The Evolution of Private Equity Fund Value*

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Abstract

This paper provides the first large-sample analysis of buyout and venture capital fund values over their lifetimes. Specifically, we examine interim fund investment multiples (TVPIs), internal rates of return (IRRs), and direct-alphas based on the current reported net asset values (NAVs) at each quarter of a fund's life. Using a sample of 1,400 mature buyout and VC funds, we find that the typical fund experiences a fall-off in returns after it is about 7 to 8 years old. However, the remaining performance is highly variable for funds of all ages and the dispersion in returns also tends to increase after funds are about 8 years old. We examine the cross-sectional determinants of remaining fund value and find that several fund-specific and market-wide factors determine future performance and that these vary by type and age of fund. For example, young funds tend to be harmed by high levels of market-wide dry powder whereas older funds appear to benefit.

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1 Introduction

Valuation of seasoned closed-end drawdown funds, such as private equity buyout and venture capital (VC) funds, is difficult because the vast majority of assets have no observed market values. Still, it is important to understand the economic value of funds over their life for any number of portfolio management and compliance reasons. Investors typically rely on net asset values (NAVs) reported by fund general partners (GPs). From these interim NAVs, imperfect as they may be, it is possible to calculate performance metrics for the remaining life of a fund once the fund's future cash flows are observed. In this analysis, we conduct these calculations on a large sample of buyout and VC funds to better understand what remaining-life fund performance looks like assuming investments are made at reported NAVs. Our analysis provides an assessment of performance trends over the life of a typical fund as well as the cross-sectional variation in performance. Implicitly, this allows for understanding when during the life of a fund the NAVs are "too high" or "too low" on average, but more importantly we are able to estimate the determinants of future fund performance from the cross-section of funds.

As a practical matter, it is critical for limited partner investors (LPs) to understand the valuation pattern over a fund's life, because LPs often make decisions based on estimates of current value and future expected returns. For instance, LPs need to regularly report valuations for their various stakeholders such as trustees (in the case of endowments, foundations, funds-of-funds, etc.) and regulators (in the case of insurance companies, pension funds, etc.). LPs also regularly rely on valuations for helping determine secondary sale or purchase prices. In addition, valuations are a key reference point for asset allocation and risk management decisions.

The literature has established that NAVs do not follow a random price process that would be expected in an informationally efficient market, and specifically, exhibit too smooth of a

valuation pattern (Brown, Ghysels, & Gredil, 2020). Specifically, fund managers have historically been sluggish to update assessments of the fund valuation (Gompers and Lerner, 1997). Since November 2007, most funds have been required to adopt mark-to-market rules (e.g., FAS 157 also knows as ASC 820), which have likely made reported values better measures of true economic value over the last decade (Harris et al., 2014, Scharfman, 2012, and Nykyforovych, 2017).[1] However, there remains considerable discretion in valuation methodologies and existing research documents systemic misvaluations. For instance, Brown, Gredil, and Kaplan (2019) find underperforming managers overstate valuation during the time of follow-on fund raising, while top-performing managers understate valuation. As a consequence, fund NAVs likely incorporate a subjective assessment of true economic value.

Surprisingly, the value of funds over their lifetimes is not well-documented in the literature. We are aware of no large-sample evidence documenting the range of interim valuations relative to its final value. To fill this void, our paper undertakes the first large-sample analysis of private equity buyout fund and venture capital fund values during their lifetimes. We examine both simple performance metrics (e.g., IRRs and TVPIs) as well as market-adjusted performance (e.g., direct alphas using the method of Gredil, Griffiths, and Stucke, 2014).

We find that both absolute and relative performance of the median fund tends to decline after a fund is about 7 or 8 years old. For example, the direct alpha for buyout funds switches from positive to negative when the median fund is 7 years old. While the median VC fund always has a negative direct alpha, it becomes more negative as the fund ages. And, contrary to common wisdom, the uncertainty measured by remaining IRR and remaining direct alpha increases as funds

[1] In the context of this paper, we think of true economic value as the value of fractional fund ownership that would be observed in a liquid two-sided market for ownership stakes.

get older. In fact, we document that future fund performance is highly variable among funds at each fund age.

We also examine what factors explain the cross-sectional and age-specific variation and document a variety of interesting results. We find that, contrary to common wisdom, buyout funds with substantial un-called capital (so-called, "dry powder") towards the end of the investment period outperform their peers. Strong realized returns (as measured by capital distributions to date) predict better future performance of buyout funds. Consistent with previous literature, we also find persistence in fund performances and that larger funds tend to outperform smaller funds. At times when *market-wide* dry powder is high, subsequent performance for young funds will be lower, but performance for older funds will be higher. This is consistent with funds making investments facing higher competition but older funds benefiting from a strong market for exits.

Recent strong returns in public equities and widening credit spreads predict lower future performance for buyout funds. We also document that reported fund performance relative to NAV appears to decline after adoption of fair-value accounting (e.g., FAS 157). In general, more factors are significant for explaining future buyout fund performance than future VC fund performance.

In total, we study fund valuation from the perspective of fund performance over the fund's lifetime and the factors that affect this. This study contributes to the literature on private equity valuations, but also is relevant to participants in the private equity market, especially secondary market investors. Our findings such as higher performance volatility and diminishing alpha in older funds are informative for secondary market investors while making decisions on investing in older funds.

The paper is organized as follows: Section 2 provides a discussion of data and descriptive statistics for our sample. Section 3 examines the evolution of value over the life-cycle of funds for

three performance metrics. In Section 4, we examine the fund-specific and market-wide factors that determine the remaining performances using a regression model. Finally, Section 5 concludes.

2 Data and Descriptive Statistics

This study uses private equity fund cash flow and valuation information provided by Burgiss, a global provider of investment decision support tools for private capital market. Sourced directly from limited partners (LPs), Burgiss data represent a nearly complete sample of institutional-quality private funds and have been used extensively in recent academic work.[2] Cash flows are net of fees and carried interest paid to GPs and thus represent the actual returns achieved by LPs. We include data in our analysis for all mature funds beginning in 1987 through the end of 2017 from all geographies. We examine only mature funds in this study so that we can have a good understanding of what happens to valuations through the full performance lifecycle based on actual cash flows. We generally define a "mature" fund as having (1) a fund vintage prior to 2009 and (2) NAV less than 5% of the fund's total commitment value. We also allow for mature funds where the NAV is more than 5% of commitment value if the vintage year is before 2003. The sample is limited to funds that draw more than 50% and less than 150% of fund total committed capital. In total, we examine cash flow data through the end of 2017 for 657 buyout and 743 venture capital funds from 20 vintage years covering 1987 to 2008.

Results presented in Table I show that, as expected, almost all funds from vintages 1987 to 2002 meet our definition of mature. For example, there are 38 mature buyout and 28 mature VC funds in 2002, which account for 95% of all buyout funds and 100% of all VC funds in the Burgiss dataset with the same vintage. For most vintage years with less than 100% maturity rate, average

[2] See for example, Harris, Jenkinson, and Kaplan (2014, 2016).

mature fund sizes are quite comparable in average size to all funds of the same asset class.[3] For instance, the mature buyout (VC) funds with vintage 2004 have an average size of $793 ($186) millions, which is 101% (75%) of the average size of all buyout (VC) funds with a vintage.

