The Economics of Private Equity Funds

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This article 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 1993 and 2006. We build a model to estimate the expected revenue to managers as a function of their investor contracts, and we test how this estimated revenue varies across the characteristics of our sample funds. Among our sample funds, about two-thirds of expected revenue comes from fixed-revenue components that are not sensitive to performance. We find sharp differences between venture capital (VC) and buyout (BO) funds. BO managers build on their prior experience by increasing the size of their funds faster than VC managers do. This leads to significantly higher revenue per partner and per professional in later BO funds. The results suggest that the BO business is more scalable than the VC business and that past success has a differential impact on the terms of their future funds. (*JEL* G10, G20, G24)

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 peak years of the early twenty-first-century cycle, these buyout funds were responsible for about one-quarter of all global merger and acquisition (M&A) activity. Venture capital funds—the other main type of private equity—raised nearly

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$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 advisers. Nevertheless, relatively little is known about industrial organization of the private equity sector, mostly due to data limitations. This article 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 general partners (GPs) 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 ten 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 three to five 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 GPs. 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 article, 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 first paper on this topic was Gompers and Lerner (1999), who focus exclusively on VC funds and explore the cross-sectional and time-series variation in the fund terms. Litvak (2009) addresses similar issues from a legal perspective and extends the Gompers and Lerner analysis to consider several additional terms from the partnership agreements. Neither

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), Agarwal, Naveen, and Naik (2006), Panageas and Westerfield (2009), and Aragon and Qian (2007) for analyses of fee structures in the hedge fund industry.

of these papers addresses buyout funds—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 be captured only 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 taken in our article.[2] We abstract from all performance issues by assuming fixed expected performance either across all funds or as a function of fund terms.

In Section 1, we discuss our data sources, define the key revenue variables used in the article, and summarize these variables for our sample funds. Our main dataset 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 1993 and 2006, of which ninety-four are VC funds and 144 are BO funds.

In Section 2, we develop an expected-revenue model for private equity firms. Section 2.1 discusses the model for management fees, Section 2.2 discusses the model for the largest component of variable revenue ("carried interest"), and Section 2.3 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 1.) Section 2.4 discusses the simulation model. As compared with previous models in the literature, our main contributions here are to adopt an option-pricing framework for the valuation of carried interest and to anchor all of our key model inputs to industry data. This framework allows us to identify several important determinants of fund revenue that have not previously been measured. Section 3 summarizes the outputs of the model. We find that many of the common differences in contracts can lead to large differences in expected revenue.

Section 4 provides the main empirical results of the article. Using the revenue estimates from the models of Section 2, we empirically test for the relationship of various revenue measures with fund characteristics and past performance. Among our sample funds, about two-thirds of the expected revenue comes from fixed-revenue components. We find striking differences between VC and BO funds. In general, BO funds earn substantially higher revenue per partner and per professional than do VC funds. The main driver of this result is that experienced BO firms raise successively larger funds, with growth in

[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 (2009), Groh and Gottschalg (2007), Cao and Lerner (2009), and Guo, Hotchkiss, and Song (2010).

assets much larger than for comparable VC firms. Even though experience has a significantly negative effect on revenue per dollar for BO funds, the size effect dominates, and later BO funds earn a higher revenue per partner/professional than novice BO funds. In contrast, prior experience has no effect on either revenue per dollar or fund size per partner/professional for VC funds. Section 5 concludes with a discussion of our results. Our main interpretation is that the BO business is much more scalable than the VC business, and this difference in scalability translates into significant differences in fund size and contract terms.

1. Data and Summary Statistics

1.1 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 1993 and 2006. These funds represent all the prospective funds that the Investor considered investing in, not just the funds it ended up investing in, which alleviates potential sample selection concerns. In addition to terms and conditions, we also obtained information on the fund management firms' past investment experience, performance measures of past funds, investment focus, and team composition. We use the terms and conditions data and our models 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 2005), 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 have become publicly available. These data are summarized in the *Private Equity Performance Monitor* 2006 (Private Equity Intelligence 2006), which we use (in combination with internal data from the Investor) to benchmark the performance of funds that were raised in the past by GP firms of our sample funds. This benchmarking is aided by industry-level returns data from the *Investment Benchmarks Reports*, which is published by Venture Economics (2006a, 2006b).

Our models of fee, carry, and transaction fee revenues require assumptions about the pace of investments and exits as inputs. Ideally, we observe the precise timing and values of investments and exits (including write-offs) of all investments made by the universe of funds and construct value-weighted investment and exit pace accordingly. In practice, data that are available to researchers are less than perfect. Specifically, fund-level net cash flow data do not provide us with exit timing, especially for write-offs, whereas

Table 1
Sample summary statistics

Panel A: Venture capital fund characteristics (ninety-four 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

This table presents sample summary statistics for the 238 VC and BO funds in our sample. Panel A gives the data on the ninety-four 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 nonpartner investment professionals in the management firm. "# of investments" is fund size divided by the expected size of investments.

portfolio company-level databases are not reliably traceable to specific funds.[3] Thus, we impute the average fund-level investment pace using proprietary fund-level cash flow data (provided by PE Intelligence) and the average portfolio-company-level exit pace using Sand Hill Econometrics' portfolio company-level database.

1.2 Definitions and summary statistics

Table 1 presents summary statistics for our sample. The sample consists of 238 funds, of which ninety-four are VC funds and 144 are BO funds. Overall, about three-quarters of these funds in terms of number (or 60% in terms of dollar commitments) 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 $225 M in committed capital, and the median BO fund has $600 M. Note that the interquartile range for the size of BO funds is

[3] See, for example, Maats et al. (2008) for data consistency and reliability issues.

$297 M to $1500 M, versus a much smaller range of $100 M to $394 M for VC funds.

In any study that uses only a sample from the full universe of funds, one must be concerned about the possibility of selection bias. For the items in table 1—which includes most of the things that are known for the full universe—our sample looks fairly representative. Private Equity Performance Monitor 2006 reports that, among the 6,073 funds raised between 1991 and 2005 and included in their database, North American-focused funds accounted for 60% in terms of number and 70% in terms of commitments. Thus, in terms of geographic breakdown, our sample of funds appears similar to the full universe.

Untabulated analysis of 1,397 U.S. BO funds and 2,807 U.S. VC funds included in the VentureXpert database for 1993–2005[4] indicates that the mean (median) fund sizes in the universe of BO and VC funds were $492 M ($175 M) and $126 M ($50 M), respectively.[5] As is evident in the large discrepancy between the mean and the median, the fund size distribution is highly skewed in the private equity industry: the top 10% of the largest BO (VC) funds in the same sample account for about 55% (50%) of the total dollar amounts raised, and the bottom 50% of the smallest BO (VC) funds account for only about 7.2% (8.0%) of the total dollar amounts raised, respectively.

We further match each of our sample funds to the same-vintage-year fund sample from VentureXpert and find that the average BO (VC) fund in our sample is in the 71st (80th) percentile of the same-vintage-year fund universe.[6] While our sample funds are larger than the median fund in a broader universe, we think that our sample is representative of funds that typically attract investment from large institutional investors. If we eliminate funds smaller than $50 M from the comparison—approximately the bottom half of funds in VentureXpert—then our sample median and mean size for both VC and BO funds are very close to the median and mean among the >$50 M funds in the broader sample.[7]

Table 1 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

[4] The most recent year in which the VentureXpert data are available is 2005.

[5] We use the U.S. fund sample from VentureXpert for comparisons because the non-U.S. fund samples in VentureXpert are less standardized and less comprehensively covered. Private Equity Performance Monitor 2006 reports that a global (both U.S. and non-U.S.) sample of 1,335 BO funds raised between 1991 and 2005 had total commitments of $720.8 B, or $540 M per fund; similarly, 2,754 VC funds during the same period together raised $378.3 B, or $137 M per fund. Thus, it appears that the average size of funds is similar between the U.S. and non-U.S. funds and that VentureXpert samples more heavily from relatively small funds.

[6] Results are unreported and are available upon request.

[7] Consider an LP who wishes to manage a $500 M private equity portfolio by making $50 M in new commitments every year. To diversify such commitments across ten funds, she needs to commit $5 M to each fund. If she is one of the ten investors, the fund size must be at least $50 M. Consistent with this view, only three VC funds and none of the BO funds in our sample are smaller than $50 M.

are small organizations, with the median VC fund having only nine professionals (= partners + nonpartners) and the median BO fund having thirteen professionals. The largest VC fund in our example is staffed by less than fifty professionals; the largest buyout fund is staffed by less than one hundred.[8] Once again, these results are consistent with evidence from other sources: the National Venture Capital Association (2007) reports an average of between ten and eleven professionals per VC firm for every year since 1986, and Asset Alternatives (2005) reports only a few private equity organizations with more than one hundred investment professionals.

GPs must provide information materials to the Investor 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 Panel A and Panel B. The median VC fund expects to make twenty 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 twelve investments, or 2.4 per partner. In the model of Section 2.2, the expected 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 (PV) of revenue.

GPs earn the bulk of fixed revenue—which is not based on the performance of the fund—through management fees. 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 GPs 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 constant

[8] 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 allow us to distinguish between these two measures.

percentage of committed capital. For example, if a fund charges 2% annual management fees on committed capital for ten years, then the lifetime fees of the ten-year fund would be 20% of committed capital, with investment capital comprising the other 80%. In recent years, many funds have adopted a decreasing fee schedule, with the percentage falling after the investment period. For example, a fund might have a 2% fee during a 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 2.1, we discuss the assumptions used in our model and the data behind these assumptions.

