0.0038)	(-0.0080)	(0.0091)	(0.0114)
*BO dummy	-0.0005	0.0006	0.0067	0.0085	0.0091
	(-0.0019)	(0.0028)	(0.0059)	(0.0068)	(0.0085)
Year F.E.	Yes	Yes	Yes	Yes	Yes
constant term	Yes	Yes	Yes	Yes	Yes
p -values for H_0: β_{BO}-β_{VC}=0	0.08	0.03	0.02	0.003	0.002
R^2	0.99	0.98	0.99	0.96	0.98
N of observations	236	236	236	236	236

	Panel D: Fund Size		
Dependent variable	log (fund size)	log(fund size per partner)	log(fund size per professional)
log(sequence)			
***VC dummy (β_{VC})**	0.3885	0.2191	0.1503
	(0.1364)***	(0.1352)	(0.1306)
***BO dummy (β_{BO})**	1.0134	0.5693	0.6182
	(0.1444)***	(0.1404)***	(0.1311)***
log(# of top-quartile funds)			
*VC dummy	0.1811	0.0689	0.0656
	(0.2844)	(0.2767)	(0.2578)
*BO dummy	0.0271	0.0150	-0.0434
	(0.2111)	(0.2053)	(-0.1993)
Year F.E.	Yes	Yes	Yes
constant term	Yes	Yes	Yes
p -values for H_0: $\beta_{BO}-\beta_{VC}=0$	0.002	0.07	0.01
R^2	0.98	0.97	0.96
N of observations	236	234	221

