Performance Persistence in Private Equity Funds

Ji-Woong Chung[1]
The Chinese University of Hong Kong

This version: October 27, 2010

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[1] Contact information: Department of Finance, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. E-mail: jwchung@baf.cuhk.edu.hk.

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Abstract

Performance persistence in the private equity industry is short lived. Current fund performance is positively and significantly associated with the performance of the first follow-on fund, but not with that of the second or third follow-on funds. Moreover, even this statistically significant association between two consecutive funds' performance is not economically large. The returns of the best performing quartile portfolio drops by about half, and those of the worst performing portfolio improve substantially from one fund to the next, making the difference in performance between the top and bottom portfolios insignificant. Therefore, it appears that the performance of private equity funds converges in the long run. The commonality of relevant market conditions between two consecutive funds largely explains performance persistence, so this finding does not support the view that general partners have proprietary skills. However, I also find that private equity capital chases past performance and that excessive fund growth, conditional on past performance, erodes performance and reduces persistence, which could occur even when fund managers have differential skills. Although this study is not conclusive about whether general partners have unique skills, these findings have important implications for investors in the private equity industry in their investment decision making.

1. Introduction

Does the past performance of private equity funds contain information about future performance? If so, how much information is contained? How strong and persistent is the relationship between current and future fund performance? What economic factors explain this relationship? What implications does this relationship have for investors in private equity? This paper provides empirical answers to these questions.

While many studies have examined whether performance persists in the mutual fund and hedge fund industries, which are important asset classes of institutional investors, few studies have investigated the issue in the context of private equity funds. Recently, Kaplan and Schoar (2005) document the persistence of private equity fund performance. They ascribe this persistence to the differential and proprietary skills of funds' general partners ("GPs"), leaving the puzzling question of why GPs do not appropriate more rents from investors by, for example, charging higher fees. Several subsequent studies, such as Glode and Green (2008) and Hotchberg, Ljungqvist, and Vissing-Jorgensen (2009),[2] have attempted to rationalize this phenomenon.

Obviously, whether, how, and the degree to which performance persists are important questions for investors in private equity funds. The answer to these questions will affect limited partners' ("LPs") investment strategies, their relationship with GPs, and the terms of the contract between the two parties. Given the importance of the subject from both practical and academic perspectives, a more thorough study is needed to shed light on the aforementioned unanswered questions; the form, the strength, and the economic magnitude of performance persistence in the private equity industry is still unknown.

This paper examines performance correlation between a current fund and its immediate follow-on fund, as well as the subsequent second and third follow-on funds. I employ methodologies typically found in the mutual fund literature: contingency table tests, Pearson and Spearman correlations, and cross sectional regressions of future fund performance on current performance. To quantify the economic

[2] Both studies assume that incumbent LPs have information (over outside potential LPs) which can be used to lever their bargaining power against GPs.

magnitude of performance persistence, I also measure and compare the future performance of quartile portfolios ranked on past performance.

I find that, consistent with some previous studies,[3] current fund performance is significantly and positively related to the performance of the next fund. However, current fund performance is not correlated with the second and third follow-on funds. Currently best and worst performing funds perform similarly in their second and third follow-on funds. Therefore, performance persistence is short lived, and, interestingly, performance converges across funds over time.

What are the implications of this finding for investors in the private equity industry? First, the transient performance persistence raises doubt as to whether GPs have differential skills. Second, LPs should be careful in using information contained in the second or prior funds because this information has very likely become stale. Typically, a private equity firm raises a follow-on fund three to five years after a preceding fundraising. In other words, at the time of a fundraising, investors cannot fully evaluate the performance of the most recently raised fund, although the interim performance may have valuable information about the final outcome at the end of a fund's life.[4] Therefore, investors are likely to base their investment decision on the performance information contained in the several preceding funds. However, my finding suggests that the second or prior funds' performance can be a misleading indicator of future performance.[5]

Next, I investigate why performance persists transiently. Two potential explanations are studied. First, I examine the effect of the common market environment on persistence. Since a private equity fund's life is about ten years, and a follow-on fund is usually raised three to five years after a proceeding fund raising, successive funds share several years of an overlapping investment period during which the common economic condition or shocks can influence the performance of preceding and following funds

[3] For example, Kaplan and Schoar (2005), Phalippou and Gottschalg (2009), and Axelson, Jenkinson, Stromberg, and Weisbach (2010) document a statistically significant association between the current and first follow-on fund performance.
[4] Chung, Sensoy, Stern, and Weisbach (2010) document that the correlation between the interim IRR at the time of a follow-on fund raising and the final IRR ranges from 40% to 60%, depending on specification and fund type.
[5] Investors' ability to obtain soft information about GPs' skill and expected performance which is not reflected in the hard information would mitigate this problem.

simultaneously. Therefore, persistence can be affected by the length of the overlapping investment period of successive funds. Second, I consider the effect of capital inflows on persistence. As Berk and Green (2004) argue in the context of the mutual fund industry – as they, in fact, assume – if investors of private equity direct capital to those managers with a higher past performance and if the inflow of capital is associated with a decline in future performance, performance persistence will disappear.

I find that the longer the time gap (the number of years elapsed) between two consecutive fund raisings, the weaker the performance persistence. In other words, as the duration of overlapping investment periods becomes shorter, there is less of a performance correlation between current and follow-on funds. On average, a one year increase in the number of years between two successive funds leads to a 0.10 (or 27%) decrease in performance persistence. However, I find this evidence only for buyout funds.

The paper finds more direct evidence that the commonality of macroeconomic conditions increases the performance correlations of successive funds. Specifically, I find that similar IPO and stock market conditions, macro economy and credit market conditions over two successive funds' lives increase performance persistence. The effect of the commonality on persistence is stronger for buyout funds.

Next, I show that better performing funds raise larger follow-on funds than their worse performing counterparts, confirming the findings of Kaplan and Schoar (2005) and Chung, Berk, Stern, and Weisbach (2010). However, funds which have grown more subsequently underperform. The return-chasing-capital phenomenon is slightly more pronounced for buyout funds, and the diminishing returns to capital inflows are found only among venture capital funds. These results suggest that the resources and skills necessary for managing venture capital funds are not readily scalable compared to buyout funds.

Importantly, capital inflows conditional on performance reduce performance persistence. One standard deviation increase in fund growth reduces performance persistence by about 0.17 (or 44%). A 2.25 standard deviation increase in fund growth, which occurs with a probability of about 3.1%, completely eliminates persistence, albeit only for venture capital funds.

While I find that overlapping investment period and capital inflows affect performance persistence, the former is more significant for buyout funds while the latter is more important to venture capital funds. This asymmetry appears to be consistent with the view that the venture capital industry is labor-intensive while the buyout industry is capital-intensive. In managing the portfolio companies of a venture capital firm, fund managers provide not only capital but also various kinds of resources such as industry networks and management skills. An increase in fund size which will in turn increase either the target size or the number of investments will require a greater amount of management care. To the extent that the resources of a venture capital firm are not quickly or readily scalable, capital inflows will likely lead to a decline in performance. This pattern is similar to that of mutual funds (Sirri and Tufano (1998), Lynch and Musto (2003), Chen, Hong, Huang, and Kubik (2004)) as well as hedge funds (Fung, Hsieh, Niak, and Ramadorai (2008)), in that LPs direct more capital toward funds with superior performance and funds face decreasing returns to capital inflows.