Panel A of table 2 presents summary statistics on management-fee terms for the sample funds. The most common initial fee level is 2%, though the majority of funds give some concessions to LPs after the investment period is over, for example, switching to invested capital basis (42.6% of VC funds and 84.0% of BO funds), lowering the fee level (55.3% of VC funds and 45.1% of BO funds), or both (16.0% of VC funds and 38.9% of BO funds). Based on these facts, we should expect lifetime fees to be less than 20% of committed capital for most funds. Consistent with this expectation, in untabulated results, we find that the median level of lifetime fees is 12% (17.75%) of committed capital for BO (VC) funds in our sample, with an interquartile range between 10% (14%) and 13.5% (21.25%).

All GPs can earn variable (performance based) revenue from carried interest. 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 GP. 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%, 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 Panel B of table 2.

Table 2
Fund terms

	VC	BO
Panel A: Fee terms		
# of funds with initial fee level[1]		
greater than 2%	40	11
equal to 2%	44	59
less than 2%	9	74
% of funds changing fee basis after investment period	42.6%	84.0%
% of funds changing fee level after investment period	55.3%	45.1%
% of funds changing both basis and level	16.0%	38.9%
Panel B: Carry terms		
# of funds with carry level		
greater than 20%	4	0
equal to 20%	89	144
less than 20%	1	0
% of funds requiring return of fees before carry	93.6%	83.3%
% of funds with hurdle return	44.7%	92.4%
# of funds with hurdle level[2]		
greater than 8%	5	18
equal to 8%	28	104
less than 8%	7	11

[1] For one of the ninety-four VC funds, the initial % level of fees is unknown.
[2] For two of the forty-two VC funds with hurdle returns, the % level of hurdles is unknown.

This table presents summary statistics on fund terms for the VC and buyout funds raised in the 1993–2006 period. Panel A presents the statistics for fee terms; Panel B presents the results for the carry terms. "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 five years for a ten-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 prespecified 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.

The overwhelming majority of funds—including all 144 BO funds—use 20% as their carry level.[9] Among the ninety-four VC funds, one has a carry level of 17.5%, three have carry levels of 25%, and one has a carry level of 30%. The exact origin of the 20% 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 sources.[10] Notwithstanding this tiny variation in the carry level, we find that other fund terms can give rise to significant variation in expected carried interest.

[9] The clustering of the carry level around 20% is consistent with the prior literature; for example, Gompers and Lerner (1999) report that 81% of their sample VC funds use a carry level between 20% and 21%.

[10] See Kaplan (1999) and Metrick and Yasuda (2010) 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 93.6% of the VC funds and 83.3% 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* clause. Consider a \$100 M fund with a carry level of 20%, a carry basis of committed capital, a hurdle return of 8%, and a 100% 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 \$120 M, with \$108 M of these proceeds coming exactly one year after the first investment, \$2 M coming one year later, and \$10 M coming the year after that. Under these rules, all \$108 M of the original proceeds would go to the LPs. This distribution satisfies the 8% hurdle rate requirement for the \$100 M 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% (\$2 M) out of the total \$10 M in profits. For the final distribution, the \$10 M would be split \$8 M for the LPs and \$2 M 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 \$20 M in profits (\$120 M in proceeds on \$100 M of committed capital), and the GPs received 20% (\$4 M) of these profits. A fund with a catch-up percentage below 100% would still (eventually) receive 20% of the profits, albeit at a slower pace than the fund in the above example. If, however, the fund had only earned \$8 M or less in profits over this time period, then all these profits would have gone to the LPs.

Table 2 shows that hurdle returns are much more prevalent among BO funds than among VC funds (92.4% vs. 44.7%). Among funds with a hurdle rate, the modal rate of 8% 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 6% and 10%. The majority of funds with a hurdle have a catch-up rate of 100% (not shown in the table), and most of the remaining funds have a catch-up rate of 80%. 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. For example, one common timing rule allows carried interest to be collected as a fixed (say 20%) percentage of the fund profits, where the profit at any given point in time is defined as cumulative exit values minus the *contributed* capital. Once the fund is fully invested and completed, contributed capital reaches committed capital, and the fund profit definition reverts to cumulative exit values in excess of carry basis. However, for a fund that is still alive and incomplete, this timing rule gives GPs a potentially early opportunity to collect carried interest that would not be available otherwise.

When such early carry is taken, the LPs typically have the ability to "clawback" all or some of these distributions if later performance is insufficient to return the full carry basis or the LPs' share of the finalized fund profit (if any). For example, consider a $250 M fund with management fees of 2% of committed capital each year, a carry level of 25%, a carry basis of committed capital, no carry hurdle, a carry timing rule of "contributed capital back first," and a clawback provision. Suppose the fund made investments totaling $100 M in the first three years and had no exits. In year 4, it made no new investments and had its first exit totaling $150 M. In year 5, it made new investments totaling $100 M and no exits. Thereafter, assume it made no more exits, and all remaining investments were written off for a 100% loss at the end of year 10. Since the contributed capital as of year 4 = 100 + 2%*250*4 = 120, GPs could earn an (early) carry of 25%*(150 – 120) = $7.5 M in year 4. At the end of year 10, contributed capital = 100 + 100 + 2%*250*10 = 250 = committed capital. However, only $142.5 M ($150 M – $7.5 M) has been returned to LPs. Thus, the clawback provision requires that GPs return $7.5 M to LPs.[11]

Aside from management fees and carried interest, the other two components of revenue are transaction fees and monitoring fees. Both of these fees are common features for BO funds but are rare for VC funds. When a BO fund buys or sells a company, it effectively charges 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 she owns less than 100% of the company and shares less than 100% of these transaction fees with her LPs. About 85% of BO fund agreements require that GPs share at least some portion of these transaction fees with their LPs, with one-third of all funds required to return all transaction fees to LPs. Another 41% of funds use a 50/50 sharing rule between GPs and LPs, with the remaining 11% of funds allocating between 50% and 100% for the LPs. While VC funds often have these sharing

[11] Other carry timing rules that allow early carry distributions include (i) return contributed capital plus hurdle returns (see the discussion above) and (ii) fair-value tests, where a return of only a portion of contributed capital is required before carry is triggered, as long as the portfolio maintains a certain threshold level of (unrealized) capital gain. Variations on rules (i) and (ii) (and the rule discussed in the text) could use "invested" instead of "contributed" capital. We extensively incorporate timing rules into our model by considering (i) early carry, no hurdle (as in the example above); (ii) early carry with hurdle without catch-up; (iii) early carry with hurdle with catch-up; and (iv) no early carry. For extensions of the model incorporating fair-value tests, see Choi, Metrick, and Yasuda (2009).

rules written into their partnership agreements, transaction fees are nevertheless rare in VC transactions and thus are not covered in our analysis. As will be discussed in Section 2.3, transaction fees can be considered as a fixed-revenue component, since (in our model) they are not dependent on fund performance.

In addition to transaction fees, BO funds often charge a monitoring fee to their portfolio companies. The ostensible purpose of these fees is to compensate the funds for time and effort spent in working with their portfolio companies. In most cases, these fees are shared, with LPs receiving 80% and GPs receiving 20%. We did not consistently code for the differences in the sharing rule for monitoring fees, so in our model we assume that all BO funds use the same 80/20 rule. While there is no set schedule for these fees, industry practitioners have told us that these fees range between 1% and 5% of earnings before interest, tax, depreciation, and amortization (EBITDA) each year, with smaller portfolio companies charged at the higher end of that range. In Section 2.3, 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.

2. A Model of Expected Revenue for Private Equity Funds

In this section, we discuss our models for the PV of GP revenue. Section 2.1 presents a model of management fees that takes account of differences observed in our sample. Section 2.2 presents a model for carry revenue, based on a risk-neutral option-pricing approach. Section 2.3 appends a model for transaction fees and monitoring fees onto the model of Section 2.2. Section 2.4 presents a flowchart of the model and describes the steps in more detail.

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? The main reason is that the number of funds for which we have fund terms information is too small for us to conduct meaningful ex post analyses. Furthermore, since many of our sample funds were raised recently, the number of funds with finalized returns for which we have fund terms information is even fewer than our full sample of 238. Finally, the cash flow data at the fund level simply tell us the netted out cash flows between the funds and LPs, which are insufficient for the purpose of our analysis. Such data do not tell us when exits and write-offs occur, how much the exit values of individual investments were, how much fees were paid, how much carry was paid, etc., all of which are essential in estimating expected PVs of revenues to GPs. Overall, the ex post analysis would not be feasible with our sample of funds. Thus, we adopt an ex ante analysis by modeling the expected value of various fund terms. This analysis has the added benefit of providing a flexible model of expected GP revenue that can be used in other applications.

2.1 Management fees

In our model, we assume that funds are fully invested at the end of the investment period.[12] Using quarterly cash flow data drawn from over 500 completed funds,[13] 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 ten-year VC fund that has a five-year investment period invests 30%, 24%, 31%, 12%, and 3% of its investment capital in years 1 through 5, 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. (The distributional assumptions for these exit times will be explained below in Section 2.2.) For the benchmark case, we assume that VC funds make twenty-five investments per fund and that each investment is equal in size. For BO funds, the benchmark case uses eleven investments.