Table II reports the distribution of ages when a fund meets our definition of mature. Most buyout funds reach maturity when they are 11 to 17 years old with the most common age being 12 years (89 funds). The average age for buyout funds to reach maturity is 14 years old. VC funds follow a similar pattern but are more likely to mature when they are slightly older (most common age is 17 and average age is 15 years old). We also find that smaller funds are likely to reach maturity somewhat earlier than larger funds.

3 Life-cycle Valuations

We now turn to the primary question in this paper: How do valuations vary over a fund's life? We start by discussing our methods of measuring fund valuation as a function of fund age. In theory, fund value at any given time is just the present value of all future net cash flows. Because our sample comprises (by design) only mature funds, we have a quite complete picture of future cash flows. Specifically, mature funds are either fully liquidated or close to final liquidation, thus their end values are zero or close to zero.[4] Then, by comparing fund NAV at each age with all future cash flows (plus terminal NAV, if any), we can evaluate the relative valuation of funds at any time during their life. Likewise, we can observe the cross-sectional distribution of valuations for funds of different ages. This provides some indication of cross-sectional fund risk and whether

[3] Though mature funds are relatively small for buyout funds with vintage 2008 and VC fund with vintage 2006-2008, they account for only about 3% of our final sample and even less on a value-weighted basis.
[4] However, we do need to make the assumption that any remaining terminal value at the end of the sample period is properly characterized by NAVs. As our results subsequently show, this could result in a slight bias of our valuation results.

it is increasing or decreasing in fund age. For example, these metrics can be thought of as characterizing the uncertainty facing buyers and sellers in the secondary market.

We utilize three performance measures to compare NAVs at each point in a fund's life with future cash flows. For each performance measure, we assume investors buy the fund at current NAV and contribute any future capital calls, in exchange for all future distributions. We calculate two *absolute* performance metrics for the remaining life of a fund. First, the remaining total value to paid-in capital (RTVPI) is the sum of all the future distributions divided by the sum of future contributions plus current NAV. Second, the remaining internal rate of return (RIRR) is defined as the LP's annualized IRR from buying the fund at an interim NAV and holding it to maturity. This RIRR is also calculated at each fund age. In addition, to these absolute metrics, we calculate one *relative* performance metric that compares the fund's future performance to a public market benchmark. Specifically we calculate the remaining direct-alpha (RDA) following the Gredil, Griffiths, and Stucke (2014) direct alpha method with the assumption that the current NAV is the first capital call. We prefer the RDA metric in this application to a similar Public Market Equivalent (e.g., Kaplan and Schoar, 2005) because we are explicitly examining performance as a function of (a shortening) fund life—the RDA measure is annualized as compared to a PME metric that represents performance for the full remaining life of the fund (and should mechanically converge to one). We use the S&P 500 as the public market benchmark for our RDA analysis. We calculate these three performance metrics for every quarter of a fund's life up to age 15 years. We do not examine funds older than 15 years because the sample is small, valuations are low, and the performance metrics can become very noisy.

The remaining performance measures for buyout funds and VC funds as a function of fund age are plotted in Figures 1 and 2, respectively. Panel A of Figure 1 graphs the RTVPI for buyout

funds. The red line represents the median RTVPI and shows that, as expected, valuation multiples approach 1.0 as a fund matures. The plot reveals that a large majority of total gross return for the median fund is realized before a fund is 8 years old. Specifically, the RTVPI for an 8-year-old fund is just 1.18 compared to the full-life TVPI of 1.75. However, there exists substantial cross-sectional variation in RTVPIs at all fund ages. The blue and green lines show the 10^{th} and 90^{th} percentiles of RTVPIs for buyout funds and exhibit little narrowing over the life of the fund and almost none after age 8. For example, the 90^{th} percentile of RTVPIs is 2.18 for a fund that is 7 years old and 2.11 for a fund that is 13 years old. The yellow and orange lines plot the 25^{th} to 75^{th} interquartile ranges and tend to exhibit the same patterns as the 10^{th} and 90^{th} percentiles, just with less variation.

RTVPIs may give a distorted view of percentage returns late in a fund's life since NAVs (the basis) can be much lower and the holding period will be shorter. In other words, it is possible that a fund has lower nominal dollar returns but the percentage returns are high. To see if this is the case, Panel B of Figure 1 shows RIRRs for buyout funds. Again, the median RIRR (red line) shows that returns approach zeros as funds age. In fact, median RIRRs start to taper off steadily at about the same time as for RTVPIs – around age 6-8 years. However, the 90^{th} percentile (green line) and 10^{th} percentile (blue line) values for RIRR display a huge dispersion in performance across all ages and this dispersion increases with age. (This is expected given the persistent dispersion in RTVPIs shown in Panel A.) Consequently, the chance of large percentage gains or losses from transacting in mature funds in the secondary market increases with fund age. This finding may seem counter to common wisdom regarding secondary purchases where buyers often express a feeling that funds are lower risk because they are able to observe exactly which companies are in the fund's portfolio. We note that one of the reasons the return dispersion widens

is that there are fewer assets remaining in the portfolio and thus there is less diversification and more idiosyncratic risk. Also, timing of exits for these tail assets is highly variable. The perception of lower risk may derive from the fact that visibility of existing portfolio holdings increases the ability to price these risks.

Panel C of Figure 1 plots RDAs for buyout funds. Consistent with the prior results, the RDAs switch from positive values to negative values when the median fund is 7 years old. In fact, RDAs become quite negative, less than -7% annually, by the time the median fund is 11 years old. As suggested by the results for RIRR there is tremendous dispersion in RDAs for buyout funds. For funds that are 7 years old, the range of RDAs from the 10^{th} to 90^{th} percentiles varies from -25.8% to 32.6%. The spread in RDAs increases steadily by fund age, both on the upside and downside.

Figure 2 plots values of our remaining performance metrics as a function of fund age for VCs. The general patterns for VC funds are similar, though there are important differences. Panel A plots values for RTVPIs for VC funds and shows that the median VC fund also experiences a visible moderation in performance around age 7. Yet the performance of the median fund improves for a few years after that only to dip below 1.0 when it is 12 years old. The 10^{th} and 90^{th} percentile plots show that the dispersion in VC multiples is even greater than for buyout funds though the spread narrows steadily as funds age.

The median RIRRs plotted in Panel B of Figure 2 show a very similar pattern to the RTVPIs. Investors on average earn a return close to zero from the median VC fund after it is about 7 years old. As was the case for buyout funds the cross-sectional dispersion in VC funds is substantial and generally increasing with age after a fund is about 7 years old. The remaining direct alphas for VC funds are plotted in Panel C. The median VC fund always has a negative RDA and

performance deteriorates as the median fund ages. This result is consistent with prior studies that show the median VC fund underperforms public market benchmarks.[5] The dispersion in RDA performance across funds also tends to increase with fund age.