The performance of buyout funds, on the other hand, tends to be largely affected by macroeconomic conditions such as the credit market. Since each buyout transaction incurs a large amount of leverage, the pricing and liquidity of credit directly affect buyout performance.[6] Funds raised near to each other in time, therefore, are likely to be affected by common macroeconomic conditions and to exhibit higher performance correlation.

The overall evidence suggests that the performance of private equity funds persists only for the short run and that even this short-run persistence appears to be largely explained by common market conditions facing neighboring funds. This result does not support the view that GPs have differential and proprietary skills. However, the short-run persistence is also explained by excessive capital flows conditional on past fund performance. According to the Berk and Green (2004) model, the return-chasing capital and diminishing returns to capital flows do not necessarily contradict the view that GPs have differential ability. Therefore, the findings in this paper are not definitively conclusive about whether or

[6] For example, Axelson, Jenkins, Stromberg, and Weisbach (2010) show that the economy-wide cost of credit drives both the quantity and the capital structure of buyout transactions, although they do not directly examine the relationship between credit market conditions and performance.

not GPs have unique skills. But the findings have important implications for investors in the private equity industry in their investment decision making.

The next section briefly describes the data. Section 3 tests performance persistence and examines the dynamics of it. Also funds' survivorship bias and sample selection bias of the database are discussed. Section 4 investigates the causes of performance persistence in the short run and Section 5 concludes.

2. Data

The paper employs fund-level data such as vintage year, funds' IRRs, and fund size provided by Preqin.[7] I consider buyout and venture capital funds, two main asset classes of private equity. The total number of buyout (venture capital) funds is 2,250 (4,588), from which 888 (1,157) funds report IRRs. See Table 1 for the distribution of funds by fund type and vintage year. In later analyses I estimate the relation between current and follow-on fund performance. In doing this I aggregate funds in a given year and compute the fund-size-weighted IRR when a private equity firm raises multiple funds in a given year. Large private equity partnerships tend to raise multiple funds targeting different investors or geographical regions. For each preceding fund, I consider whether a follow-on fund can be observed in the database. I define a follow-on fund as the next fund raised by the same partnership. Thus each preceding fund is allowed to have at most one follow-on fund. If a fund does not have a follow-on fund, it is not included in the analysis. Lastly, I drop funds that were raised after 2005 to eliminate the potential bias that results from using the interim IRRs of unrealized (unliquidated) recent funds.

Table 1 reports the descriptive statistics (1st quartile, mean, median, 3rd quartile, and standard deviation) on fund performance and fund size by fund type (buyout or venture capital) and vintage year. Fund size information is available in Preqin for most funds: about 90% of funds report fund size data. However, performance data (IRR or multiples) is missing for the majority of the funds in Preqin. I discuss the potential biases in the analysis using the incomplete performance data in Section 3.5. Figure 1 plots

[7] See Chung et al. (2010) for a more detailed description of Preqin.

fund performance and committed capital by vintage year. The time trend of committed capital is largely consistent with other studies (e.g. Acharya et al. (2009), Stromberg, (2009)) that use a different database (e.g. Venture Economics or Capital IQ); there are peaks in fund raising in 2000 and 2007, and after the financial crisis in 2007-8, there is a large drop in fund raising activities in the private equity industry.

Table 1 shows venture capital funds' substantial underperformance since the late 1990s. This is not solely due to the fact that many of the recent funds are not yet completely liquidated (i.e. not completely realized),[8] as, even when only liquidated (realized) funds after the year 2000 are included, I find a similar trend, i.e. venture capital performance is substantially lower post-2000 than it was in previous years.

Comparing time series of venture capital and buyout fund performance, in Figure 1, reveals that buyout funds tend to comove together in terms of returns. In addition, the standard deviation of buyout funds is almost half of that of venture capital funds: 23.4 versus 50.1. This suggests that buyout funds may be more simultaneously affected by certain common factors than venture capital funds are and that venture capital investments appear to be riskier. I examine this issue further in Section 4.3.

3. Testing Performance Persistence

I examine whether GPs of better (worse) performing funds tend to continue to outperform (underperform) others in subsequent funds. To this end, I first compute the conditional probability that a partnership's subsequent funds will either stay in the same performance quartile as the current funds, or move into one of the other three quartiles (Section 3.1). If the funds in one portfolio tend to stay in the same portfolio, this will suggest that there is persistence in performance. Second, performance persistence is tested by examining the Pearson and Spearman correlations between current fund performance and follow-on fund performance in Section 3.2. Third, Section 3.3 examines performance persistence in a multivariate

[8] Industry practitioners often show concern about the poor performance of venture capital in recent years given its level of risk taking. See, for example, an article by Ray Maxwell (http://altassets.net/private-equity-features/article/nz18642.html) or one by Claire Miller (http://www.nytimes.com/2009/07/07/technology/start-ups/07venture.html).

regression framework, which will show whether performance persists after controlling for relevant factors. Lastly, in Section 3.4, I form quartile performance portfolios by ranking the current fund performance and tracing the subsequent performance of the initial performance quartile portfolios. Observing the subsequent performance will enable me to measure the economic magnitude of performance persistence.

The following analyses use unadjusted IRRs, as opposed to risk or style adjusted IRRs, as a measure of private equity performance. Obviously, it is difficult to know what kind of risks and how much risk private equity investments are exposed to. The kinds of investments made by a fund are not known, nor are the risk characteristics of those investments, as this information is not readily publicly available. I therefore do not attempt to adjust for risk. Alternatively, I may adjust investment returns by benchmarking according to a fund's investment characteristics (as Daniel, Grinblatt, Titman, and Wermers (1997) do for mutual funds). For example, private equity investment returns can be adjusted by the portfolio returns of other private equity funds with same industry and geographic focus and so on. This style adjustment is difficult to implement, however, because, unlike mutual funds, there are substantially smaller number of funds in the market, which limits the number of style dimensions that can be controlled for. Second, unlike other studies where the measurement of performance of private equity funds is a central question (e.g., Phalippou, and Gottschalg (2009)), the focus of this study is estimating the performance persistence within a private equity partnership. To the extent that investment risks and characteristics of the funds by the same private equity partnership do not change substantially over time, whether to use raw or risk-adjusted performance measure would be less of a concern.

In addition, it is not clear why one needs to adjust for such risk or style. Unlike mutual funds, private equity funds have absolute target returns, not benchmarked target returns. In addition, the compensation scheme of GPs is based on absolute returns, not benchmark adjusted returns. Therefore, the level of risk they take and their style of investment is less important for private equity partners and investors. For these reasons, I focus on the examination of unadjusted investment returns, while also, in the appendices, providing results using benchmark adjusted IRRs. The styles used to form the benchmark

portfolio are vintage year, geographic focus, and stage/investment type (early stage, later stage, expansion, or buyout). The benchmark adjusted IRRs are the raw IRRs minus the median of IRRs of the benchmark portfolio.

3.1. Transitional Probabilities

This section examines whether there is any association between current and future fund performance. Table 2 reports transitional probabilities, i.e. the conditional probability that a partnership's subsequent funds will either stay in the same performance quartile as the current funds, or whether it will move into one of the other three quartiles. If funds tend to stay in the same performance quartile over time, this would suggest that performance tends to persist.