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.[14] For each fund in our sample, we solve for the exact investment capital and lifetime fees such that

$$\text{committed capital} = \text{investment capital} + \text{lifetime fees} + \text{establishment cost}. \quad (1)$$

Since fees are a contractual obligation of the LPs, we treat these fees as a risk-free revenue stream to the GP with a 5% discount rate.[15] Using this discount rate, we obtain the PV of management fees for each fund. For example, consider a \$100 M BO fund that charges 2% fees on committed capital for the first five years and 2% fees on net invested capital for the next five years and has a 1% establishment cost. For the first five years of the fund, the 2% fee implies \$2 million in fees each year. The calculation gets more complicated starting in year 6, when the fees will be 2% of net invested capital, because both net invested capital and total investment capital are (initially) unknown. Let X = investment capital. We use the simulated exit schedule discussed above to express net invested capital in each of years 6 through 10 as a percent of X. Thus, fees in years 6–10 = (46.0% + 37.7% + 30.9% +25.3%+20.7%)*X*

12 PE Performance Monitor 2006 indicates (pp. 323 and 326) that median 1996 vintage BO funds (which are ten years old in 2006) are 99.3% called, and median 1995 vintage year funds and older are 100% called. Similarly, median 1996 vintage VC funds (and in fact all vintage years older than 1999) are 100% called. These statistics suggest that mature funds are fully called on average.

13 We thank Private Equity Intelligence for providing us with these data.

14 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 as a percentage of fund size. We assume that the GPs charge the maximum amount allowed in the partnership agreement. A common maximum is \$1 million.

15 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 risk-free for the GPs.

2% = 0.0321X.[16] From Equation (1), 100 = X + 2*5 + 0.0321X + 0.01*100. X = (100-10-1)/1.0321 = 86.23. Lifetime fees = 100-1-X=12.77. Once we obtain the solution to X, we can calculate the expected fees in years 6–10 and discount all fees using the risk-free discount rate of 5% to obtain the PV of fees. Thus, lifetime fees are $12.77 M, the PV of these fees is $11.07 M, and investment capital is $86.23 M for this example.

2.2 Carried interest

For GPs, carried interest is a fraction of an option-like position 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 practice, the aggregation at the fund level and multiple, staggered investments in the fund (among other things) make carried interest considerably more complex than a simple call option. To derive solutions to the problem of valuing these option-like positions on the funds, we use numerical methods. In our model, we use simulation to obtain the exit dates and exit payoffs for each of the underlying investments, and then we use risk-neutral valuation to estimate the value of the carried-interest option on these investments as of the fund inception date. For a portfolio of publicly 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 2.2.1, 2.2.2, 2.2.3, and 2.2.4, respectively.

2.2.1 The value of private equity services. If a fund starts with $100 M in committed capital and has lifetime fees of $20 M, then there is $80 M left over in investment capital. If this firm expects to make twenty investments,

[16] This simulated average net invested capital amount (as percent of X) is also a function of the duration of investment period because a shorter (longer) investment period accelerates (decelerates) the investment pace of a fund. We run separate simulations for different investment periods to account for variation in this fund term across our sample funds. The results used in the example above corresponds to a ten-year fund with a five-year investment period.

then each investment will receive an average of \$4 M in cash. In the simplest possible setting, with no value added or selection ability by GPs, we could simulate paths for each of these twenty investments, with starting values of \$4 M for each investment. Then, the expected present discounted value for each investment at exit would also be \$4 M, and the total PV for all twenty investments would be \$80 M. In expectation, the GPs would take some fraction of that value in carried interest, and the remaining value to the LPs would be less than \$80 M. Now, since the LPs have committed \$100 M to the fund, an expected value of less than \$80 M is not going to make sense in equilibrium. Instead, the GPs will need to add value somewhere to justify their fees and carry.

In our simulation model, we assume a fixed value added by GPs in each investment. In the basic version of the model used in the text, we set this value added such that a fund with \$100 M of committed capital would have a total starting value of investments at \$106.71. This number is chosen so that the expected value to LPs is exactly equal to committed capital for the special case of our baseline VC fund. The way to think of this number is that for every \$100 in committed capital, the LPs pay some amount in fees and the GPs then put in their value added (after which the value is \$106.71) and take out another expected amount in carried interest, after which exactly \$100 (in expectation) is left over for the LPs. Figure A1 in the Appendix illustrates this relationship.

We choose to use the same starting value for every fund in order to simplify our analysis and focus attention on the impact of various fund terms. In Section 4.3, we discuss the robustness of our results to different assumptions about this starting value. In principle, one could also be interested in an equilibrium treatment of these starting values, so that GP value added is allowed to vary for each fund as a function of its terms, with that starting value set so that LP expected values are exactly equal to committed capital for every fund. The Appendix develops the notation and intuition behind this equilibrium approach.

2.2.2 Volatility and correlation. To estimate volatility for investments by VC funds, we rely on Cochrane (2005). Cochrane begins with a capital asset pricing model (CAPM) of expected (log) returns for VC investments. He then uses a relatively comprehensive database of venture capital investments to estimate the parameters of the model. In general, these data suffer from sample-selection problems: we observe returns for a company only upon some financing or liquidation event. To solve this problem, Cochrane simultaneously estimates thresholds for initial public offerings (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%. We round this estimate up to 90% 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 BO funds is approximately equal to 1. 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 $600 M making twelve investments, the average equity investment would be $50 M and typical leverage of 2:1 would imply a $150 M company.[17] For a company of this size, we use a small-stock volatility estimate of 60% 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%. For VC funds, there is no analogous empirical evidence. In the absence of such evidence, we adopt an estimate of 50%. As compared with the BO correlation of 20%, 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 4.3, we discuss the implications of using different estimates for this pairwise correlation.

2.2.3 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 and Yasuda (2010) shows that the median first-round VC investment has an expected holding period of five years, with annual probability of exit close to 20%. 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 correlations on large portfolios, and in robustness checks using small portfolios we have not found any clear pattern between correlation structures and expected carried interest.

2.2.4 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

[17] See Kaplan and Stein (1993), among others, for discussions of the financial structure of leveraged buyouts. See Axelson, Stromberg, and Weisbach (2009) for a theoretical analysis of the relation between the financial structure of buyout transactions and that of private equity partnerships as equilibrium outcomes.

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 applicable for only an investor that can diversify the nonsystematic 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 direct estimates of expected compensation to the GPs.

2.3 Transaction fees and monitoring fees

2.3.1 Transaction fees. In the purchase of a new portfolio company, BO funds typically charge a transaction fee to that company that is between 1% and 2% of transaction value. It is not clear exactly what these transaction fees are paying for, since GPs should already be receiving their fixed costs from management fees. We think of these transaction fees as just being one way that BO funds can earn revenue. From the perspective of an LP, all that matters is that some fraction of the committed capital is not going directly to purchase a company, so the GP must somehow find a way to create enough value to replace that loss.

It is difficult to find reliable information about the frequency and size of these fees. The only published research on this topic comes from Consus Group (2008), which searched public filings to find an average fee of 1.37% of firm value for transactions where fees were paid. There is no research to tell us the frequency of transactions that have zero fees. In informal interviews with industry practitioners, we have been told that fees are almost universal for purchases of control stakes, less common and smaller for sales of control stakes, and rare for purchases of minority stakes and in IPO sales.

In our model, we take a simplified approach and charge a full 1.37% transaction fee at entry (purchase) and zero transaction fees on all exits (sales). On the entry side, this assumption will lead to somewhat higher fees, since in reality some BO fund investments are for minority stakes, which would have lower fees. On the exit side, this assumption will lead to somewhat lower fees, since some sales do receive a fee; since the largest exits are IPOs, which usually do not earn fees, we think that this bias will be small. In any case, the two biases go in opposite directions and, we hope, should cancel enough to allow good first-order estimates.

With our assumption that fees are assessed only at entry, the computation of these fees is straightforward. For a firm with $\$X$ of investment capital and a leverage ratio of Y to 1, the total purchase price of investments at entry will be $\$X * (Y + 1)$, and the total assessed transaction fee will be $0.0137 * \$X * (Y + 1)$. All that remains is to take the PV of these fees to account for the investment pace of the fund and to credit the contractual fraction of this total back to the LPs. Since the total amount of these entry transaction fees is not dependent on the performance of the fund, we categorize them as fixed revenue to the GP. Some example computations are discussed in Section 3.3, and computations for our sample funds are summarized in Section 4.1. These fees also play a role in the estimation of carried interest because the fees are subtracted from firm value before any price paths are simulated. This step is explained more fully in Section 2.4.

2.3.2 Monitoring fees. As with transaction fees, we think of monitoring fees as just another way for BO funds to earn a revenue stream. While it may seem odd that funds are effectively paying themselves a fee to run companies that they own, the sharing rules with LPs can make this an indirect way for the LPs to pay the GPs for their services. From the perspective of the LPs, it should not matter whether these payments come directly through management fees or indirectly through monitoring fees, as long as the GP can create sufficient value to justify them. As with transaction fees, it is difficult to get hard evidence on the size and frequency of these fees, and our data sources from the Investor are silent on the topic. In informal discussions with practitioners, we were told that annual monitoring fees typically vary between 1% and 5% of EBITDA, with smaller companies at the high end of this range and larger companies at the low end. Since these fees vary with firm performance, we include them as a component of variable revenue to the GPs.