We can tie these results to other anecdotal findings. For example, it is widely believed that older funds usually sell at a discount to NAV in the secondary market. This is consistent with the direct alpha for the median buyout fund dropping to less than zero after it is seven years old. Likewise, it is also not surprising that the direct alpha for the median VC fund is always negative across fund ages, given the right skewness of VC fund performance. Furthermore, this negative direct alpha, combined with the growing performance uncertainty as funds age, will drive deeper discounts for older funds on the secondary market.[6]

4 Determinants of Future Fund Performance

The previous analysis shows that the remaing performance among funds is highly variable in the cross-section regardless of fund age. In addition, the skewness of fund remaining performance is large in some cases, especially for venture captial funds and for older buyout funds. We can interpret these findings as showing that a large majority of profits are generated by a relatively small number of funds. For example, the fact that the remaining direct alpha is negative for the median VC fund of any age shows that fewer than half of funds generate an economic profit. That the 90th percentile of RDA is 20% (or more) indicates that there are some VC funds with exceptional performance at any age. Thus, as a practical matter, it is of great interest to know what characteristics determine future performance. In this section, we explore what fund-specific

[5] However, the average fund outperforms because of substantial positive skewness in VC performance. For example, examining the 10th and 90th percentiles relative to the median shows younger VC funds have greater positive skew for both RTVPI and RIRR. Interestingly, the positive skewness almost disappears for older VC funds.
[6] Anecdotally, given the shorter duration investors expect to hold these older assets, buyers focus less on IRR, and more on require minimum multiples, which can lead to bigger discounts.

and market-wide factors explain future performance and how the importance of these factors varies over fund life.

4.1 Hypotheses and Variable Definitions

Fund-specific characteristics reflect fund quality as well as the fund manager's preferences and skills. Prior research on performance persistence (e.g. Harris, Jenkinson, Kaplan, and Stucke, 2015) shows that managers with strong past performance are likely to deliver better performance for the current fund. To investigate how important manager track record is for current fund remaining performance, we use the manager's average ranking of funds over the past 10 years (i.e., previous TVPI, IRR and DA rank) to predict the remaining performance of the current fund.

Fund dry powder is defined as the currently committed, yet undrawn, capital scaled by fund total committed capital (i.e., fund size). Dry powder could be a measure of managerial timing ability. For example, a relatively high level of dry powder at a given fund age, could reflect the manager's judgement that there are relatively few favorable investment opportunities and thus a deliberate decision to delay the investments. Gredil (2019) shows that entry and exit timing decisions by GPs add value at the industry level relative to a constant public market investment strategy.

Fundraising activity is typically associated with things going well with a manager's current fund and consequently could be considered a quality indicator or positive expectation for the market environment in the coming years. On the other hand, positive window dressing during the fundraising period could mean worse performance for the remaing fund life (see Brown, Gredil, and Kaplan, 2019, and Jenkinson, Sousa, and Stucke, 2013). Here we use a fundraising dummy variable to determine empirically if there is a relationship between fundraising and future

performance. This variable is equal to 1 if the manager launches (makes an initial investment from) a susequent fund within one year, and 0 otherwise.

A strong realized return, or ability to generate early "points on the board," is often viewed as a potential positive indicator for remaining performance. We use the ratio of distributed capital to paid-in capital (DPI) as a measure of realized exit activity. To control for outliers, DPI is winsorized at the 99% level for buyout funds and 98% level for VC funds. Given the large positive skewness of DPI, we transform the variable by taking the square root.

Kaplan and Schoar (2005) document that PE performance increases with fund size, while Humphery-Jenner (2012) find large PE funds earn lower returns. On one hand, managers of larger funds are likely to be more established and tend to have stronger process and better channels for exiting, thus larger funds might outperformance smaller ones. On the other hand, diseconomies of scale or greater competition for big transactions could result in lower returns for larger funds. We use the logarithm of total committed capital as a measure of fund size.

Because performance may differ by geography, we also include a dummy variable that is equal to one for funds domiciled in the U.S. and zero for all other funds.

In addition to fund-specific factors we also examine how broad market conditions affect future fund performance. Both market conditions and the legal enviroment have been shown to drive private equity investment (See Aldatmaz, Brown, and Demeric-Kunt, 2020). For instance, when deal volume is high, it may impair the competitive position of young funds at the investment stage—young funds compete for a finite number of deals and thus bid up prices. In contrast, the demand by younger funds could be good for older funds as existing investments will benefit from the high valuation environment and there is more demand for secondary exits. We use market-wide dry powder, the committed, yet uncalled, capital from all funds of the same strategy (e.g.,

buyout or VC), as a percentage of total committed capital to measure the available capital in the market.

Another way to measure the valuation enviroment is the public stock market price-to-earnings (P/E) ratio. When the P/E ratio is high, it means public assets are relatively expensive. In this enviroment, private asset valuations have also been shown to be high (see Robinson and Sensoy, 2016). Assets bought during this time might therefore generate lower subsequent returns. We use the P/E ratio of the S&P 500 index to measure the public market valuation enviroment.

Public market conditions potentially also affect future private market performance in general. As documented by Kaplan and Schoar (2005) and Brown et al. (2020), funds raised in a market boom tend to perform poorly. Here we use the previous one-year percentage return on the S&P 500 index to measure the public market returns to examine the remaining fund performance for funds of different ages.

A widening credit spread could be a drag on future fund returns because of higher deal financing costs. This is especially true for buyout fund investments which usually involve substantial leverage at the portfolio company level. We use the 12-month change of Moody's BAA spread to measure this credit spread change.

Economic and market conditions differ by region. To examine how variation in regional conditions affects future fund performance, we calculate MSCI region index returns for public equity markets relative to MSCI world index return for the previous 3 years. We use one of four regions based on where the fund is domiciled: (1) Americas, (2) Asia & Pacific, (3) Western Europe, and (4) Middle East & Africa & Eastern Europe.

Regulatory and reporting changes may also affect the behavior of fund managers and thus affect the fund valuation and payout patterns. The most significant of these is the wide-spread move to mark-to-market accounting around 2007-2009 (e.g., FAS 157 in the U.S.). We include in our analysis a dummy variable (FAS 157 dummy) that is equal to one for years after 2007 (and zero otherwise) to help identify the impact of "fair value measurements" on future fund performance.

4.2 Buyout Funds

Regression results for buyout funds are presented in Table III. Panel A presents results for remaining TVPI, Panel B presents results for remaining IRR, and Panel C presents results for remaining direct-alpha. The findings indicate that many factors related to the market environment as well as fund's own characteristics are statistically significant predictors of fund remaining performance. At a high level, we observe that the importance of most factors changes over a fund's life, so what explains the future performance of a young fund differs from that of an older fund. However, in most cases the sign of the relation stays the same and it is the magnitude (and statistical significance) that changes over time. There are two potential reasons for these changes over time. First, the determinants for specific funds could change as funds age. Second, the sample is changing over time as some funds become fully resolved and so exit the analysis. This second effect is only pronounced for fund ages 10, 11, and 12. We also note that several of the market-wide factors are related to future fund *absolute* performance (RTVPI & RIRR) but not *relative* performance (RDA). This suggests that market-wide characteristics are better at predicting the market-wide component of future fund returns and is consistent with the findings of Brown et. al. (2020).

We now turn to examining the results for specific determinants of buyout fund performance in Table III. The significant positive coefficients on the previous fund ranking show that GPs with strong past performance are more likely to generate value for the remaining investments in the current fund. This effect is quite consistent across funds of various ages, as well as all three performance metrics, and only fades for older funds (>10 years) which typically have few asset remaining in their portfolios. This finding is consistent with prior evidence on performance persistence by GPs (See Kaplan and Schoar, 2005 and Harris et al., 2015).