The first rows of each panel (the raw headings with "Expected") report the expected fraction of funds which should belong to one of the performance quartiles under the assumption that the classification into one of the follow-on performance quartiles is purely random. I compute transitional probabilities from the current fund performance quartile into the first through third follow-on fund performance quartiles to see how long performance would persist. I use unadjusted IRR as a measure of performance (reported in Table 2); the results using benchmark adjusted IRRs are reported in Appendix A.

The probabilities that current funds in the top performing portfolio (1st quartile in the second row) stay in the top performing portfolio in their follow-on funds (1st quartile in the column heading) are 37.08% and 35.46% for buyout and venture capital funds, respectively. These probabilities are substantially greater than the expected probabilities, which are 21.14% and 26.59% for buyout and venture capital funds, respectively. The worst performing portfolio (4th quartile) also tends to continue to subsequently underperform. The conditional probability that current funds in the 4th quartile portfolio stay in the same quartile is 45.28% and 43.68% for buyout and venture capital funds, respectively; these figures are almost twice as large as the expected probabilities. The Chi-square tests also reject the null

hypothesis of no association between current and follow-on fund performance. Therefore, there is a strong persistence from current fund performance to the first follow-on fund performance.

The second and third sub-panels of Panel A and B also examine transitional probabilities from the current fund to the second and third follow-on funds. Here I do not find strong evidence that funds in one performance quartile tend to remain in the same performance quartile later. For buyout funds, it appears that funds tend to stay in the same quartile in their second follow-on funds as suggested by the marginally significant Chi-square statistics. However, the Chi-square test does not reject the hypothesis that the transition from current fund quartile to the third follow-on fund quartile portfolio is random. For venture capital funds, all the transitional probabilities do not show a statistically significant non-randomness. The results are almost identical when using benchmark adjusted IRRs instead of unadjusted IRRs (See Appendix A).

In sum, even though there is some performance persistence from the current funds to the immediately subsequent follow-on funds, performance persistence does not last after the first follow-on funds except in buyout funds' transition from the current to the second follow-on fund. I confirm this result below using different methodologies.

3.2. Correlation between current fund performance and follow-on fund performance

I test performance persistence using the Pearson and Spearman correlations between current funds' performances and the performances of its first, second, and third follow-on. The results are presented in Table 3, with the corresponding results using benchmark adjusted IRRs, as opposed to raw IRRs, reported in Appendix B. Panel A of Table 3 presents the Pearson correlation and Panel B reports the Spearman correlation. The first row of each sub-panel uses all funds that have IRR data for any of their following funds. The second through fourth row of each sub-panel requires that a private equity firm raise first through third follow-on funds and that it report IRR data for those funds. For example, the row headed with "F~F+3" include only private equity firms which have IRR data for their first through third follow-on funds.

The Pearson correlation between current funds' IRRs and their first follow-on funds' IRRs is 35% and 16% for buyout and for venture capital funds, respectively; these figures are statistically significant at the 1% level. The Pearson as well as Spearman correlations between the current funds and the second and third follow-on funds are not statistically significant for venture capital funds. But for buyout funds, the Pearson and Spearman correlations between current funds and the second follow-on funds are 12% and 17%, respectively, and statistically significant at the 10% and 5% levels, respectively, when all funds with IRR data in any of the following funds are used. However, note that the linear relationship between current and second follow-on funds drops almost by half: from 35% to 12% for buyout and from 29% to 17% for venture capital funds. When IRR data is required to be available for all follow-on funds, there is no association between current fund performance and that of all follow-on funds.

Essentially, the results are qualitatively identical to those from the test that uses transitional probabilities. There is performance persistence from the current fund to the immediately subsequent follow-on fund, but this performance persistence does not tend to last beyond the first follow-on fund.

3.3. Multivariate regression

Next, I show the association (persistence) of current and future fund performance in a multivariate regression framework. Current fund performance is regressed on the performance of the first, second, and third previous funds, each of which corresponds to the first, second, and third panel in Table 4. Specifically I estimate the following regression equation:

$$(IRR)_{i,t} = \alpha + \beta\,(IRR)_{i,t-\tau} + \gamma\,(\text{Fund Size})_{i,t} + \varepsilon_{i,t}, \qquad (1)$$

where τ is 1, 2, or 3. $(IRR)_{i,t-\tau}$ is the τ-th previous fund IRR and $(\text{Fund Size})_{i,t}$ is the current fund's size, respectively. If the coefficient estimate of β is positive and significant, this would suggest that past fund performance contains information about future performance.

In Table 4, Columns (1) and (2) report the estimates for buyout and Columns (3) and (4) for venture capital funds. In Columns (1) and (3), unadjusted IRRs (logarithmized) are used for the estimation and vintage year fixed effects are included. In Columns (2) and (4), I use benchmark adjusted IRRs (again logarithmized) instead of unadjusted IRRs. The benchmark adjusted IRRs are the difference between unadjusted IRRs and benchmark IRRs, which are the median IRRs of portfolios of funds with the same vintage year, geographic focus, and investment type (early stage, later stage, expansion, or buyout). Standard errors are clustered at the PE firm level.

In the case of both buyout and venture capital funds, current fund performance is not strongly associated with the second and third previous funds. For buyout funds, in Model (1) where I use unadjusted IRRs, current performance is marginally statistically significantly related to the second previous fund performance. Other than that, all the other coefficients are statistically insignificant and are generally consistent with the results from tests that use transition probabilities and correlations. By and large, performance persistence lasts for only one "period" for both buyout and venture capital funds. In other words, only the performances of two consecutively raised funds are significantly related. However, this statistical significance somewhat overstates the economic significance as I discuss in the next section.

The estimates are quantitatively similar regardless of different specifications. Consider, for example, Columns (1) and (3) where unadjusted IRRs are used to estimate the persistence of performance. The coefficients on the first previous fund's IRR are 0.444 for buyout and 0.234 for venture capital funds. Since both dependent variable and independent variables are logarithmic, I can interpret the coefficients as the elasticity of the current fund’s IRR on the preceding fund’s IRR. Therefore, a one percentage increase in the first previous fund’s IRR leads to a 0.444 (0.234) percentage increase in the current fund’s IRR for a buyout fund (venture capital fund). Put differently, since the average and standard deviation of logarithmic IRRs of the first previous funds are 0.783 and 0.086 for buyout and 0.781 and 0.182 for venture capital funds, a one standard deviation increase in the first previous fund performance will increase the average current fund performance by 10.9% for buyout and 23.3% for venture capital funds from the respective means.

3.4. Subsequent performance of initial performance quartile

Lastly, I examine subsequent performance by performance quartile portfolio. In each year, I rank funds by their performance (based on IRRs) and form quartile portfolios, with 1 being the best performing portfolio and 4 being the worst performing portfolio. Then I compute the average and median IRRs of the first through third follow-on funds of each initial performance quartile portfolio. In doing so, I can examine the economic magnitude of performance persistence. Table 5 reports the results using unadjusted IRRs. As seen in Figure 1, performance of private equity funds varies substantially by vintage year. Therefore, it seems reasonable here to adjust raw IRRs with vintage year benchmark IRRs or to use IRR rankings instead of the raw IRRs to mitigate this "vintage effect." The results are qualitatively identical irrelevant of different performance measures employed. See Appendix C for the results using benchmark adjusted IRRs.