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 PV of the contract. For computational convenience, we assess all monitoring fees at exit, assuming a five-year contract with annual fees at 2% 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 5, this proportion would be forty basis points of firm value per year, which we assess all at once as 0.40 * 5 years = 2% of firm value at exit. In all versions of the model, we use the typical sharing rule and allocate 80% of this value to the LPs and 20% to the GPs. The mechanics of this computation and its timing in the simulation model are described in the next section.

2.4 The simulation model

Figure 1 gives a flowchart for the simulation model that incorporates all the discussion of Sections 2.2 and 2.3. In STEP 1, we set the fund terms for each set of trials. These terms then determine the sharing rules at time of exit. Consider first the benchmark VC case, with a 20% carry on committed capital basis with no hurdle rate. In this benchmark case, the fund makes 25 investments, distributed temporally as discussed in Section 2.1. In STEP 2, we set the start-

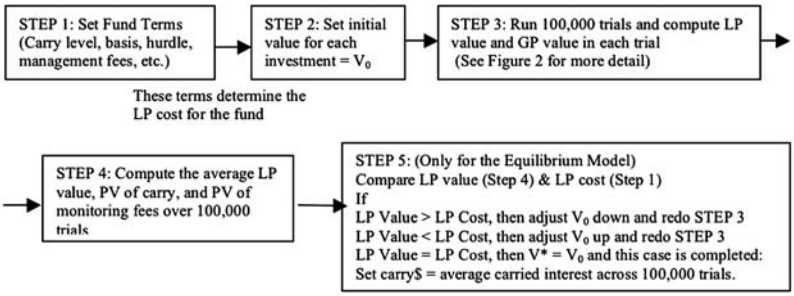


Figure 1
Main flowchart for simulation
This figure presents a flowchart for the simulation model. In STEP 1, we set the fund terms for each set of trials. In STEP 2, we set the starting value for fund investments to be V_0. In the baseline analysis of Section 2, V_0 is set to \$106.71 M. For the equilibrium approach in Section 4, V_0 varies and is iteratively solved for each fund. In either case, transaction fees are immediately deducted from this value for BO funds before valuation paths are simulated in STEP 3. In STEP 3, we run 100,000 trials for all investments and calculate PVs of monitoring fees, carry, and distributions to LPs for every exit event in each trial. In STEP 4, we compute the expected PV of carry and monitoring fees as well as the PV of LP value as the average over 100,000 trials. For the equilibrium model in Section 4, we proceed to STEP 5, where we compare the estimated LP value from STEP 4 with the LP cost from STEP 1, adjust V_0 up or down accordingly, and repeat STEPs 3 and 4 iteratively until the LP value equals the LP cost.

ing value for fund investments to be V_0. In the baseline analysis, V_0 is set to \$106.71 M. For BO funds, this total value is immediately reduced by the level of transaction fees: for the baseline case with 2:1 leverage and \$88 M investment capital, we get a reduction of 3 * 1.37% * \$88 M = \$3.62 M. For the equilibrium approach described in Section 4, V_0 is allowed to vary. At the end of this section, we describe the equilibrium approach in more detail.

STEP 3 contains the main work of the simulation: 100,000 trials for all investments. Figure 2 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% annual rate. Exits are independent across investments and are uncorrelated with investment value. Since funds typically last for ten years, with up to two years of extension subject to LPs' approval, we truncate the maximum exit time at twelve 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%. As discussed in Section 2.2.2, this volatility is divided into common and idiosyncratic components to imply a 50% cross-correlation between any pair of existing investments. In STEP 3C, we deduct monitoring fees (for BO funds), and then 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 risk-free discount rate to take the PV of these components as of day 0. These PVs are the GP value (=PV of carried interest, transaction fees, and monitoring fees) and the LP value.

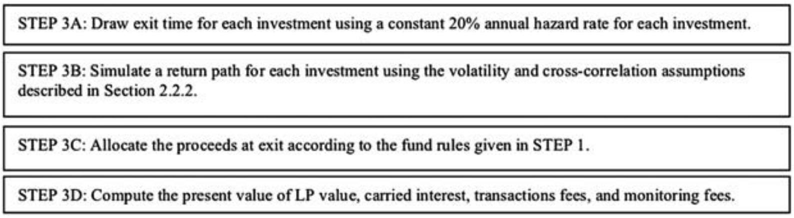


Figure 2
Flowchart for each trial
This figure presents a flowchart for a single trial in STEP 3 of figure 1. In STEP 3A, we draw an exit time for each investment (for a total of twenty-five investments for the base case VC fund). In STEP 3B, we simulate a valuation path for each investment. In STEP 3C, we deduct monitoring fees (for BO funds), and then use the fund rules (as defined in STEP 1 of figure 1) to divide the value at exit into carried interest and the LP distribution. In STEP 3D, we use the 5% risk-free discount rate to compute the PV of LP value, carried interest, transaction fees, and monitoring fees as of the inception date of the fund.

Returning now to figure 1, we move to STEP 4, where we compute the average carried interest and (for BO funds) monitoring fees across all 100,000 trials. In the case of the equilibrium model, there is one additional step. 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 A1, 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 or investment capital), investment capital (80%, 82%, ..., 100% of commitment capital), hurdle/timing (no hurdle with early carry, no early carry, 6% with catch-up, 8% with catch-up, 10% with catch-up, or 8% without catch-up), number of investments (5, 11, or 25 for BO and 15, 25, or 35 for VC), and percent share of transaction fees (0%, 50%, or 100% for BO; none for VC). Overall, we solve for 594 sets (3 * 11 * 6 * 3) of VC fund terms and 3,564 sets (3 * 2 * 11 * 6 * 3 * 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. These and other assumptions are relaxed/altered for robustness checks in Section 4.3.

3. Model Outputs

Section 3.1 gives outputs for management fees, Section 3.2 gives outputs for carried interest, and Section 3.3 gives outputs for transaction and monitoring fees.

3.1 Fee model outputs

Table 3 summarizes outputs for the fee model of Section 2.1. The middle cell of Panel A shows the results of the base case fund: 2% initial fee level, no fee level change, no fee basis change, and ten-year fund. For this fund, the PV of (lifetime) fees is $16.14. (These values are expressed in dollars per $100 of committed capital.) A shift to a constant fee level of 1.5% per year decreases the PV of fees to $12.10. Panel B shows the results for a ten-year fund with an investment period of five 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%, this basis change reduces the lifetime fees to $11.09, a reduction of $5.05 from the base case. Thus, a shift in the fee basis from committed capital to net invested capital (in the postinvestment period) has a greater effect on the lifetime fees than a fifty basis point shift in the fee level.

Panel C presents the results for a fund that changes its fee level after the five-year investment period. The middle cell in the panel shows the results of a fund that charges an initial fee level of 2%, which goes down to 1.5% after the investment period. The fee basis is committed capital throughout the lifetime of the fund. For this fund, the PV of fees is $14.37, a reduction of $1.77 from the base case fund (the middle cell in Panel A).

Finally, Panel D shows the results of changing both the fee basis and the 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 reduces the fee level to 1.5% (from the initial level of 2%) after the investment period. For this fund, the PV of fees is $10.60, a reduction of $5.54 from the base case fund.

3.2 Carry-model outputs

Figure 3 summarizes the results of simulating (risk-adjusted) PVs of the carry model. The circled number in Panel 5 shows the results for the base case VC fund: 20% carry level, carry basis = committed capital, no hurdle return, timing rule = contributed capital returned first with clawback,[18] and 25 investments in the fund.[19] The PV of carried interest for this base case is $8.33. (As with all numbers in figure 3, these values are expressed in dollars per $100 of committed capital.) A shift to a hurdle rate of 8% (with 100% catch-up rate) leads

[18] In our model, we assume perfect enforceability of clawback. Thus, our calculations do not capture the practical difficulty (or potential costs) of enforcing clawback.

[19] The fund term characteristics of the base case fund are set to those of the modal fund in the sample for both VC and BO funds.

Table 3
Management-fee model: outputs

Panel A: No fee basis / level change

		Initial fee level		
		1.50%	2.00%	2.50%
Duration	10	**$12.10**	**$16.14**	$20.17

Panel B: Fee basis changes to invested

		Initial fee level		
		1.50%	2.00%	2.50%
Duration	10	$8.37	**$11.09**	$13.77

Panel C: Fee level goes down

		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	$10.34	$12.60	$14.87
fee	1.50%	NA	**$14.37**	$16.64
level	2.00%	NA	NA	$18.40

Panel D: Both basis and level change

		Initial fee level		
		1.50%	2.00%	2.50%
New	1.00%	$7.86	$10.10	$12.33
fee	1.50%	NA	**$10.60**	$12.82
level	2.00%	NA	NA	$13.30

This table summarizes outputs of the management-fee model. The outputs represent PV of fees expressed in dollars per $100 of committed capital. Panel A presents the results for the base case funds with neither fee basis nor fee level change; Panel B shows results for the funds that experience fee basis change; Panel C shows results for the funds that experience fee level change in the postinvestment period; and Panel D shows results for the funds that experience both fee basis and fee level change. Lifetime fees are the sum of management fees paid to GP over the lifetime of the fund. A risk-free rate of 5% is used to discount the fees. Fund lifetime and investment period are assumed to be ten years and five years, respectively.