The results in Table III also show that funds with more dry powder (in years 4 to 6) have better future performance. This is consistent with managers adding value through good investment timing and inconsistent with managers making poor-quality transactions late in the investment period just to put money to work. The effect diminishes after year 6 because most funds are fully invested by that point.

Fundraising by buyout GPs is generally associated with better remaining returns for current funds. While the size (and significance) of the effect varies considerably with age, the periodicity ties roughly to the 2-3 year fundraising cycle that typical for most GPs.

One of the strongest and most consistent results in Table III is the positive relation between capital distributed to date (DPI) and future fund performance. The positive coefficients on DPI, especially for older funds when managers are exiting investments, show that a strong realized return predicts a better remaining performance of the same fund. This result is consistent with skilled managers adding value not just to exited investments, but also to existing and future investments. This find may also associate with a strong alignment of interests. Prior research documents clusters of good or bad decisions from fund managers or group of managers (Braun et al, 2019). For the absolute performance measures (RTVPI and RIRR) the result is strongest for

older funds. For relative remaining performance (RDA) the result is very strong for funds of all ages.

We also find that larger funds tend to outperform smaller funds, but the effect is most pronounced for older funds (and only significant for relative performance for fund 8 years and older). One possible explanation for this finding is that larger funds have more resources to manage an older fund with fewer assets and that this allows for better value creation during the harvesting and wind-down phase. In addition, tail assets held by large funds are more likely to be good quality, mature and resilient asset compare to smaller funds and there are often differences in valuation standards between large and small funds. Anecdotally, it is widely believed that there are fewer surprises on the downside for large funds than for small funds.

Overall, many of the fund-specific characteristics are important determinants of both absolute and relative future performance. We now turn to examining the relevance of market-wide factors for buyout funds. Table III shows that a high level of market-wide dry powder tends to hurt the future performance for funds in years 4 or 5. This is consistent with more available capital driving up current asset valuations and effectively increasing the cost of new investments for these younger funds. Interestingly, market-wide dry powder is a positive force for the older funds, especially for future relative performance (RDA), as existing investments benefit from the high valuation environment upon exit.

The S&P 500 P/E ratio is not generally a significant determinant of future performance after accounting for other factors. This is an interesting result because of the widespread belief that doing buyout transactions when public market valuation is high will hurt returns, yet we find only weak evidence of this for either absolute or relative future performance. While the pairwise correlation between market-wide valuations and performance does exist, our results indicate that

other market-wide (and fund-level) characteristics explain it. That noted, there does exist a negative relation between recent broad public market returns and future *absolute* fund performance, as well as a positive relation between regional market returns and future *absolute* fund performance. Neither of these results hold for future *relative* fund performance (e.g., RDA in Panel C).

A widening credit spread is negatively related to RTVPI and RIRR for buyouts but the effect is not statistically reliable for relative performance. This again suggest that many market-wide factors affecting buyout performance (in this case financing costs) are subsumed by market-wide future returns.

The negative coefficients on the FAS 157 dummy variable indicate that buyout fund remaining performance has been lower after the adoption of mark-to-market value in 2008. This may be related to other market-wide factors we do not measure or because the change to fair value accounting required a wide-spread revaluation of assets. For example, the result is consistent with buyout fund valuation being generally lower and more conservative before fair value accounting (e.g., Cumming and Walz, 2009, and Nykyforovych, 2017). However, the analysis is confounded by the contemporaneous decline in performance from the Global Financial Crisis, so it is difficult to draw any firm conclusions.

4.3 Venture Capital Funds

We next explore the determinants of VC fund remaining performance. While the business model for VC funds is quite different from that of the typical buyout fund, prior research has shown both types of funds share many common performance features such as performance persistence, fundraising cyclicality, etc. For simplicity, and to make the results comparable, Table IV reports regression results for VC funds analogous to those reported in Table III for buyout funds. All explanatory variables are defined in the same way as in Table III.

Overall, we find that fewer of the fund-specific factors (reported in Table IV) are reliable determinants of future VC fund performance. The most consistent finding is that larger VC funds perform better. This result is consistent across all fund ages and all three performance measures though size is an especially good predictor when funds are younger. One explanation consistent with this finding is that better quality GPs raise more capital (yet we see little effect of previous fund rank on returns). In contrast to buyout funds, fund-level dry powder has a significantly negative effect on future absolute performance. This suggests that when VC funds have put less money to work late in the investment period they are more likely to have either had a hard time identifying good investments or are likely to make lower-returning subsequent investments. Because this result is not significant for relative performance (Panel C) it is likely related to overall market conditions. Other factors are not reliably significant though there is some weak evidence that young VC's raising a next fund perform better on both an absolute and relative basis.

Table IV also reports results for the effects of market-wide factors on future VC fund performance. We observe a very strong negative relation between market-wide dry powder and future performance for funds that are 4 to 8 years old. This result is likely due to the difficulty of finding good investments at reasonable valuations as more capital competes for deals and is similar to the finding for young buyout funds. We also note that, similar to buyout funds, the coefficients for relative performance (RDA in Panel C) also generally turn positive for older funds, although the results are not statistically significant. This finding is consistent with high market-wide dry powder increasing exit opportunities on a market-adjusted basis. Results in Table IV also indicate that performance for young VC funds is positively impacted by strong returns of regional public stock markets. The effect is observed for all three performance measures but only significant for funds that are 4 and 5 years old. Relative performance of older VC funds is positively impacted

by strong returns of public stock market. This may imply positive impact of market condition on venture exit strategy, for example the IPO market. We find the same negative relation between VC fund performance and the FAS 157 dummy variable as for buyout funds suggesting NAVs were on average marked up after adoption.

5 Conclusions

This paper provides a first look at the private equity performance over the life-cycle of funds. With our sample of 1,400 mature buyout and VC funds spanning three decades, we find that performance (relative to reported NAVs) of both the typical buyout and VC fund tends to decline after a fund if 7 or 8 years old. For example, remaining direct-alpha for the median buyout fund switches from positive to negative when the fund is 7 years old. However, the decline in subsequent performance is evident for both (median) buyout and VC funds across all three performance measures. This result implies that older funds should tend to transact at larger discounts in the secondary market. We also document substantial cross-sectional variation in fund performance across all fund ages, both on an absolute and relative basis.

We also examine determinants of future fund returns and find that several fund-specific and market-wide factors are important for both absolute and market-adjusted performance. Different factors are important for buyout and VC funds and the importance of specific factors changes over a typical fund's lifetime. Our results suggest that i) delegating timing of investments to GPs improves performance on average, ii) high market-wide dry powder generally hurts young funds but is beneficial for older funds exiting investments, and iii) there is more ability to predict future buyout fund performance than VC fund performance.

Future research could extend our analyses to other fund asset classes, such as real estate fund, private credit, and infrastructure funds. Also, all of our performance analysis is based on the

assumption of current fund value being represented by NAVs, but of course these do not represent true prices at which transactions occur. With the growth of the secondary market in recent years, it would be interesting to repeat our analysis with fund values obtained from actual transaction prices to determine how many of the effects we document are reflected in market pricing.