In Table 5, the column headed with F reports the mean and median IRRs of current funds which are used to form the quartile portfolio. The column headings F+t where t=1, 2, or 3 report the mean and median IRRs of the t-th follow-on funds of funds in each initial quartile portfolio. Panel A reports the results for buyout funds, and Panel B for venture capital funds. In the first sub-panel (first five rows), the mean and median IRRs are computed using all funds with performance data available in Preqin. Since performance reporting is not compulsory, private equity partnerships' reports of performance information are often intermittent, and much of the performance data is missing. To see whether funds' survivor into the database affects the results, I also require that funds have first through third follow-on fund performance data; I report the results in the sub-panels B, C, and D using this sample. For example, sub-panel D requires that a private equity firm raise the first, second, and third follow-on funds and that IRR data is reported for all those follow-on funds.

For buyout funds (Panel A), the average (median) IRR of the currently top performing portfolio (Portfolio 1) is 39.5% (33.0%) (see column "F"); that of the bottom performing portfolio (Portfolio 4) is -4.4% (-2.3%). The differences in means and medians between the two most extreme portfolios are

statistically significant. In the case of the first follow-on fund performance (column "F+1"), the mean (median) of the initially top performing portfolio drops to 24.4% (19.7% for the median) and that of the initially bottom performing portfolio increases to 7.7% (6.2%). Again, the difference in performance between top and bottom portfolios is statistically significant. However, the economic magnitude of the difference substantially declines from one fund to the immediately subsequent follow-on fund. The differences between the best and worst portfolios are not statistically significant for the second and third follow-on funds. This result is also true for venture capital funds.

When private equity firms are required to raise the first through third follow-on funds (sub-panel D in Panel B), even the difference between the top and bottom portfolios for the immediate follow-on funds is statistically insignificant. By the time the third follow-on funds are raised, the initially best and worst performing fund portfolios are indistinguishable in terms of performance. Graphs A and B of Figure 2 plot the median of current and subsequent funds' IRRs by initial quartile portfolios. The performance convergence across portfolios over time can be clearly observed.

With funds that survive (i.e. report performance data) through their third follow-on funds, I find a similar result. Studies on mutual fund performance find that spurious persistence patterns may arise when fund survival depends on historical performance (Baquero, ter Horst, and Verbeek, 2005; Brown, Goetzmann, Ibbotson, and Ross, 1992; Carpenter and Lynch, 1999; ter Horst, Nijman, and Verbeek, 2001). It seems, however, that the high attrition rate does not spuriously increase performance persistence in private equity funds.

If better performing funds are more likely to raise follow-on funds or if they are more likely to voluntarily disclose performance, I would expect to see increases in performance as longer survival is required, i.e. in moving from sub-panels B (first five rows) to D (last five rows) in Table 5. This seems to be true. The averages of IRR in Table 5 are 19.7, 24.1, and 30.2% when requiring funds to have the first, second, and third follow-on funds, respectively, for buyout funds (Panel A) and 23.2, 29.8, and 36.8 %, respectively, for venture capital funds (Panel B). However, the same dynamic over time – performance convergence across quartile portfolios – is still found.

3.5. Robustness of the results

3.5.1. Comparison with Kaplan and Schoar (2005)

This result, that performance persistence is short-living, may seem to be at odds with that of Kaplan and Schoar (2005). Kaplan and Schoar's Table VII and VIII (pp. 1806 and 1807) report a statistically significant relation between a fund's current performance and that of its second previous fund.[9]

There are several differences between the sample of Kaplan and Schoar and that of this study. I investigate these differences in an attempt to understand the source of the discrepancy of the results. First, Kaplan and Schoar exclude funds with less than $5 million of committed capital in 1990 dollars whereas I do not. There are only 12 such funds (2 buyout and 10 venture capital funds) among funds that are eventually entered into the analysis. Besides, excluding them does not change the results qualitatively. Second, their primary measure of performance is the public market equivalent (PME) which is the ratio of discounted cash inflows and cash outflows where contemporaneous S&P 500 returns are used for discounting. They also report the result using the internal rate of return reported by private equity partnerships, and find a statistically significant association between current fund's performance and the first and second previous funds' performance. They report that PME and IRR have a correlation of 0.88. I also construct the PME measure for funds with cash flows data available (83 buyout funds and 156 venture capital funds) and find that the correlation between PME and IRR is 0.94 (0.68 for buyout funds and 0.95 for venture capital funds). Therefore, using a different measure of performance does not seem to be the source of the discrepancy. Lastly, Kaplan and Schoar study funds with vintage year before 1996, whereas I examine funds whose vintage year is before 2006. To see whether the differing sample window leads to the discrepancy, I replicate Table 4 using only funds which were raised before 1996. The result is reported in Appendix D. The magnitudes of the coefficient estimates substantially increase especially for

[9] Note, however, that they do not find such a significant relationship when they estimate the regressions for buyout and venture capital funds separately in their Table VII.

venture capital funds, but there is no statistically significant association between current fund performance and its second or third previous funds performance.

Unfortunately, on balance, I do not find why the results of my study are somewhat different from those from Kaplan and Schoar. A more careful comparison of the source databases (Preqin vs. Venture Economics) may be necessary.

3.5.2. Survivorship and sample selection bias

Can the finding be a mechanical result due to some unobservable industry characteristics? Can the results hitherto be driven by the biases in the database? I explore alternative explanations for the findings and discuss how potential biases in the database would affect the results.

It may be that among funds in portfolio 4 (the worst performing fund portfolio), only those which investors believe would perform better in the future are able to raise follow-on funds. If investors in private equity have the ability to distinguish funds which were simply unlucky from those which lack skills, then an improvement in performance may be observed among those funds in portfolio 4 which succeed in raising subsequent funds which is, in fact, what I find. However, the same survivorship bias cannot explain performance impairment in the top performing portfolios.

Alternatively, it is possible that GPs of successful PE firms – those with skills – tend to leave their original firm to start their own PE firms. This may explain why better performing funds cannot sustain their performance in the long run. In addition, unsuccessful PE firm may hire GPs with talents, leading to an increase in performance. These are interesting questions to ask, however, the data on individual GPs is not available, making it difficult to test these alternative explanations.

Another concern with the data is a potential sample selection bias. Alleviating this concern is that Preqin collects the performance data (85%) from the Freedom of Information Act and, occasionally, from

fund managers.[10] However, it is still possible that funds in Preqin are systematically different from those which are covered by Preqin. In particular, if funds with strong performance persistence tend not to enter into the database, my analysis would underestimate the true performance persistence in private equity funds. Importantly, funds and LPs of those funds which continue to outperform may not want to disclose their performance to Preqin or elsewhere. Those funds do not need to disclose and market their next funds since they may already have investor base from which they could raise enough amount of capital. LPs of those funds may not want to disclose performance data either because they may not want to increase competition among investors and increase fund size to the detriment of performance. Even though well known best performing private equity firms such as KKR, Carlyle, TPG are included in the analysis, I cannot perfectly validate this hypothesis and the results in this study should be interpreted with this caveat in mind.