Figure 1: Equilibrium Framework for Private Equity Funds

$$E(a + b) = E(\text{management fees} + \text{GP value})$$

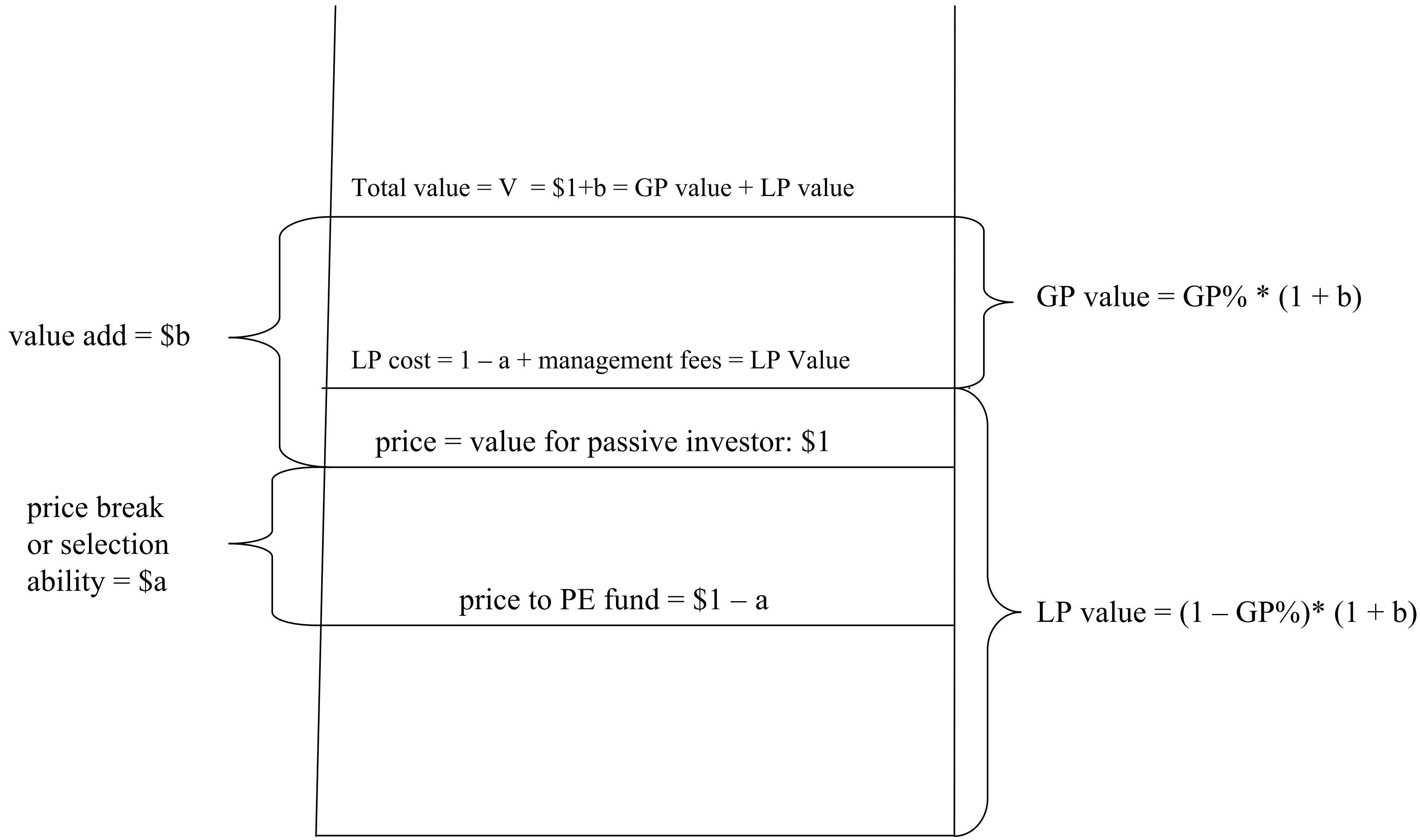

Figure 2: Main Flowchart for Simulation

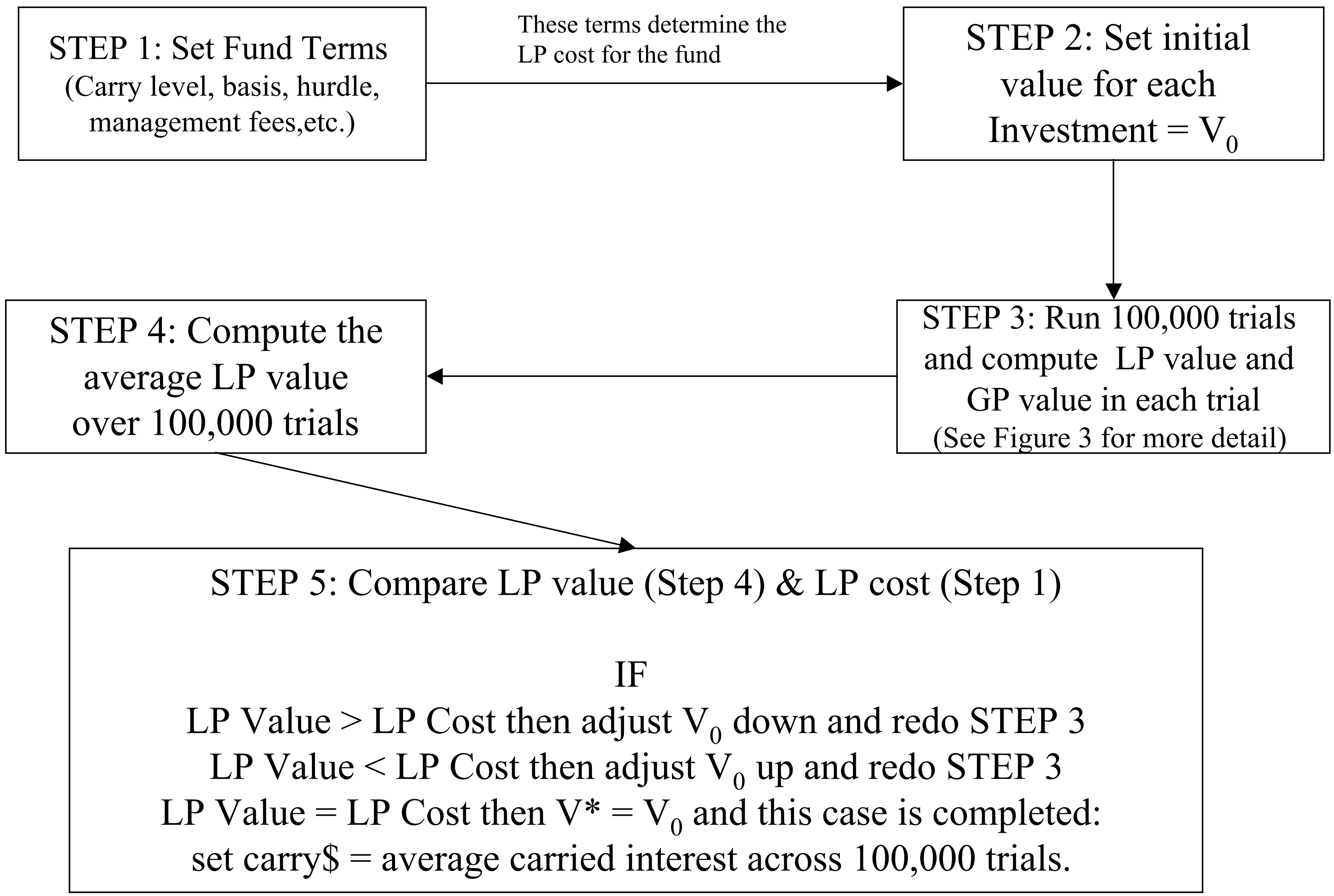

Figure 3: Flowchart for Each Trial

STEP 3A: Draw exit time for each investment using a constant 20% annual hazard rate for each investment.

STEP 3B: Simulate a return path for each investment using the volatility and cross-correlation assumptions described in Section III.B.2

STEP 3C: Allocate the proceeds at exit according to the fund rules given in STEP 1.

STEP 3D: Compute the present value of LP value, carried interest, transactions fees, and monitoring fees.

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