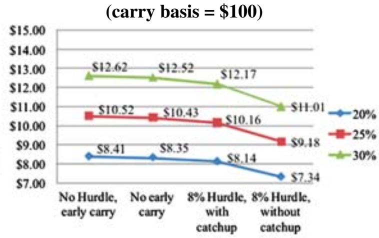
to a reduction of $0.29 in the PV of carry, while a shift to a carry level of 25% would increase the PV of carry by $2.07. Panel A-2 shows the results for a VC fund that makes only fifteen investments. With this smaller number of investments, the overall fund portfolio is less well diversified, so the volatility of the portfolio is higher and the option value (carried interest) is higher. As compared with the results in Panel 5, the PV of carried interest increases by between $0.08 and $0.16, depending on the fund terms.

Figure 3
Carried interest model: outputs
This figure presents the simulation results for the PVs of carried interest (in $, per $100 of committed capital) as functions of fund terms. Panel A summarizes results for VC funds with either twenty-five or fifteen investments, and Panel B summarizes the results for BO funds with either eleven or five investments. Investment capital is set to 82% (88%) of the committed capital for VC (BO) funds, following the median sample fund characteristics as described in the text. The catch-up rate is 100%. Transaction fee sharing rule of 50:50 is assumed for BO funds. "No hurdle, early carry" means that GPs are entitled to carry after returning the contributed (or invested) capital to LP, subject to clawback. "No early carry" means that GPs must return all of carry basis (committed capital or investment capital) before they are entitled to carry, thus ruling out any necessity for clawback. "8% Hurdle, with catch-up" means GPs are entitled to 100% catch-up and subsequent normal carry after returning contributed (or invested) capital plus 8% annual compounded hurdle return to LP, subject to clawback. "8% Hurdle, without catch-up" means GPs are entitled to carry (but no catch-up) after returning contributed (or invested) capital plus 8% annual compounded hurdle return to LP, subject to clawback.

Panel A: Venture Capital Funds

Panel A-1: 25 investments, committed capital basis (carry basis = $100)

Panel A-2: 15 investments, committed capital basis (carry basis = $100)

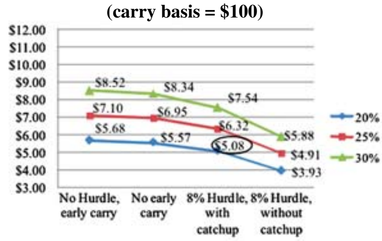


Panel A-3: 25 investments, investment capital basis (carry basis = $82)

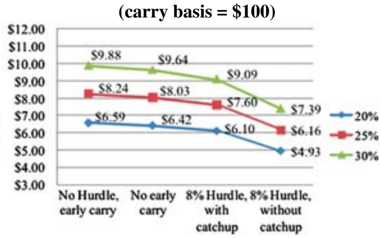
Panel A-4: 15 investments, investment capital basis (carry basis = $82)

Panel B: Buyout Funds

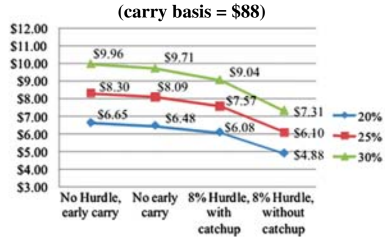
Panel B-1: 11 investments, committed capital basis (carry basis = $100)



Panel B-2: 5 investments, committed capital basis (carry basis = $100)



Panel B-3: 11 investments, investment capital basis (carry basis = $88)



Panel B-4: 5 investments, investment capital basis (carry basis = $88)

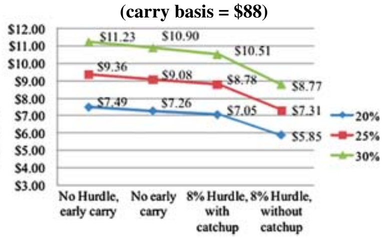


Table 4
Transaction / monitoring fee model: outputs

	Monitoring fees	Transaction fees
Case 1: 11 investments, $88 investment capital, 50% fee, 2:1 leverage	$0.87	$1.68
Case 2: Number of investments drop to 5	$0.88	$1.71
Case 3: Investment capital decreases to $80 (out of $100)	$0.82	$1.53
Case 4: GPs take 100% of transaction fees	$0.87	$3.37
Case 5: Leverage increases to 4:1	$1.37	$2.81

This table presents the model outputs for the PVs of transaction fees and monitoring fees (in $, per $100 of committed capital) as functions of BO fund terms. Case 1 represents the modal BO fund, which is a fund with investment capital = $88, number of investments = 11, 50% sharing rule for transaction fees, 20% sharing rule for monitoring fees, and 2:1 leverage. Case 2 presents the results for the same fund as Case 1, except that the number of investments drops to five from eleven. Case 3 presents the results for the same fund as Case 1, except that the investment capital decreases to $80 from $88. Case 4 presents the results for the same fund as Case 1, except that GPs take 100% of transaction fees (and LPs take 0%). Case 5 presents the results for the same fund as Case 1, except that the leverage increases to 4:1.

Panels A-3 and A-4 show the results using an investment-capital basis, where investment capital is set to 82% of committed capital.[20] In comparing the numbers in these panels with their analogues in Panels 5 and A-2, we can see that the decrease in carry basis leads to increases in the PV of carry that are typically around $1.10 for a 20% carry and $1.40 for a 25% carry.

Panel B of figure 3 summarizes the results for BO funds. The base case, the circled number in Panel B-1, has eleven investments, 20% carry level, 8% hurdle with 100% catch-up, and a carry basis of committed capital. The PV of carried interest in this base case is $5.08 per $100 of committed capital. This is $3.25 lower than the base case for VC funds (the circled number in Panel 5). In addition to the hurdle rate, the main drivers of this difference are the higher volatility for VC investments (90% vs. 60% for BO investments) and the higher pairwise correlation between VC investments (50% vs. 20% 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 numbers in Panel B-1 show how the PV of carry is affected by changing one input at a time. A move to no hurdle leads to a gain of $0.60 in PV of carry. An increase of the carry level to 25%—a level not used by any of the BO funds in our sample—would increase PV of carry by $1.24.

Panel B-2 shows the PV of carry with five investments per fund. This change is worth between $0.85 and $1.55 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 88% of committed capital. As compared with their analogues, this change to an investment capital basis leads to increases in PV of carried interest ranging from $0.84 to $1.50.

[20] The size of investment capital is set to the median VC fund in our sample, which charges 18% of committed capital in lifetime fees. For BO funds, investment capital is set to its sample median, which is 88% of committed capital (see Panel B).

3.3 Transaction fees and monitoring fees

Table 4 summarizes the model outputs for transaction fees and monitoring fees. Case 1 represents the modal BO fund, which is a fund with investment capital = $88, number of investments = 11, 50% sharing rule (for GPs) for transaction fees, 20% sharing rule (for GPs) for monitoring fees, and 2:1 leverage. For this modal fund, the PV of monitoring fees to the GP is $0.87 M per $100 M of committed capital. Since the GPs are only receiving 20% of the total monitoring fees, this total implies that 4 * $0.87 M = $3.68 M of monitoring fees are being returned to the LPs as a credit against the carried interest basis. The transaction fees for this modal fund are $1.68 M. Given the 50% sharing rule, this means that another $1.68 M is being returned to LPs.

The other rows of table 4 illustrate the effects of changing various fund terms or investment patterns. Cases 2 and 3 are similar to Case 1, demonstrating that changes in the number of investments or in investment capital have little effect on these fees. In Case 4, we change the sharing rule to give 100% of the transaction fees to the GP: as compared with the base case, this has the obvious effect of doubling the GP total to $3.37. Outside of changes in the sharing rules, the biggest impact on monitoring fees and transaction fees is driven by changes in leverage. Recall that monitoring fees are typically charged as a fraction of EBITDA, and transaction fees are charged as a fraction of transaction value. In both cases, any increase in firm value will lead to a (nearly) proportional increase in estimated fees. For example, the transaction fees in Case 1 of $1.68 M reflect a leverage ratio of 2:1, so that each dollar of investment capital can purchase $3 of firm value. For Case 5, the leverage ratio is 4:1, so each dollar of investment capital can purchase $5 of firm value. With that change, the transaction fees increase by the ratio of 5:3 over the base case, for a total of $2.81 M. For monitoring fees, the computation is not as straightforward, since the fees are assessed at exit and do not represent a linear claim on firm value. Section 2.4 discusses the mechanics of the monitoring fee calculation; for Case 5, we get an estimate of $1.37 M per $100 M of committed capital.