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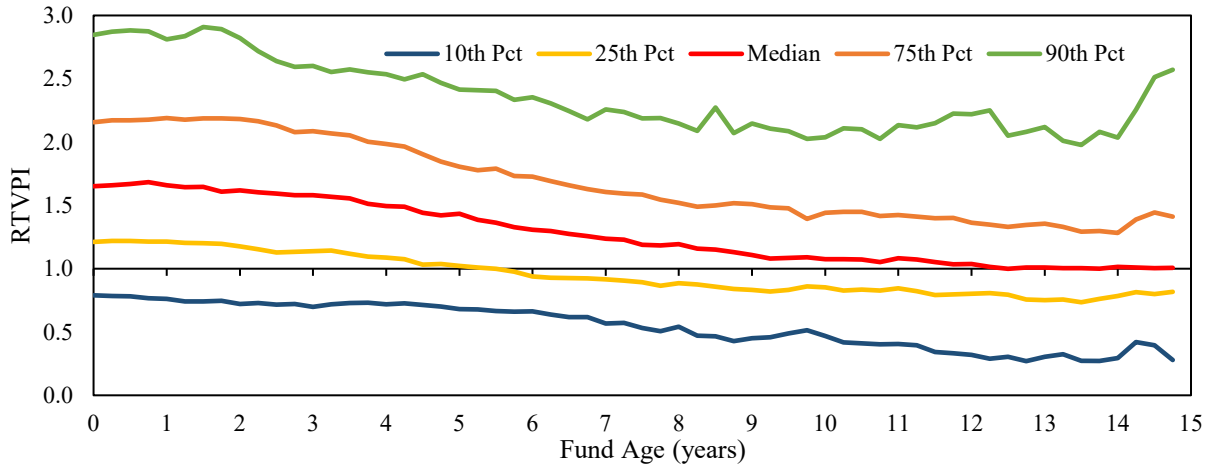
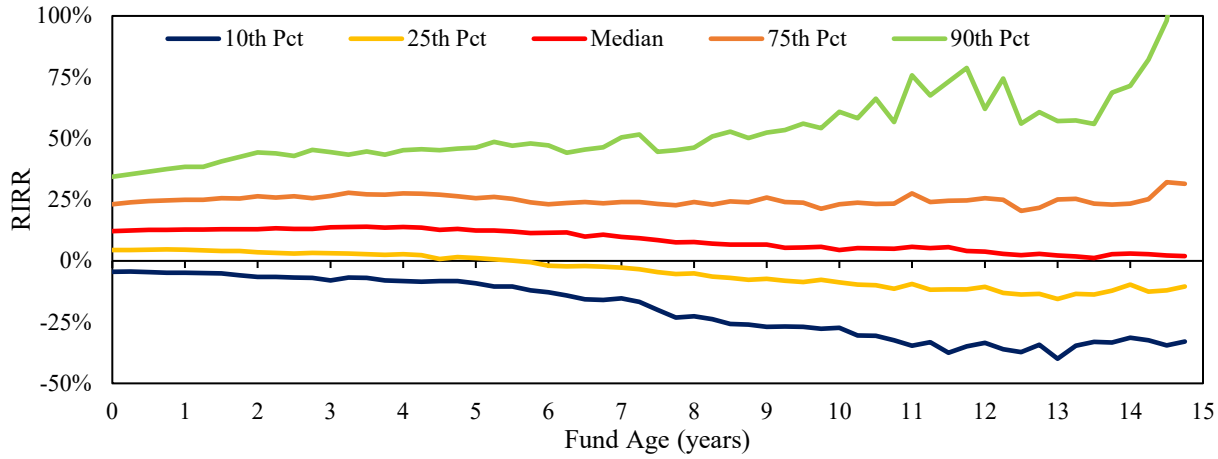
Figure 1: Graphs of Buyout Fund Remaining Performance

This figure plots buyout fund remaining performance over a fund life (in years). These figures are for the sample of mature funds. Remaining performance is measured in three ways: the remaining TVPI (RTVPI) in Panel A, the remaining IRR (RIRR) in Panel B, and the remaining direct alpha in Panel C. The green line plots the breakpoint for the top 10th percentile. The red line reports the median. The blue line reports the breakpoint for the bottom 10th percentile.

Panel A: Remaining TVPI (RTVPI) Performance



Panel B: Remaining IRR (RIRR) Performance



Panel C: Remaining Direct-Alpha (RDA) Performance

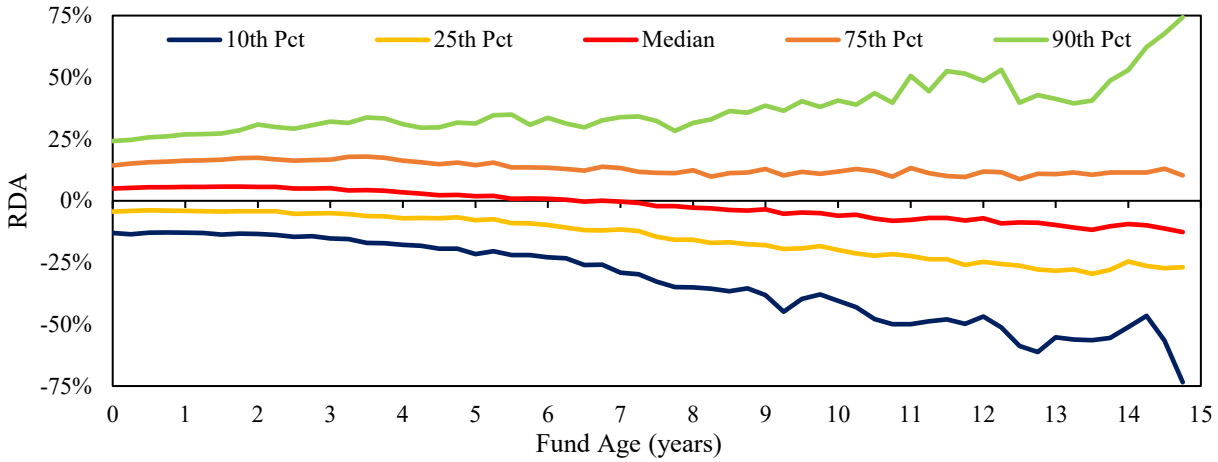
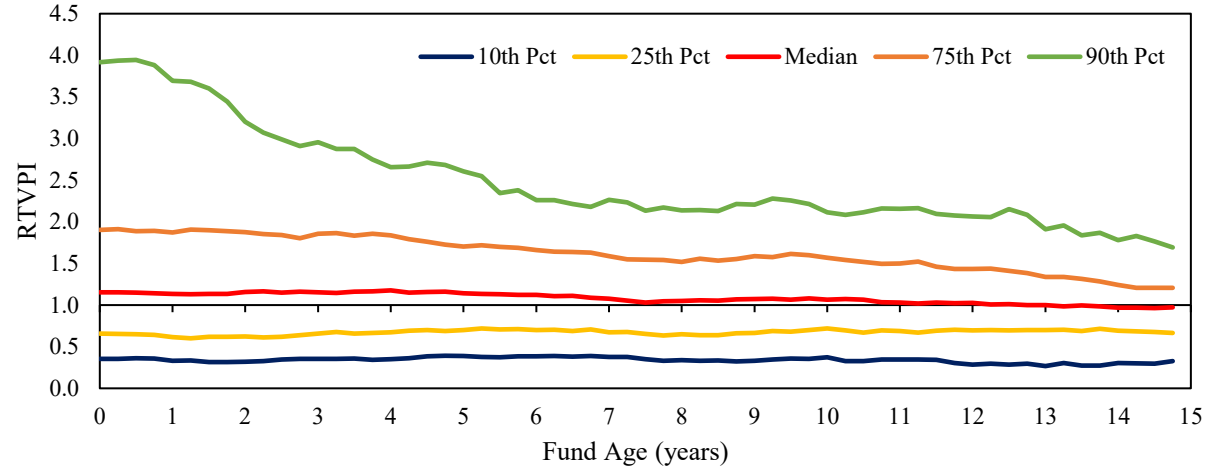