3.5.3. Different screens, sub-sampling and specifications

I repeat the analyses using different methodologies and sub-samples, and find the qualitatively same results. First, I redo the analyses by excluding the top and bottom performing portfolios because, as Figure 2 shows, the long-run performance convergence appears to occur only for the top and bottom quartile portfolios. Second, I repeat the analyses using IRR rankings instead of IRRs to further eliminate the vintage year effect, i.e. the phenomenon that private equity performance is sensitive to when a fund was raised. Third, I use quintile or decile performance portfolios instead of quartile portfolios to see whether the arbitrarily chosen number of portfolios affects the results (especially in Table 5). Lastly, I drop funds which are artificially combined. As mentioned above, I consolidate multiple funds which are raised in the same year by a private equity firm. This could falsely generate the findings, so the study is repeated with these combined funds excluded. Again, the main finding − short-run performance persistence − continue to show regardless of using different methods and samplings.

[10] Preqin contains "the performance data is available for over 4,900 private equity funds for all types and geographic focus, which represents about 70% of all capital every raised" (http://www.preqin.com/item/private-equity-performance-analyst/1/11)

4. Determinants of Performance Persistence

This section aims to understand why performance persists in the short-run and why it disappears in the long-run. I first investigate whether and how economic commonality influences performance persistence in private equity funds. Then I examine the interaction between fund performance and capital flows to see whether fund flows affect performance persistence.

4.1. The effect of the time gap on performance persistence

Can common economic conditions explain performance persistence? Typically, private equity partnerships raise follow-on funds three to five years after the preceding fundraising. Since a private equity partnership usually lasts ten to thirteen years, two neighboring funds have five to ten years of overlap in their investment periods. These features of private equity industry imply that successive funds are likely to be exposed to common economic conditions, and the performance of successive funds may therefore be highly correlated due to this underlying economic commonality.

One prediction is that the longer an investment period is shared by successive funds, the greater the performance correlation will be.[11] If two funds are further apart in time, they are also more likely to be dissimilar in terms of performance. To test this prediction, I estimate the following ordinary least square equation:

$$(IRR)_{i,t} = \alpha + \beta\,(IRR)_{i,t-1} + \gamma\,(\text{Time Gap})_{i,t-1} + \delta\,(\text{Time Gap})_{i,t-1}\,(IRR)_{i,t-1} + \varepsilon_{i,t}$$

$$= \alpha + [\beta + \delta\,(\text{Time Gap})_{i,t-1}](IRR)_{i,t-1} + \gamma\,(\text{Time Gap})_{i,t-1} + \varepsilon_{i,t,} \qquad (2)$$

where $(\text{Time Gap})_{i,t-1}$ is the log of the number of years between two successive fundraisings. The time gap and IRR variables are centered on the respective means. Vintage year fixed effects are included and

[11] Kaplan and Schoar (2005) also estimate a similar regression specification using a time gap variable and find a positive but statistically insignificant coefficient on the interaction term of the time gap variable and previous fund's performance although they do not report the estimation results,.

standard errors are clustered at the PE firm level. If the estimate of δ is negative, this would suggest that performance persistence decreases as the time gap grows, conditional on the previous fund's performance. The IRR and time gap variables are demeaned to reduce the possible multi-collearity problem and to ease the interpretation of the interaction term (McClelland and Judd (1993)). Table 6 reports the estimation results.

The coefficient estimate on the interaction term is negative, but only for buyout funds. The estimate of the coefficient, δ, is -0.419 in column (1) and the standard deviation of the log of the time gap is 0.410. Therefore a one standard deviation increase in the log of time gap results in a decrease in persistence by 0.171 (or 44%). Put differently, if the time gap increases by one year from its mean (3.6 years), performance persistence will decrease by 0.102 (or 27%). In addition, performance persistence will disappear if the log of the time gap increases by a 2.25 standard deviation from its mean. The probability that this would happen under the empirical distribution of the log of the time gap is about 0.016. Similarly, the probability that performance persistence would reduce in half is approximately 0.129.

In columns (5) and (6), I interact the buyout dummy variable with the interaction of IRR and the time gap to see whether the effect of the time gap variable on persistence is different for buyout and venture capital funds. The coefficient on this triple interaction term is negative and statistically significant, suggesting that the performance persistence of buyout funds is more affected by common economic factors than that of venture capital funds. This result is consistent with what Figure 1 alludes to – a strong co-movement of buyout funds' performance compared to that of venture capital funds. This implies that buyout funds tend to be more simultaneously affected by some common factors than venture capital funds are.

4.2. Common market conditions

In the previous section, I find suggestive evidence that common economic conditions underlying the successive funds with overlapping investment periods may affect performance persistence. What are the

relevant economic factors influencing private equity fund's performance and its persistence? I first briefly describe the investment cycles of private equity funds to gain insight into what macro economic conditions may matter to private equity performance.

Fundraising usually takes from six months to two years depending on market conditions and various factors such as past performance and a PE's reputation. Only accredited investors can invest in private equity funds, and institutions such as pension funds, university endowments, insurance companies, foundations, and family offices and trusts are major investors in this market. Fund of funds which invest in other private equity funds also play an increasingly important role in the private equity industry. These investors "commit" a certain amount of capital to a partnership, which means that they do not invest the committed capital up front but, over the course of a fund's life, capital is "drawn down" when needed, up to a committed amount.

As noted above, a typical private equity fund is managed for ten years with two to three year extensions conditional on an agreement between the GPs and LPs. During first several years GPs focus on investments (the acquisition of target firms by buyout funds and the provision of financing to portfolio companies by venture capital funds); during the later part of a fund's life, GPs focus on divesting their investments before the partnership contract expires. Figure 3 plots investors' typical cash contribution and the cash distribution to investors from a private equity partnership over a fund's life. The pattern is usually called "J-curve" (Graph C) in that lots of draw-downs and investments are made early in the fund's life while cash inflows start kicking in as a fund liquidates (divests) its early investments through trade sales and IPOs. The duration of the investment period in a portfolio company varies substantially. But on average buyout funds are known to hold a portfolio company shorter than venture capital funds: 3 years, on average, versus 5 years.

Buyout funds almost always leverage each investment (acquisition) with large amount of debt, whereas venture capital funds do not usually do so. How much and at what price they borrow debt are important determinants of performance in buyouts. Targets of buyout funds have stable cash flows, a long track record, a high level of cash, and low leverage, whereas targets of venture capital funds are young

without much of a track record or profits; they also face substantial risks associated with product development and marketing.

Private equity funds can improve returns by increasing (or reducing) multiples at exit (multiples at acquisitions), improving performance (earnings or cash flows) or by using an appropriate level of leverage at a cheaper price. Therefore, various market conditions at the inception of funds, the time of investments, and the time of divestments directly affect funds' performance. For example, pricing and liquidity of capital are important determinants of private equity performance, especially for buyout funds. Exit market conditions such as the IPO market and mergers and acquisitions market directly affect a fund's performance. In addition, the market-wide price (multiples) at which business are purchased and sold as well as public stock market multiples are also important.

Ultimately, I seek to examine the extent to which the correlation of economic conditions explains the correlation of the performances of two consecutive funds. To test this, I begin by constructing a market similarity measure ("MSM"):

$$MSM_{i,t} = abs[\ (\text{Market Condition})_{i,t+1} / (\text{Market Condition})_{i,t} - 1\ ], \quad (3)$$

which is the absolute value of the ratio of market condition during a follow-on fund's life to what it was during a current fund's life. A larger MSM value implies that the market conditions of the current and subsequent funds' lives are more dissimilar.