4. Empirical Results

4.1 Descriptive statistics

Using the models from Section 2, we estimate the PVs of all revenue components for all sample funds. Table 5 presents the summary statistics of these components. Panel A presents the results for the VC fund sample; Panel B presents the results for the BO 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 $22.84 ($23.16) per $100 among VC funds and $17.72 ($17.80) per $100

Table 5
Summary statistics: Revenue estimates

Panel A: Venture capital fund characteristics (94 funds)

PV of	Mean	25%	Median	75%
Carry per $100	$8.36	$8.09	$8.20	$8.37
Management fees per $100	$14.80	$12.04	$14.61	$17.61
Total revenue per $100	$23.16	$20.24	$22.84	$26.11
Carry per partner	$6.55	$2.03	$4.08	$7.05
Management fees per partner	$10.57	$3.69	$7.13	$12.67
Total revenue per partner	$17.11	$5.73	$10.89	$19.89
Carry per professional	$2.51	$1.01	$1.93	$3.27
Management fees per professional	$4.19	$1.73	$3.43	$5.20
Total revenue per professional	$6.70	$2.70	$5.52	$8.20

Panel B: Buyout firm characteristics (144 funds)

PV of	Mean	25%	Median	75%
Carry per $100	$5.28	$4.93	$5.21	$5.66
Variable revenue per $100	$6.16	$5.80	$6.08	$6.54
Management fees per $100	$10.35	$8.77	$10.34	$11.65
Fixed revenue per $100	$11.64	$9.73	$11.31	$13.11
Total revenue per $100	$17.80	$15.75	$17.72	$19.60
Carry per partner	$10.13	$3.24	$6.31	$12.25
Variable revenue per partner	$11.85	$3.77	$7.35	$14.85
Management fees per partner	$18.47	$6.85	$12.93	$24.33
Fixed revenue per partner	$20.85	$6.89	$13.98	$26.21
Total revenue per partner	$32.69	$10.66	$22.40	$42.08
Carry per professional	$3.52	$1.25	$2.25	$3.88
Variable revenue per professional	$4.13	$1.44	$2.64	$4.58
Management fees per professional	$6.52	$2.74	$4.67	$7.41
Fixed revenue per professional	$7.35	$3.10	$5.12	$8.21
Total revenue per professional	$11.47	$4.61	$7.81	$13.17

This table presents sample summary statistics for revenue estimates. Panel A gives the data on the ninety-four venture capital (VC) funds and Panel B gives the data on the 144 buyout (BO) funds. Carry per $100 is the PV of carried interest in $ per hundred dollars under management. Carry per partner is the PV of carried interest per partner in $millions. Carry per professional (partners plus nonpartners) is the PV of carried interest per professional in $millions. Other measures are defined similarly. Variable revenue is the sum of carried interest and monitoring fees. Fixed revenue is the sum of management fees and transaction fees. Each measure was constructed using the model described in Section 2 and reflecting the relevant terms for each fund.

for BO funds. Interestingly, in both categories, close to two-thirds of the total revenues derive from fixed-revenue components and about one-third from the variable-revenue components.[21]

Although the median PV of carried interest is much lower for BO funds ($5.21) than for VC funds ($8.20), BO funds can make up some of this difference in variable revenue through monitoring fees. In total, the median BO fund receives $0.87 per $100 of committed capital in PV of monitoring fees, thus

[21] These numbers are pretax figures. Currently, management fees are taxed at income tax level, while carried interest are treated as capital gains and thus are subject to lower tax levels. This implies that posttax fees are smaller as the percentage of the total posttax earnings for GPs. Fees are also used to cover operating expenses of funds such as rent and nonpartner staff salary; thus, individual GPs' take-home portion of fees depends on the size of the fund and fixed vs. variable portions of fund expenses. Generally, the larger the fund, the smaller are the percentage of fees used for expenses and thus the larger are the percentage of fees GPs take home.

raising the median variable revenue per \$100 to \$6.08. For management fees, VC funds receive a median of \$14.61 per \$100 vs. \$10.34 per \$100 for BO funds. The latter group makes up some of this difference in transaction fees, where the median BO fund receives \$0.97 per \$100, thus raising the median fixed revenue per \$100 to \$11.31.

Although VC funds have a higher unit PV of revenue, BO managers compensate for this by raising larger funds than VC managers. As discussed in Section 1, the median BO fund has \$600 M in committed capital versus \$225 M 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 \$22.40 M (\$32.69 M) for BO funds versus \$10.89 M (\$17.11 M) for VC funds. The analogous figures for total revenue per professional are \$7.81 M (\$11.47 M) for BO funds versus \$5.52 M (\$6.70 M) for VC funds. At the 75th percentile, BO funds enjoy an even greater advantage over VC funds.

4.2 Regression results

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

$$Revenue\_Measure_i = \alpha + \beta_1 Sequence_i + \beta_2 TopQ_i + yeardummies + e_i. \quad (2)$$

The dependent variable, *Revenue_Measure*, refers to any of the revenue measures that are estimated using our various models, matched to the actual terms of funds in the sample, and reported in table 5. Each of these measures is 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, 2006b). While both are measures of past success, *TopQ* is an explicit and observable measure of superior (raw) performance, while *Sequence* is a measure of GPs' experience[22] and ability to raise subsequent funds by generating interest among LPs. We also include year fixed effects (separately for VC and

[22] Zarutskie (2009) reports that specialized human capital of VC management teams is positively correlated with investment success of the funds. While it would be interesting to examine whether human capital of the management team has a similar positive correlation with chosen fund terms, we lack such data on human capital for our fund sample.

BO segments, since they have separate market cycles) to control for any unobserved year-specific and segment-specific factors.

Table 6 summarizes the results of these regressions. In each case, we estimate the regressions for the full sample, with separate coefficients on each variable (including constant terms and year dummies) 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 except for carry per dollar and variable revenue per dollar in Panel C. This is likely due to the fact that it is a noisy variable.[23] 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.[24]

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 1% 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 nonpartner 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. Furthermore, the *TopQ* coefficient is positive and significant for VC funds in carry-per-dollar and variable-revenue-per-dollar specifications. Thus, this cross-sectional evidence suggests that BO funds actually decrease their revenue per unit of committed capital as they grow more experienced, whereas VC funds act in the opposite way by charging more carry.

23 While it is adjusted for vintage-year-specific factors, it is not risk adjusted. Also, PE firms with less than four past funds have low values of *TopQ*, even if all of their past funds are in the top quartile. We reestimated our regressions with just *TopQ* (without *Sequence*) and just *Sequence* (without *TopQ*) and confirm that the t-stats remain significant for *Sequence* and insignificant for *TopQ*.

24 One of the funds in our VC fund sample has an extremely high level of expected revenue per partner and does not appear to be a normal VC fund but rather a blend of hedge fund and a private equity fund. If we were to remove this fund from the sample, then the sequence coefficient for VC funds would become insignificantly different from zero in all specifications in Panel A, and the differences between VC and BO funds would become even stronger.

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 1% 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.

Table 6
Regression results

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
Sequence					
***VC dummy (β_{VC})**	4.5508	4.5508	7.0303	7.0303	11.5811
	(1.6597)***	(1.8349)**	(2.5987)***	(2.8500)**	(4.6485)**
***BO dummy (β_{BO})**	5.5262	6.5409	9.0387	9.5164	16.0573
	(1.7235)***	(1.9054)***	(2.6986)***	(2.9596)***	(4.8272)***
TopQ					
*VC dummy	−2.4632	−2.4632	−4.4013	−4.4013	−6.8645
	(3.3958)	(3.7541)	(5.3169)	(5.8311)	(9.5107)
*BO dummy	−0.3511	−0.5071	0.5211	0.0935	−0.4136
	(2.5199)	(2.7858)	(3.9456)	(4.3271)	(7.0576)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Constant terms	Yes	Yes	Yes	Yes	Yes
p-values for H_0:					
$\beta_{BO} - \beta_{VC} = 0$	0.68	0.45	0.59	0.55	0.51
R^2	0.51	0.52	0.56	0.56	0.55
N of observations	234	234	234	234	234

Panel B: Per-professional revenue measure

Dependent variable	Carry per per professional	Variable revenue per professional	Fee per professional	Fixed revenue per professional	Total revenue per professional
Sequence					
***VC dummy (β_{VC})**	0.5289	0.5289	0.8991	0.8991	1.4279
	(0.5355)	(0.6168)	(0.9540)	(1.0399)	(1.6437)
***BO dummy (β_{BO})**	2.7007	3.1951	4.7567	5.1284	8.3234
	(0.5376)***	(0.6192)***	(0.9577)***	(1.0439)***	(1.6501)***
TopQ					
*VC dummy	−0.2648	−0.2648	−1.1591	−1.1591	−1.4239
	(1.0574)	(1.2181)	(1.8839)	(2.0536)	(3.2461)
*BO dummy	−0.2899	−0.3942	−0.0387	−0.2546	−0.6488
	(0.8174)	(0.9416)	(1.4564)	(1.5875)	(2.5093)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Constant terms	Yes	Yes	Yes	Yes	Yes
p-values for H_0:					
$\beta_{BO} - \beta_{VC} = 0$	0.01	0.003	0.01	0.01	0.003
R^2	0.59	0.58	0.59	0.60	0.60
N of observations	221	221	221	221	221

Table 6
(continued)

Panel C: Per-dollar revenue measure

Dependent variable	Carry per $	Variable revenue per $	Fee per $	Fixed revenue per $	Total revenue per $
Sequence					
***VC dummy (β_{VC1})**	0.0008	0.0008	0.0051	0.0051	0.0059
	(0.0010)	(0.0010)	(0.0038)	(0.0040)	(0.0043)
***BO dummy (β_{BO1})**	−0.0025	−0.0024	−0.0104	−0.0125	−0.0148
	(0.0010)**	(0.0010)**	(0.0041)**	(0.0043)***	(0.0046)***
TopQ					
***VC dummy (β_{VC2})**	0.0041	0.0041	−0.0088	−0.0088	−0.0047
	(0.0021)**	(0.0020)**	(0.0080)	(0.0084)	(0.0090)
***BO dummy (β_{BO2})**	−0.0003	−0.0003	0.0067	0.0064	0.0061
	(0.0015)	(0.0015)	(0.0059)	(0.0062)	(0.0067)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Constant terms	Yes	Yes	Yes	Yes	Yes
p-values for H_0:					
$\beta_{BO1} - \beta_{VC1} = 0$	0.03	0.03	0.01	0.003	0.001
p-values for H_0:					
$\beta_{BO2} - \beta_{VC2} = 0$	0.09	0.08			
R^2	0.99	0.99	0.96	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)
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)***
TopQ			
*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 fixed effects	Yes	Yes	Yes
Constant terms	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

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 (2) in the text). The revenue measures are the PVs of carried interest, total variable revenue (carry + monitoring fees), management fees, total fixed revenue (management fees + transaction fees), and total revenue (carry + 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). *Sequence* is the natural logarithm of the number of previous funds (including the current fund) by the same firm. *TopQ* 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 Equation (2) 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 estimated separately for VC and BO funds. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

In sum, BO managers with prior experience sharply increase the size of the funds while simultaneously lowering their expected revenue per dollar. The size effect dominates and results in significantly higher revenue per partner/professional in higher-sequence BO funds. In contrast, experience has no effect on either (total) revenue per dollar or fund size per partner/professional for VC funds.