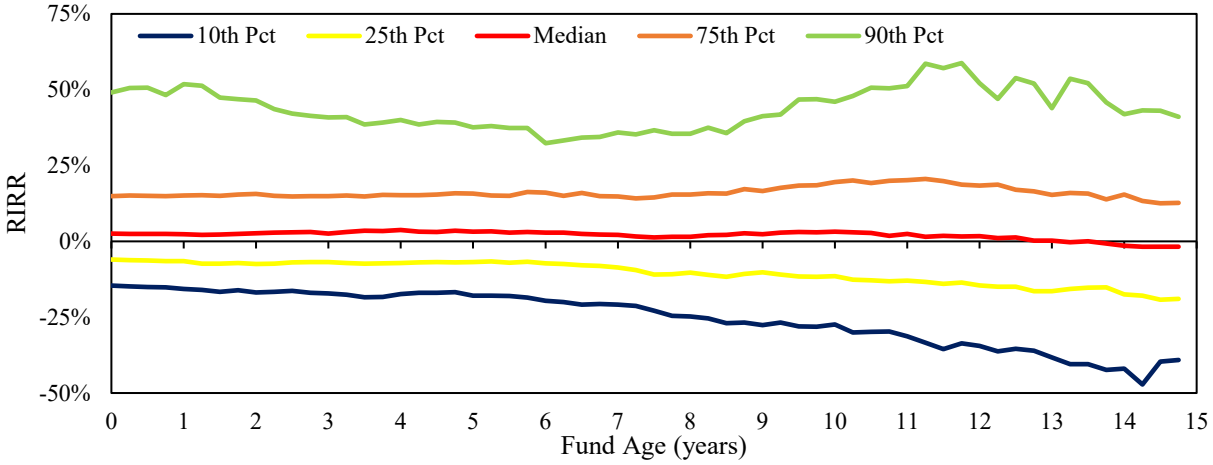
Figure 2: Graphs of Venture Capital Fund Remaining Performance

This figure plots VC fund remaining performance over a fund life (in fund quarters). These figures are for the sample of mature funds. Remaining performance is measured in three ways: the remaining IRR in Panel A, the remaining TVPI in Panel B, and the remaining direct alpha in Panel C. The green line reports the remaining performance of the top 10 percentile. The red line reports the median. The blue line reports the bottom 10 percentile.

Panel A: Remaining TVPI (RTVPI) Performance



Panel B: Remaining IRR (RIRR) Performance



Panel C: Remaining Direct-Alpha (RDA) Performance

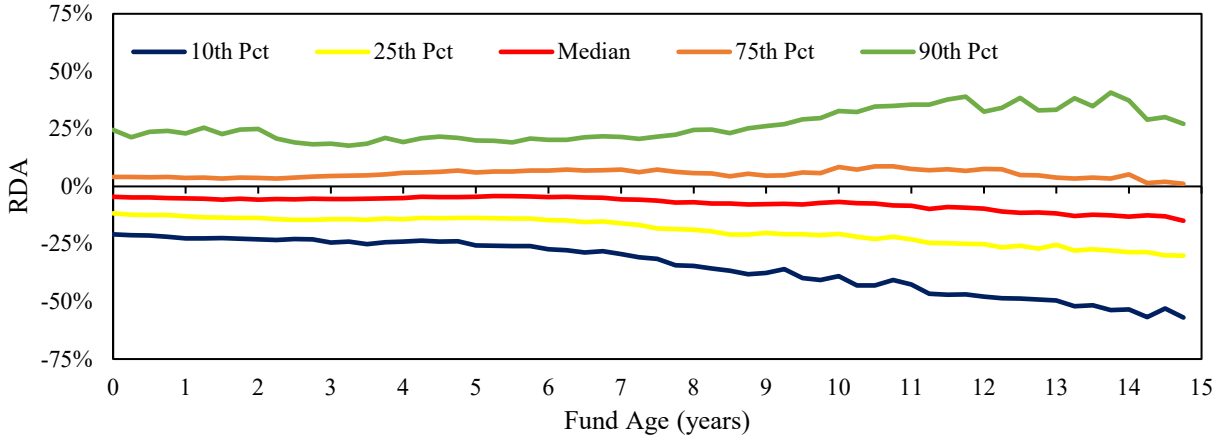


Table I: Number of Funds and Average Fund Size by Vintage

This table reports the number of mature funds and average fund size (fund commitments) is in millions of USD by vintage for buyout and VC funds separately. "Matured % of all funds" is the number of mature funds as a percentage of all funds (both mature and non-mature). "Relative avg. mature fund size" is the average size of matured funds as a percentage of average size from all funds.

	Buyout				Venture Capital			
Vintage	# of mature funds	Mature % of all funds	Avg. mature fund size	Relative avg. mature fund size	# of mature funds	Mature % of all funds	Avg. mature fund size	Relative avg. mature fund size
1987	12	100%	719	100%	30	97%	61	102%
1988	10	100%	617	100%	30	100%	68	100%
1989	12	100%	296	100%	32	100%	110	100%
1990	9	100%	310	100%	16	100%	66	100%
1991	8	100%	257	100%	8	100%	89	100%
1992	11	100%	406	100%	18	100%	83	100%
1993	9	100%	526	100%	24	100%	87	100%
1994	27	100%	377	100%	22	100%	89	100%
1995	31	97%	581	103%	31	100%	127	100%
1996	25	100%	305	100%	22	100%	131	100%
1997	43	100%	772	100%	54	100%	131	100%
1998	63	100%	806	100%	57	100%	183	100%
1999	49	100%	874	100%	110	100%	288	100%
2000	74	99%	960	101%	142	100%	316	100%
2001	46	98%	886	97%	74	97%	307	98%
2002	38	95%	794	98%	28	100%	252	100%
2003	24	65%	469	56%	10	38%	178	83%
2004	48	69%	793	101%	8	18%	186	75%
2005	42	40%	1359	119%	10	12%	193	71%
2006	39	30%	1050	62%	6	6%	144	48%
2007	19	13%	1335	86%	4	4%	158	51%
2008	18	14%	549	36%	7	7%	72	25%
Total/Avg	657	61%	684	88%	743	64%	151	82%

Table II: Number of Funds, Average Fund Size, and Average Vintage Year by Fund Age

This table reports the number of funds, average fund size (in USD millions), and average vintage year for buyout and VC funds that mature at different fund ages. Funds that mature at less than 9 years and 20 years and older are grouped together.