Based on the preceding discussion, I examine the following non-exhaustive market condition variables which could affect funds' performance as well as the performance persistence of successive funds: 1) the IPO volume from the fifth to tenth year of a fund's lifetime as a measure of exit market condition for portfolio companies,[12] 2) the GDP growth during a fund's life as a measure of general economic condition, 3) the S&P 500 stock returns over the fund lifetime also as a measure of economic condition, 4) the three month Treasury bill yield during first five years of a fund's life as a measure of

[12] The IPO volume data is obtained from Jay Ritter's website.

liquidity of credit in the market, and 5) the ratio of average S&P 500 price earnings ratio during first five years to that during subsequent five years as a proxy for the change in acquisition multiples (i.e. at what price companies are being sold and bought)[13]. These variables are designed to proxy the general condition of the economy and the exit market conditions. After constructing MSM in Equation (3), I estimate a similar regression equation as Equation (2):

$$(IRR)_{i,t} = \alpha + \beta\,(IRR)_{i,t-1} + \gamma\,(MSM)_{i,t-1} + \delta\,(MSM)_{i,t-1}\,(IRR)_{i,t-1} + \varepsilon_{i,t}$$

$$= \alpha + [\beta + \delta\,(MSM)_{i,t-1}](IRR)_{i,t-1} + \gamma\,(MSM)_{i,t-1} + \varepsilon_{i,t,} \qquad (4)$$

Standard errors are clustered at the private equity firm level. The negative coefficient, δ, on the interaction term of MSM and IRR will imply that as the market conditions under which two funds are managed become dissimilar, the correlation (persistence) between the current and previous fund performance becomes smaller. IRR and MSM variables are standardized to a mean of zero and a standard deviation of one. Table 7 reports the estimation results. Appendix E reports a parallel result using benchmark adjusted IRRs.

All the coefficients estimate of δ are negative. In column (1), for example, the negative coefficient suggests that as the IPO market conditions of the current and follow-on funds become more dissimilar, performance persistence weakens. The MSM variable is normalized to a mean of zero and a standard deviation of one. Therefore, the coefficient of the interaction term between IRR and MSM, –0.217, suggests that a one standard deviation increase in the dissimilarity measure, MSM, leads to a -0.217 decrease in performance persistence. In addition, the effect of IPO volume and GDP growth on performance persistence is stronger for buyout funds, while the effect on persistence of the S&P 500 stock return is more pronounced for venture capital funds (unreported).

[13] The S&P500 price earnings ration is obtained from Robert Shiller's website.

The overall evidence suggests that as the common economic conditions under which the successive funds are managed become more similar, there is more performance persistence in private equity funds.

The fact that performance persists only for a short period of time and that even this persistence can be largely explained by the commonality of market conditions is not consistent with the view that GPs have unique and proprietary skills. Since whether individual fund managers continue to stay with a PE firm cannot be observed, the findings do not necessarily imply that individual fund managers do not have heterogeneous skills. However, it is clear that PE firms cannot sustain their performance consistently in the long run.

4.3. Fund flows and fund performance

Previous studies find that capital tends to chase past returns in the mutual fund industry (e.g. Sirri and Tufano, 1997) as well as in the hedge fund industry (Fung, Hsieh, Naik, and Ramadorai, 2008), and there are decreasing returns to scale in mutual funds (Chen, Hong, Huang, and Kubik, 2004) and hedge funds (Fung et al. 2008). Similarly, Chung, Sensoy, Stern, and Weisbach (2010) also document that superior performance leads to greater fund inflows in the private equity partnership. And Lopez de-Silane, Phalippou, and Gottschalg (2009) find a negative relation between fund scale and performance among buyout funds. Based on these recent findings and on Berk and Green's (2004) argument in the context of the mutual fund industry, it seems natural to suspect that return-chasing capital and decreasing returns to capital flows would erode the persistence of private equity fund performance. Seen in this light, the finding that performance does not persist does not necessarily imply an absence of differential ability across GPs. In other words, if a PE fund performs well, then it is likely that the PE partnership is able to raise a larger follow-on fund. However, if there are diminishing returns to scale, GPs who now manage larger funds will not be able to perform as well as before. Therefore, performance persistence is seen to decline over time.

Before studying whether this argument holds, I first consider the relationship between fund flows and fund performance. In Table 8, I examine how current fund performance affects future fundraising. Table 9 investigates how current fund inflows influence future fund performance. Specifically, Tables 8 and 9 report the estimates of the following equations:

$$\text{Table 8: } (\text{Fund Growth})_{i,t} = \alpha + \beta\,(\text{IRR})_{i,t-1} + \gamma\,(\text{Fund Size})_{i,t-1} + \varepsilon_{i,t,} \quad (5)$$

$$\text{Table 9: } (\text{IRR})_{i,t} = \alpha + \beta\,(\text{Fund growth})_{i,\,t-1} + \gamma\,(\text{IRR})_{i,\,t-1} + \delta\,(\text{Fund Size})_{i,\,t} + \varepsilon_{i,t,} \quad (6)$$

where fund growth, IRRs, and fund size are all logarithmized and vintage fixed effects are included in the equations. The subscripts *t* and *t-1* represent the current and preceding fund, respectively. Standard errors are clustered at the PE firm level.

In the last two columns ((5) and (6)) of Tables 8 and 9, I also include the interaction term between the buyout dummy variable (1 if a fund is a buyout fund and 0 if it is a venture capital fund) and $(\text{IRR})_{t-1}$ (in Table 8) and between the buyout dummy variable and $(\text{Fund growth})_{t-1}$ (in Table 9), to see whether the effect of past performance or past fund growth is different for buyout and venture capital funds. Columns (1), (3), and (5) in each table use unadjusted IRR as an independent and dependent variable, and columns (2), (4), and (6) use benchmark adjusted IRRs. As noted above, one reason to use benchmark adjusted IRRs is to control for the effect of the substantial variability of fund performances by vintage year. The first two columns ((1) and (2)) report the estimates for buyout funds and the second two columns ((3) and (4)) are for venture capital funds. All regressions include the logarithm of fund size of the preceding funds as a control variable because it may be difficult for larger funds to grow at the same rate as smaller funds.

Consistent with Chung et al. (2010), I find positive and statistically significant coefficients on preceding funds' IRRs. Past fund performance has a strong impact on follow-on fundraisings. This effect is marginally stronger for buyout funds. When I estimate a regression that includes the interaction of the buyout fund dummy variable and the preceding fund IRR, the coefficient for the interaction term is

positive, but not statistically significant. After excluding recently raised funds (2001 as the cut-off), the estimate of the coefficient on the interaction term is statistically significant (not reported). This difference suggests that buyout funds are more scalable than venture capital funds, conditional on past performance. However, the scalability of buyout funds seems to have diminished in recent years because the statistical significance of the interaction term disappears as more recently raised funds are included in the regression estimations. The results are similar when using benchmark adjusted IRRs.