4.3 Robustness checks

We conduct a number of sensitivity analyses to verify that our results are not critically dependent on the way in which we estimate the expected PV of carry. These analyses include: (i) altering the parameter values of the model along four dimensions of volatility, leverage, pairwise correlations, and exit rate;[25] (ii) adopting an equilibrium approach, where firm skill is allowed to vary with fund terms so that LPs always earn exactly their cost of capital; and (iii) imposing that firm skill varies with fund terms as in (ii), but relaxing the equilibrium restriction by allowing LPs to share some of the excess returns with GPs.

Figure 4 presents the effects of altering the parameter values of the simulation model on the estimated PV of carry, PV of total revenue, and percent share of fixed revenues over total (fixed + variable) revenue. As points of reference, PVs of management fees for the base case VC and BO funds (based on the modal sample fund characteristics) are also shown. For the VC funds (Panel A), for example, shifting the volatility of individual investments to 120% (60%) from 90% increases (decreases) PV of carry from \$8.33 to \$9.15 (\$6.78). Similarly, higher pairwise correlations or lower exit rate results in higher PV of carry, as expected.

For the BO funds (Panel B), the effects of altering parameter values of the model on transaction fees and monitoring fees are also shown. For example, increasing the leverage ratio to 4:1 from 2:1 results in much larger changes in both monitoring fees and transaction fees than carried interest. This is because both transaction fees and monitoring fees are charged as a percent of the total enterprise values on the deal-by-deal basis, whereas carry is assessed only on the equity values of the portfolio companies and aggregated at the fund level.[26]

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[25] We also performed sensitivity tests for the risk-free rate and found almost no change in the PV of carry. This insensitivity is typical for option-pricing models and is due to offsetting effects: a lower interest rate will lower the expected return on the underlying asset (lowering the value of the option) but will also discount the future payoffs at a lower rate (raising the value of the option).

[26] When the leverage ratio is 4:1, transaction fees (at \$2.81 per \$100) are more than half of the expected carried interest (\$4.80 per \$100) and close to 30% of the management fees (\$10.60). Moreover, monitoring revenues increase to \$1.37 per \$100 from the base case mean of \$0.88. The transaction fees are not sensitive to performance and are not risky, while monitoring fees are performance based but are much less risky than carried interest (see table 4). Thus, the prevailing BO fee arrangement amounts to a sharp increase in fixed or near-fixed revenues to GPs in times of high leverage. Our analytical results are consistent with anecdotal evidence that suggests that transaction and monitoring fees became significant sources of incomes for mega buyout funds during the last leveraged buyout boom of 2003–2007. *Wall Street Journal* (Eastern Edition), New York, July 25, 2006.

Panel A: Venture Capital Funds

Panel B: Buyout Funds

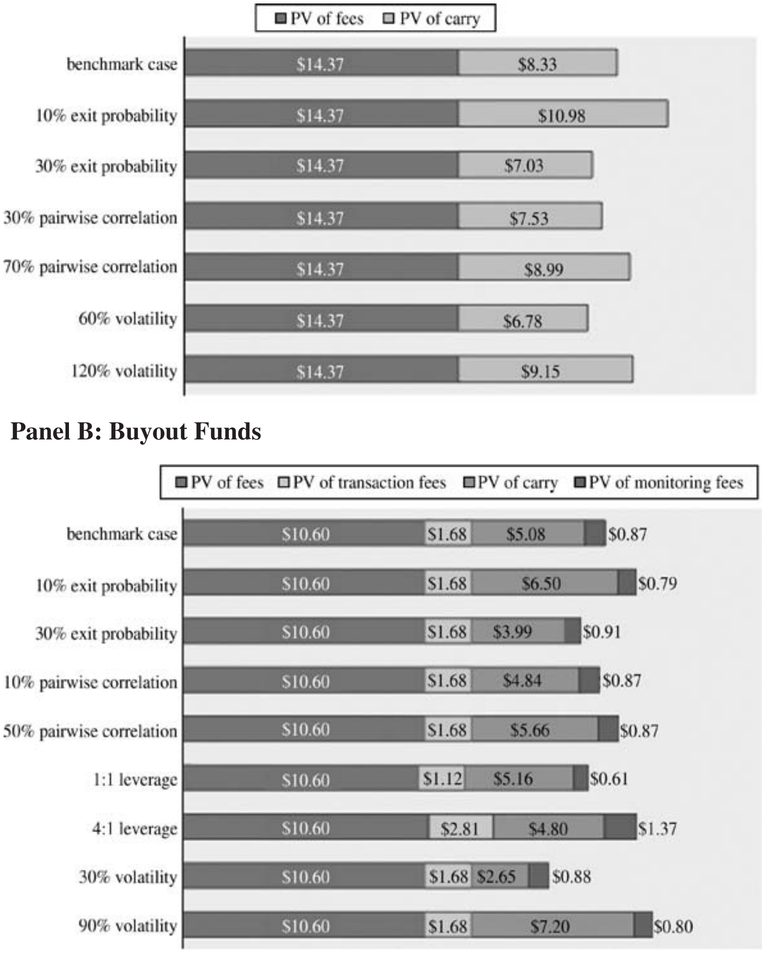

Figure 4
Sensitivity analysis
This figure presents the effects of altering the parameter values of the simulation model on the estimated PV of carry, PV of total revenue, and percent share of fixed revenues over total (fixed + variable) revenue. Panel A presents the results for VC funds; Panel B presents the results for BO funds. "pvfee_100," "pvcarry_100," "pvtrans_100," and "pvmonitor_100" are PV of management fees, carry, transaction fees, and monitoring fees for the base case VC and BO funds (based on the modal sample fund characteristics) per $100 of committed capital, respectively. "Fee/total (%)" is the percent share of pvfee_100 over total revenue (pvfee_100 + pvcarry_100) for VC funds. "fixed/total (%)" is the percent share of fixed revenue (pvfee_100 + pvtrans_100) over total revenue (pvfee_100 + pvtrans_100 + pvcarry_100 + pvmonitor_100) for BO funds. The "benchmark" refers to the base case model. "vol120" refers to an altered model that is the same as the base case model, except where the annual volatility of individual investments is set to 120%. "vol60," "vol90," and "vol30" are similarly defined. "pair70" refers to an altered model that is the same as the base case model, except that the pairwise correlation between individual investments is set to 70%. "pair30," "pair50," and "pair10" are similarly defined. "exit30" refers to an altered model that is the same as the base case model, except that the annual exit rate for individual investments is set to 30%. "exit10" is similarly defined. "lev4" refers to an altered model that is the same as the base case model, except that the leverage ratio for individual investments is set to 4:1. "lev1" is similarly defined.

In contrast, changing other parameters (volatility, pairwise correlations, and exit rate) has no impact on transaction fees (which are not sensitive to performance) and has much less impact on monitoring fees than on carried interest.

Comparing the VC and BO funds, under a wide range of parameter values, VC managers earn higher PV of carry per dollar than do BO managers. Also, the percent share of fixed revenues over the total revenue (fixed + variable) remains above 50% in all cases and is as high as 78% in some cases. Thus, our conclusion that fixed-revenue components are significant portions of managers' total revenues is quite robust to our parameter value assumptions.

Using these new estimates of PV of carry, monitoring fees, and transaction fees, we re-estimate regressions using: (i) 60% volatility for both VC and BO funds; (ii) high-volatility sample (120% for VC, 90% for BO); (iii) low-volatility sample (60% for VC, 30% for BO); (iv) high leverage (4:1); (v) low leverage (1:1); (vi) 50% pairwise correlation for both VC and BO funds; (vii) high-pairwise-correlation sample (70% for VC, 50% for BO); (viii) low-correlation sample (30% for VC, 10% for BO); (ix) high exit rate (30%); and (x) low exit rate (10%). The results are qualitatively unchanged from table 6, except for slight attenuation of the results for carry per dollar and/or variable revenue per dollar in Panel C in (2), (3), (8), and (10). In all cases, the *sequence* coefficient for BO funds in the total revenue per dollar is significantly negative and the *p*-value for the equality of the coefficient for BO and VC funds is statistically significant. The results in Panels A, B, and D are all unchanged.