	Buyout			Venture Capital		
Fund age	N	fund size	vintage	N	fund size	vintage
<9	14	425	2003	9	185	1999
9	26	481	2003	11	74	2002
10	32	685	2004	23	84	1999
11	59	785	2002	29	114	1998
12	89	942	2001	55	124	1996
13	80	637	2000	64	118	1997
14	67	718	2000	70	162	1997
15	66	749	1998	89	183	1997
16	72	965	1998	95	242	1998
17	63	811	1998	134	315	1999
18	34	827	1998	93	283	1997
19	27	1,005	1997	31	188	1996
>19	28	883	1993	40	137	1993

Table III: Determinants of Remaining Performance – Buyout Funds

This table reports regressions of buyout fund remaining performance on fund-specific and macro factors. Panel A focuses on remaining TVPI ranking, Panel B focuses on remaining IRR ranking, and Panel C focuses on remaining direct alpha ranking. In each panel, remaining performance ranking is measured in deciles within fund age across funds of all vintages and results for funds age 4 to 12 are reported sequentially. DPI is the square root of DPI defined as fund distributions to date divided by total paid in capital at each fund age. Fund dry powder is the currently-committed yet undrawn capital for a fund, scaled by the fund total committed capital. Previous TVPI/IRR/DA rank is the average TVPI/IRR/DA decile ranking of previous fund by the same manager within the same asset class and vintage in the past 10 years. Fundraising dummy equals one if the fund is going to invest from the following fund within 1 year. Fund size: is the log of total committed capital. U.S. dummy equals 1 for a U.S. domiciled fund and zero otherwise. Public market return is the S&P 500 return in the previous year. BAA spread is the change in the BAA credit spread from the previous year. Rel. regional return is the past three year MSCI regional equity market return (Americas, Asia & Pacific, Western Europe, Middle East & Africa & Eastern Europe) *relative* to the MSCI world index. Market dry powder is the dry powder of the whole asset class as a percentage of total committed capital of the asset class. S&P 500 P/E ratio is the price-to- earnings ratio of S&P 500 stocks. FAS 157 dummy is 1 for all years after 2007 and zero otherwise. All regressions use mature funds with vintages starting in 1987. The data are through 2017. *, **, *** designate coefficient values that are statistically different from zero at the 10%, 5%, and 1% level, respectively, in a two-tailed test.

Panel A: Remaining TVPI (RTVPI)

Fund Age:	4	5	6	7	8	9	10	11	12
DPI	0.526	0.682**	0.539	1.022***	0.821**	0.896**	1.466***	1.283***	1.517***
Fund dry powder	2.765***	2.328***	1.781*	0.992	-0.452	-0.656	0.226	0.471	-0.574
Previous TVPI rank	0.135**	0.150**	0.155**	0.221***	0.0962	0.162**	0.136**	0.0140	0.041
U.S. dummy	-0.239	-0.223	-0.00935	0.113	0.349	0.575**	0.519**	0.316	-0.202
Fund size	0.207**	0.190**	0.139	0.0368	0.274***	0.263***	0.275***	0.298***	0.326***
Fundraising dummy	0.579**	0.752**	0.375	1.631***	0.633	3.978***	1.665***	0.000	3.596***
Market dry powder	-5.368*	-6.289**	-3.291	-4.264	-0.101	-0.328	2.906	3.617	8.484***
Public market return	-0.958	-2.173***	-1.668**	-1.572**	-1.490*	-1.803**	-1.431	-2.187**	-0.663
S&P 500 P/E ratio	-0.070*	-0.0287	-0.059	-0.009	0.009	0.0433	-0.046	-0.062	-0.152***
Rel. regional return	1.618**	2.349***	3.005***	2.405***	3.094***	2.736***	0.852	1.337	2.694**
BAA spread	-0.246	-0.393***	-0.240	-0.284	-0.285*	-0.190	-0.416**	-0.567***	-0.129
FAS 157 dummy	-1.644***	-1.589***	-1.279***	-1.126***	-0.652*	-0.766*	-0.647	0.115	0.432
Intercept	2.459	2.302	2.955	3.515	-2.240	-3.040	-3.133	-3.007	-3.657
Observations	655	655	653	649	646	638	607	575	503
Adjusted R^2	0.114	0.112	0.067	0.073	0.078	0.093	0.093	0.074	0.094

Table III: Determinants of Remaining Fund Performance (continued)

Panel B: Remaining IRR(RIRR)

Fund Age	4	5	6	7	8	9	10	11	12
DPI	0.515	0.674**	0.531	1.018***	0.800**	0.878**	1.479***	1.307***	1.569***
Fund dry powder	2.765***	2.309***	1.710*	0.879	-0.514	-0.766	0.144	0.471	-0.561
Previous IRR rank	0.158**	0.181***	0.172**	0.211***	0.124*	0.180**	0.120*	-0.016	-0.027
U.S. dummy	-0.237	-0.210	-0.002	0.127	0.357	0.590**	0.532**	0.318	-0.204
Fund size	0.195**	0.174*	0.123	0.023	0.262***	0.244**	0.266***	0.303***	0.339***
Fundraising dummy	0.581**	0.773**	0.383	1.608***	0.675	4.127***	1.690***	0.000	3.388***
Market dry powder	-5.295*	-6.253**	-3.235	-4.153	0.122	-0.168	3.015	3.623	8.613***
Public market return	-0.958	-2.118***	-1.648**	-1.651**	-1.498*	-1.788**	-1.444	-2.207**	-0.625
S&P 500 P/E ratio	-0.071*	-0.029	-0.060	-0.013	0.008	0.043	-0.048	-0.062	-0.153***
Rel. regional return	1.639**	2.305***	2.986***	2.419***	3.082***	2.754***	0.844	1.287	2.579**
BAA spread	-0.242	-0.394***	-0.226	-0.276	-0.294*	-0.193	-0.421**	-0.567***	-0.133
FAS 157 dummy	-1.649***	-1.603***	-1.289***	-1.137***	-0.632	-0.742*	-0.630	0.116	0.455
Intercept	2.581	2.435	3.194	3.884*	-2.184	-2.816	-2.893	-2.979	-3.669
Observations	655	655	653	649	646	638	607	575	503
Adjusted R^2	0.116	0.115	0.068	0.072	0.080	0.095	0.092	0.074	0.094

Panel C: Remaining Direct Alpha (RDA)

Fund Age	4	5	6	7	8	9	10	11	12
DPI	1.425***	1.429***	1.210***	1.475***	1.320***	1.060***	1.408***	1.220***	1.336***
Fund dry powder	2.440***	2.509***	1.756*	1.855**	0.674	0.469	0.757	0.571	-1.587
Previous DA rank	0.117*	0.161**	0.142**	0.151**	0.112*	0.107	0.137**	0.072	0.075
U.S. dummy	-0.241	-0.318	-0.096	-0.053	0.319	0.583**	0.514**	0.267	-0.136
Fund size	0.129	0.090	0.126	0.146	0.314***	0.246**	0.307***	0.307***	0.151
Fundraising dummy	0.663**	0.582*	0.343	1.346**	0.799	2.545***	2.527	0.000	3.022***
Market dry powder	-2.055	-3.267	-2.756	-1.263	2.340	0.217	4.761**	6.345**	10.03***
Public market return	0.275	0.344	0.219	0.145	0.340	-0.549	1.556	0.764	0.120
S&P 500 P/E ratio	-0.022	0.027	0.010	0.069	0.070	0.084*	-0.039	-0.057	-0.121***
Rel. regional return	-1.176*	0.321	0.463	-0.506	0.708	0.567	-1.109	1.313	2.587**
BAA spread	-0.130	0.053	0.061	-0.006	-0.011	-0.057	-0.081	-0.094	0.066
FAS 157 dummy	-2.141***	-1.793***	-1.843***	-1.452***	-0.872**	-0.907**	-0.638	-0.079	-0.042
Intercept	1.944	1.920	1.592	-0.754	-5.307**	-3.408	-4.502**	-4.197*	-0.785
Observations	649	651	646	646	642	632	596	563	488
Adjusted R^2	0.159	0.131	0.113	0.127	0.117	0.085	0.108	0.070	0.093