Table 9 reports the relationship between fund flows and follow-on fund performance using unadjusted as well as benchmark adjusted IRRs. Here I include the fund growth from the preceding fund to the current fund as an independent variable. It appears that capital flows are negatively related to follow-on fund performance. However, the negative relationship is statistically significant only for venture capital funds (columns (3) and (4)). None of the coefficients of past fund growth are statistically significant for buyout funds (columns (1) and (2)). When I estimate the regression including the interaction term between the buyout fund dummy variable and the preceding fund growth, the coefficient on the interaction term is positive (columns (5) through (6)). Therefore, a venture capital firm performance tends to deteriorate more when capital inflows are greater, compared to a buyout firm. This result is consistent with the evidence in Table 8: the reason that buyout funds are more scalable than venture capital funds is because buyout funds suffer less from diminishing returns to capital inflows.

Taken together, I find that capital tends to chase returns in both buyout and venture capital funds, but the effect seems to be slightly greater for buyout funds. In addition, venture capital fund performance decreases in capital inflows, but buyout fund performance does not. These findings suggest that, conditional on fund growth, buyout funds will show stronger performance persistence than venture capital funds. I investigate this point in the next section.

4.4. The effect of fund flows on performance persistence

I examine whether fund growth affects performance persistence. Specifically I estimate the following ordinary least square equation and report the results in Table 10:

$$(IRR)_{i,t} = \alpha + \beta\,(IRR)_{i,t-1} + \gamma\,(\text{Fund Growth})_{i,t-1} + \delta\,(\text{Fund Growth})_{i,t-1}\,(IRR)_{i,t-1} + \varepsilon_{i,t}$$

$$= \alpha + [\beta + \delta\,(\text{Fund Growth})_{i,t-1}](IRR)_{i,t-1} + \gamma\,(\text{Fund Growth})_{i,t-1} + \varepsilon_{i,t,} \quad (7)$$

where $(IRR)_{i,t-1}$ and $(IRR)_{i,t}$ are current and follow-on fund performance and $(\text{Fund Growth})_{i,t-1}$ is fund growth from the current to the next fund. IRR and fund growth variables are demeaned. Vintage year fixed effects are included and standard errors are clustered at the PE firm level.

The estimate of δ will tell us how much excessive capital inflows conditional on past performance will affect future fund performance. I can also measure how capital inflows can affect the relationship (i.e. persistence) between current and follow-on fund performance by comparing the estimates of β and δ. If the estimate of δ is negative, it will suggest that performance persistence decreases as a fund has grown greater.

The coefficient estimate for the interaction term is negative and statistically significant for venture capital funds (columns (3) and (4)). This is consistent with the results in Table 9 where I find that only venture capital funds' performance deteriorates as a fund grows greater. The coefficient estimate on the interaction term of buyout dummy variable and fund growth is -0.392 for venture capital funds. The standard deviation of the log of fund growth is 0.435 and the mean is zero by definition; therefore a 2.25 increase in the standard deviation will completely eliminate the performance persistence between two successive venture capital funds. If the log of fund growth follows the standard normal distribution, the probability that a fund would grow more than a 2.25 standard deviation from its mean is about 0.012. From the empirical distribution of the log of fund growth, the probability is about 0.031. The probability that performance persistence would cut into half is approximately 0.087.

In column (5), I interact the buyout dummy variable with the interaction of IRR and fund growth to see whether the effect of fund growth on persistence is different for buyout and venture capital funds. The coefficient estimate is positive and statistically significant, suggesting that the negative effect of fund growth on persistence is indeed stronger for venture capital funds.

In sum, one potential reason that private equity fund performance persists only in the short run is because investors move capital in response to performance and because fund managers' performance is negatively associated with capital inflows, especially for venture capital funds.

The results are consistent with the hypothesis that decreasing returns to capital flows reduce performance persistence and that market commonality increases performance persistence in private equity funds. In addition, there are some subtle differences between buyout funds and venture capital funds. The effect of fund growth on persistence is stronger for venture capital funds and the effect of the time gap on persistence is stronger for buyout funds. This difference suggests that management skills and technology for managing venture capital funds are not readily scalable, while they seem to be more so for buyout funds.

Also, economic conditions seem more important for buyout funds. Especially, the effect of credit market conditions is more important for buyout funds than it is for venture capital funds because buyout funds typically leverage their investment with large amount of debt, whereas venture capitals do not usually do so. I believe the results largely are consistent with the view that the venture capital industry is more labor- (that is, management-) intensive while the buyout industry is more capital intensive.

5. Conclusion

This study examines performance persistence in private equity funds; uncovers several novel findings. First, I show that even though performance seems to persist, this persistence is short lived at best. In the long run, performance tends to converge across funds. Second, common market conditions facing successive funds increase performance persistence. Third, capital inflows into a fund after controlling for past performance reduce performance persistence.

Somewhat contrary to the interpretation of Kaplan and Schoar (2005), the evidence presented in this paper is skeptical about whether fund managers in private equity have differential and proprietary

skills. However, the short lived persistence does not necessarily imply that fund managers do not have differential skills, if one accepts the implication of the Berk and Green (2004) model.

Notwithstanding, the evidence in this paper has important implications for investors in the private equity industry. Investors need to actively monitor and rebalance their portfolios. The second or prior fund performance can be a misleading indicator of future performance. To further see how useful the performance information of the current fund is for future funds' performance, I examine the average performance of the second and third follow-on funds between the top and bottom quartile portfolios ranked based on current fund performance.[14] In an unreported table, I show that the difference between these two average returns is not statistically significant. This result suggests that holding onto a current winner is not likely to generate superior returns to investors over the long run. Using the average of the second and third previous funds' performance to rank portfolios also does not improve future performance. The difference in the performance of the top and bottom quartile portfolios based on two previous funds' performance is not statistically significant.

Lastly, but not least, I also find that the effect of capital flows on persistence is significant only for venture capital funds, and that the effect of common market condition on persistence is more important for buyout funds. This finding manifests the differing natures of the two types of funds: venture capital is more labor-intensive while buyout is more capital-intensive.

[14] Note that I do not require that a fund survive through its third follow-on fund because investors do not know whether the fund would be able to raise several follow-on funds down the road.

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Figure 1. Private equity fund performance and fund raising by vintage year

The figures plot fund performance and committed capital by vintage year for buyout funds (Graphs A and C) and venture capital funds (Graphs B and D). I use internal rate of returns (IRR) reported by private equity partnerships and collected by Preqin as a performance measure. Fund size is in 1990 dollars.