In our next robustness check, we allow manager skill to vary with fund terms. So far, all of the models in the article have assumed that GPs had a total starting value of investments at $106.71 for every $100 of committed capital. This number of $106.71 was chosen so that, for the baseline VC fund, the expected payment to LPs on $100 of committed capital was exactly $100. This baseline fund makes twenty-five investments and has 20% carried interest and no hurdle rate with a committed capital basis. Now, suppose a fund charged 25% carry but otherwise had the same terms as the baseline fund. If we give this fund $106.71 of value on day 0, then the higher carry would imply that the expected payouts to LPs would be less than 100% of committed capital. This would not make sense in equilibrium. Instead, a rational LP in the 25% carry fund would have to believe that the value added of those GPs was sufficient to at least pay back the committed capital in PV terms. To do that, the total value on day 0 would need to be more than $106.71. In the Appendix, we provide intuition and notation for this equilibrium condition.

In this robustness check, we iterate the simulations so that the starting value for investments is always enough to exactly pay back LPs their committed capital, in expectation. We then re-estimate all of the empirical results of tables 5 and 6. Because most funds have terms that are very similar to the baseline case, this equilibrium approach has only a small quantitative effect on the results, and all of the qualitative results from this section are unchanged.[27]

While an equilibrium condition is a natural starting point, it could be that this requirement is too strong, since some GPs may not raise their fees and carried interest sufficiently to capture all rents from any superior skill. In particular, since many of the most famous VC funds are well known to have excess demand for their funds, it seems likely that these GPs are not charging terms that would clear the market. One possible explanation for this behavior by GPs is that they prefer to share some rents with LPs in order to maintain a stable investor base and minimize costs of raising new funds. Since this behavior is more prevalent among VC funds, ignoring the possibility may bias our comparison between VC and BO. This possibility of rent sharing suggests that we should consider a case where some funds return more than $100 to LPs (in expectation) for every $100 of committed capital.

To perform these final robustness checks, we consider two possibilities. First, we re-estimate PV of carry, monitoring fees, and transaction fees while assuming that the PV of LP value = 110% of PV of LP cost (i.e., LPs earn 10% premium over and above their cost of investment). Second, rather than assuming that all LPs earn 10% premium, we assume that only LPs of those funds that charge above 20% carry level earn 10% premium, and LPs of all other funds earn zero premium. In both cases, untabulated regression results using these estimates are qualitatively the same as those in table 6, except for slight attenuation of the results for carry per dollar and variable revenue per dollar in Panel C.

In summary, our main results are robust to altering key parameter values and to imposing and relaxing equilibrium conditions for the model.

5. Conclusion

This article 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 1993 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 VC funds and 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 PVs for revenue per partner and revenue per professional than do VC managers. BO

[27] We used the equilibrium approach as the baseline case in a previous version of the paper. Detailed results are available from the authors.

managers build on their prior experience by increasing the size of their funds faster than VC managers do. This leads to significantly higher revenue per partner and per professional in later BO funds, despite the fact that these later funds have lower revenue per dollar. Conversely, while prior experience by VC managers does lead to significantly higher revenue per partner in later funds, it does not lead to significantly 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. The key feature of the BO business is that once a BO manager is successful in handling \$100 M companies, the same skills can be applied to manage \$1 B 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 firms to sharply increase the size of their funds—and 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 small firms, with typical valuations in the tens of millions. Their goal is to hold these firms until they are mature enough to have an exit value of \$150–\$200 M or more. The VC skills that are critical in helping firms in their developmental infancy are not applicable to more mature firms that are ten times larger and already in possession of core management skills. So when successful VC firms increase the size of their fund, they cannot just scale up the size of each firm they invest in without dissipating their source of rent.

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—when it exists—can add value to extremely large companies, whereas a VC manager's skill can add value to only small companies. Our analysis shows that this difference has significant implications for organizational economics of the two segments of the private equity industry.

Appendix: An equilibrium framework for the valuation of private equity services

When private equity managers invest in a company, they add their time, effort, and reputation to the process. These services have value, which effectively becomes embodied in the portfolio firms. In the main body of the article, we assume a fixed value for these services, with that fixed value set so that the baseline VC fund would exactly dissipate this value through its management fees and carried interest. In Section 4.3, we took an alternative approach and allowed this value to vary across funds, so that every GP in every fund would be expected to exactly capture its value added. In this appendix, we provide the details of this equilibrium condition. 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 an LP, 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

$$LP\ cost_i = f * \text{committed capital} = I_i^*(\text{committed capital}/\text{investment capital}). \quad \text{(A1)}$$

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 PV terms, as of the inception date of the fund. Equation A2 gives the PV analogue for Equation A1:

$$PV(LP\ cost_i) = PV(I_i) + f^* PV(\text{lifetime fees}). \quad \text{(A2)}$$

In the remainder of this discussion, we suppress the PV notation and simply use "LP cost" to refer to both sides of Equation A2. Now, on the benefit side, the PV of the investment V_i that belongs to the fund can be divided into two components. The *GP value*$_i$ represents the PV of all variable revenue from this investment: carried interest plus transactions fees plus monitoring fees. The *LP value*$_i$ represents the PV 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 the sum of $LP\ value_i$ equals the sum of $LP\ cost_i$. Thus, the aggregate value of the underlying assets is

$$\sum_{i=1}^{N} V_i = \sum_{i=1}^{N} LP\ value_i + \sum_{i=1}^{N} GP\ value_i = \sum_{i=1}^{N} LP\ cost_i + \sum_{i=1}^{N} GP\ value_i \quad \text{(A3)}$$

where N is the number of investments in a fund. Let $GP\ value$ be the sum of the $GP\ value_i$, $i = 1, \ldots, N$. Similarly, let V be the sum of V_i. Let *GP%* represent the expected percentage of V that belongs to the GP: $GP\% = GP\ value/V$. Then, dividing both sides of Equation A3 by V and rearranging terms, we obtain

$$\begin{aligned} 1 &= LP\ cost/V + GP\ value/V = LP\ cost/V + GP\% \\ \rightarrow V &= LP\ cost/(1 - GP\%) \end{aligned} \quad \text{(A4)}$$

Equation A4 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 A1. 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 A1. Such increased value could come from many sources: one simple case would be that the investor provides below-cost management services to the company.[28] (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 A1, this discount is shown

[28] 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.

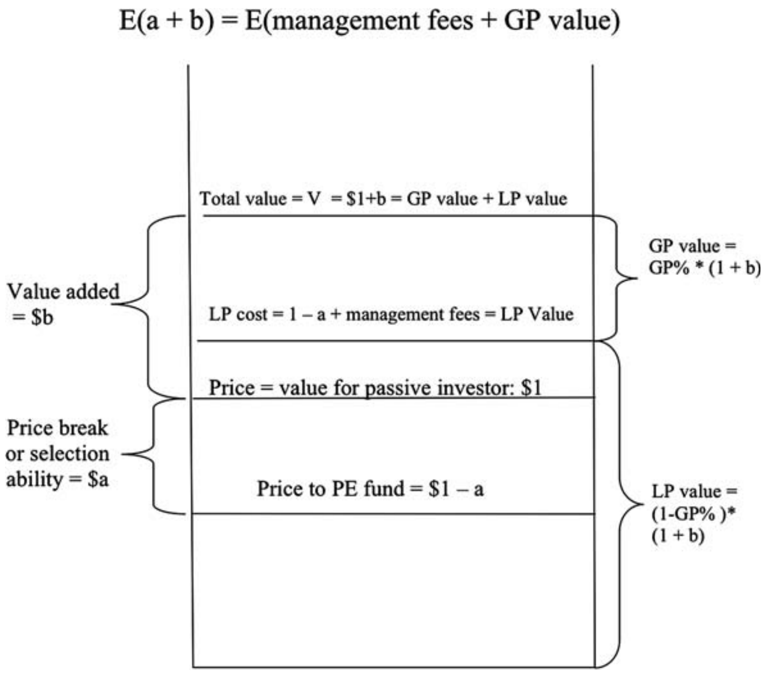

Figure A1
Equilibrium framework for private equity fund
This figure illustrates the equilibrium condition of Equation A4 in the Appendix for an investment that is worth \$1 to a passive investor. $\$b$ represents the expected PV of the value-added services that private equity fund managers (GPs) provide over the investment holding period. $\$a$ represents the expected price discount that GPs receive when they purchase the asset. The LP cost represents the investment cost plus the PV of the pro rata share of management fees to limited partners (LPs). The $GPvalue$ represents the PV of all variable revenue that GPs expect to receive from the investment. The LP value represents the leftover value of the investment that accrues to LPs, that is, $LP\ value = Total\ value(V) - GP\ value$. GP% represents the expected percentage of V that belongs to the GP.

on the left axis as $\$a$. After his discount, the fund pays $\$I_i = \$(1-a)$ for each $\$(1+b)$ value of the asset, so that $\$(a+b)$ represents the excess value to the fund.[29]

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 PV 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 A4 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 management fees completely consume any surplus. In this equilibrium, LPs receive exactly their cost of capital.

29 Hsu (2004) finds that experienced VCs actually do receive price breaks as compared with 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).

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