Table IV: Determinants of Remaining Performance – Venture Capital Funds

This table reports regressions of venture capital fund remaining performance on fund-specific and market-wide factors. Panel A reports results for remaining TVPI ranking, Panel B reports results for remaining IRR ranking, and Panel C reports results for remaining direct alpha (DA) ranking. In each panel, remaining performance ranking is measured in deciles within fund age across funds of all vintages. Results are reported for funds age 4 to 12. The sample characteristics and definitions for all variables are the same as in Table III. *, **, *** designate coefficient values that are statistically different from zero at the 10%, 5%, and 1% level, respectively, in a two-tailed test.

Panel A: Remaining TVPI (RTVPI)

Fund Age	4	5	6	7	8	9	10	11	12
DPI	-0.108	0.334	0.431**	0.275	0.173	0.207	0.159	0.180	0.395*
Fund dry powder	-1.584**	-1.629*	-1.229	-0.289	0.308	1.635	2.064	-0.722	1.488
Previous DA rank	0.005	0.039	0.054	0.108*	0.072	0.069	0.069	0.053	0.018
U.S. dummy	0.009	0.288	0.038	0.123	0.281	0.362	0.204	0.141	0.135
Fund size	0.483***	0.446***	0.482***	0.341***	0.341***	0.325***	0.283**	0.319***	0.260**
Fundraising dummy	0.544*	0.496	-0.369	0.583	-0.588	0.000	0.000	-3.705***	3.127***
Market dry powder	-16.22***	-18.26***	-20.74***	-18.76***	-9.08**	6.153	-7.013*	-4.74	-5.557
Public market return	-0.812	0.433	-0.661	-2.134**	-3.120***	2.013**	-2.043**	0.108	-0.217
S&P 500 P/E ratio	0.002	0.019	0.041	0.089**	-0.05	-0.048	0.001	-0.010	0.003
Rel. regional return	3.436***	1.454**	0.583	0.26	1.475*	0.961	1.11	0.771	-0.308
BAA spread	0.015	-0.315**	-0.108	0.368**	-0.548***	-0.003	-0.202	-0.168	-0.063
FAS 157 dummy	-2.348***	-2.184***	-2.490***	-1.846***	-1.474***	0.251	-0.781*	-0.981**	-0.736
Intercept	0.472	0.499	0.409	1.485	1.486	-3.49	0.889	-0.121	0.861
Observations	739	739	737	735	733	730	711	685	647
Adjusted R^2	0.205	0.178	0.16	0.102	0.062	0.039	0.031	0.03	0.026

Panel B: Remaining IRR (RIRR)

Fund Age	4	5	6	7	8	9	10	11	12
DPI	-0.094	0.326	0.441**	0.294*	0.204	0.223	0.192	0.216	0.436**
Fund dry powder	-1.596**	-1.630*	-1.251	-0.308	0.355	1.658	2.141	-0.64	1.590
Previous DA rank	-0.009	0.045	0.038	0.085	0.031	0.045	0.023	0.010	-0.033
U.S. dummy	0.0124	0.286	0.0373	0.121	0.280	0.365	0.206	0.140	0.140
Fund size	0.486***	0.443***	0.485***	0.343***	0.349***	0.327***	0.294**	0.328***	0.272**
Fundraising dummy	0.549*	0.494	-0.367	0.553	-0.582	0.000	0.000	-3.690***	3.169***
Market dry powder	-16.23***	-18.26***	-20.77***	-18.82***	-9.158**	6.16	-6.999*	-4.597	-5.411
Public market return	-0.813	0.424	-0.659	-2.133**	-3.104***	2.014**	-2.076**	0.128	-0.216
S&P 500 P/E ratio	0.001	0.019	0.041	0.089**	-0.050	-0.047	0.002	-0.010	0.002
Rel. regional return	3.443***	1.452**	0.569	0.239	1.426*	0.947	1.081	0.756	-0.309
BAA spread	0.012	-0.318**	-0.110	0.370**	-0.547***	-0.003	-0.204	-0.172	-0.058
FAS 157 dummy	-2.348***	-2.184***	-2.494***	-1.848***	-1.479***	0.257	-0.783*	-0.957**	-0.708
Intercept	0.484	0.545	0.441	1.574	1.535	-3.431	0.891	-0.154	0.806
Observations	739	739	737	735	733	730	711	685	647
Adjusted R^2	0.205	0.178	0.159	0.100	0.061	0.038	0.029	0.029	0.027

Table IV: Determinants of Remaining Performance – Venture Capital Funds (Continued)

Panel C: Remaining Direct-Alpha (RDA)

Fund Age	4	5	6	7	8	9	10	11	12
DPI	-0.113	0.369	0.294	0.222	0.118	0.269	0.250	0.433**	0.564***
Fund dry powder	-0.639	-1.173	-1.043	-0.132	-0.350	1.294	0.923	0.125	1.648
Previous DA rank	-0.014	0.009	0.043	0.121**	0.061	0.101	0.022	-0.050	-0.028
U.S. dummy	0.063	0.314	0.202	0.001	0.568*	0.523*	0.306	-0.087	-0.206
Fund size	0.553***	0.575***	0.602***	0.476***	0.385***	0.363***	0.362***	0.404***	0.319***
Fundraising dummy	0.662**	0.281	0.133	0.675	-0.760	0.000	0.000	-3.625***	2.996***
Market dry powder	-8.214***	-9.118***	-13.39***	-6.125*	2.662	11.38***	-2.284	4.097	5.894
Public market return	0.890	1.997**	0.406	1.351	0.327	4.172***	0.846	2.663***	2.183**
S&P 500 P/E ratio	0.042	0.011	0.0826**	0.0774*	-0.064	0.018	0.053	0.017	0.050
Rel. regional return	2.038***	1.302*	-0.739	-0.529	0.247	-0.244	0.177	0.298	-1.730
BAA spread	0.056	-0.166	0.091	0.592***	-0.045	0.376**	0.312*	0.307*	0.214
FAS 157 dummy	-2.403***	-2.485***	-2.525***	-1.605***	-1.426***	0.251	-0.749*	-0.752*	0.134
Intercept	-4.241**	-4.408**	-4.732**	-4.692**	-2.678	-7.192***	-2.795	-4.175	-4.157
Observations	735	736	733	733	731	726	710	682	643
Adjusted R^2	0.131	0.135	0.122	0.11	0.092	0.098	0.054	0.086	0.071