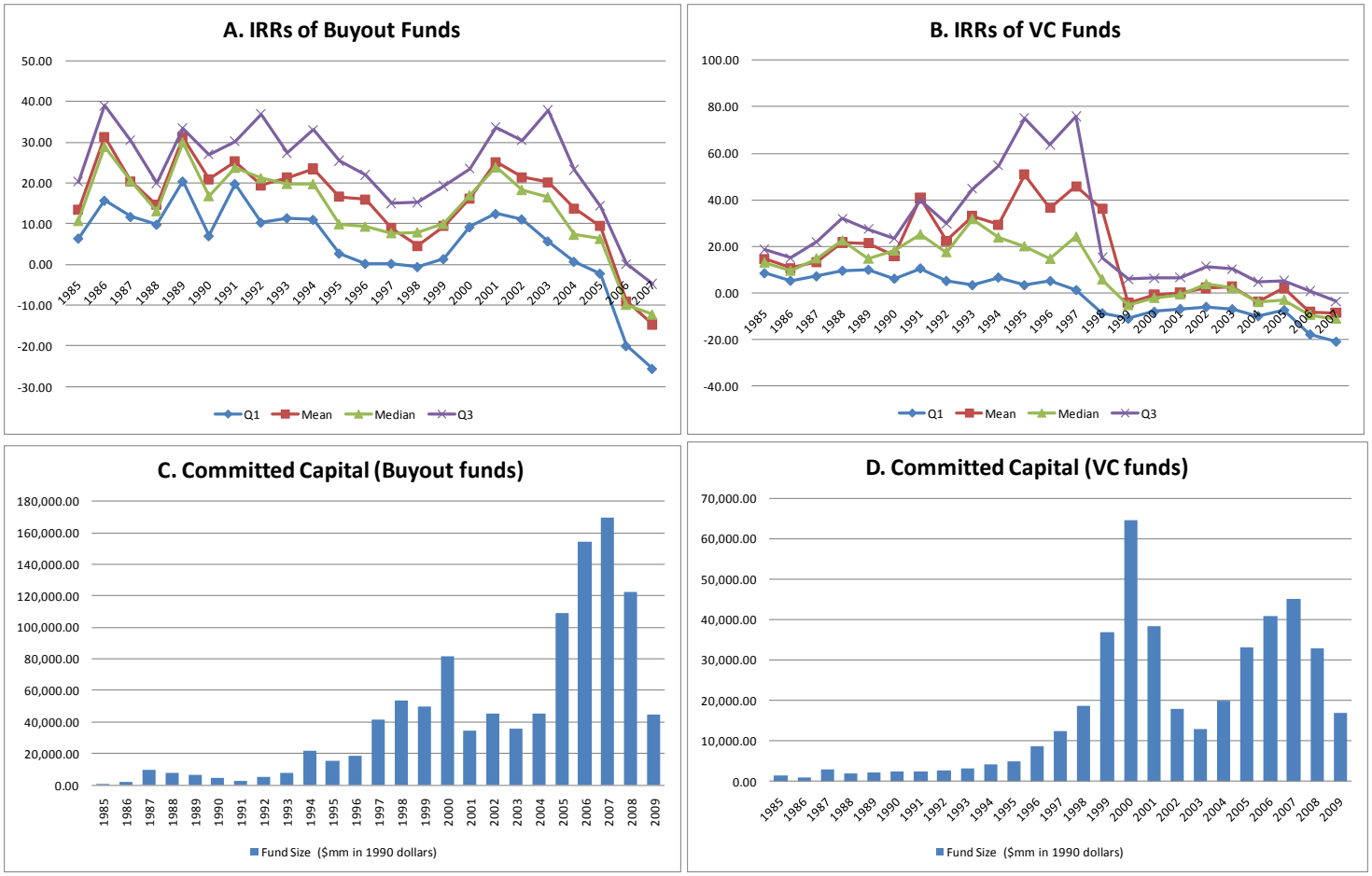

Figure 2. Performance of quartile portfolios ranked on current fund performance

Funds are sorted into four rank portfolios based on current funds' IRR. Next, median IRRs are computed for follow-on funds in each quartile and are plotted. F+t, where t takes 1, 2, or 3, represents t-th follow-on fund. F is the current funds used to form portfolios. Graph A plots buyout funds and Graph B venture capital funds.

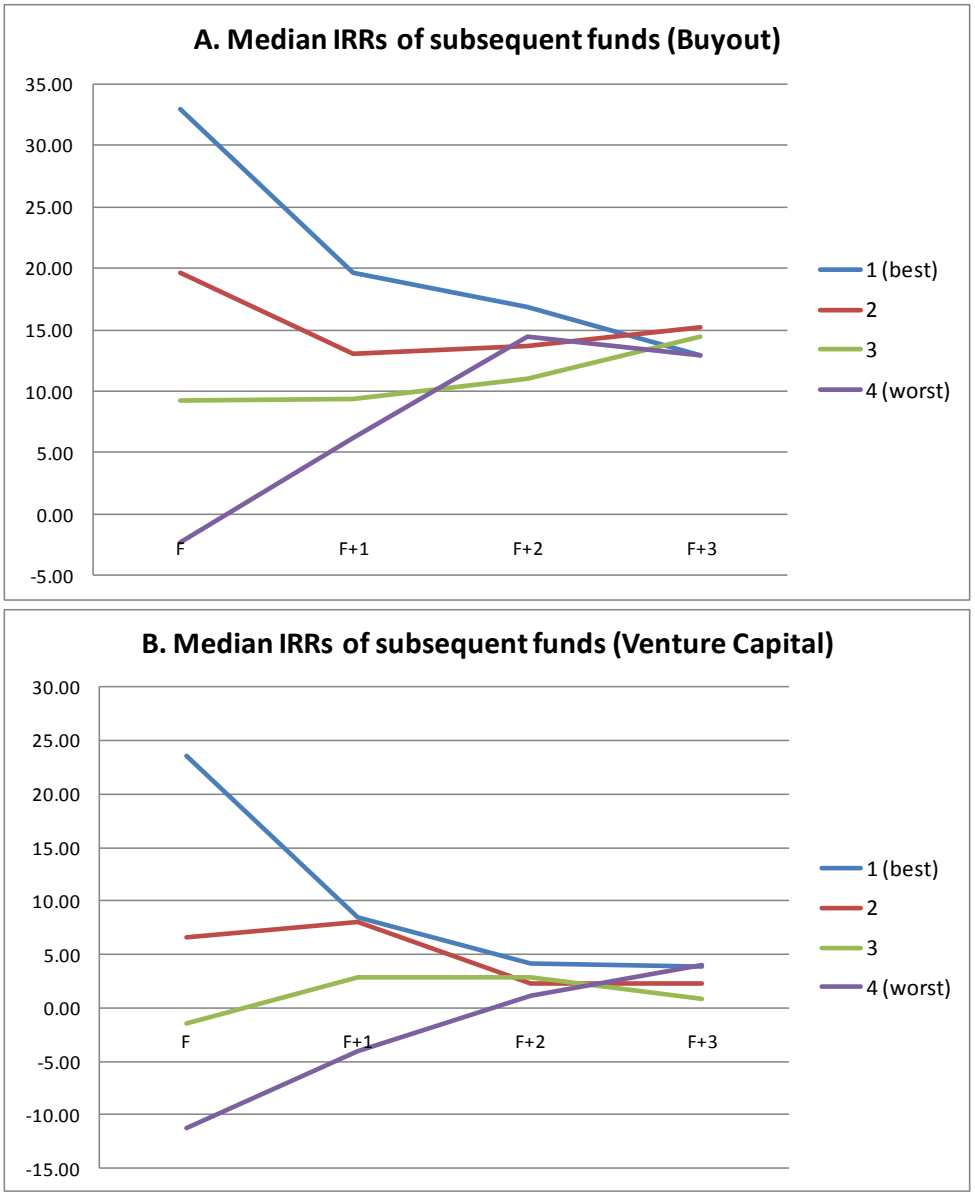

Figure 3. Cash flows of a private equity fund over its lifetime

This graph plots the cumulative contribution (Graph A), cumulative distribution (Graph B), and net cash flows (Graph C) of a private equity fund (randomly chosen from the Preqin cash flow dataset) over its fund's lifetime. The fund was raised in 1993; its size is $473 m. Cumulative contribution is the sum of all drawn down capital to that date; cumulative distribution is the sum of all profits returned to investors. Net cash flow is cumulative distribution minus cumulative contribution at a given date.

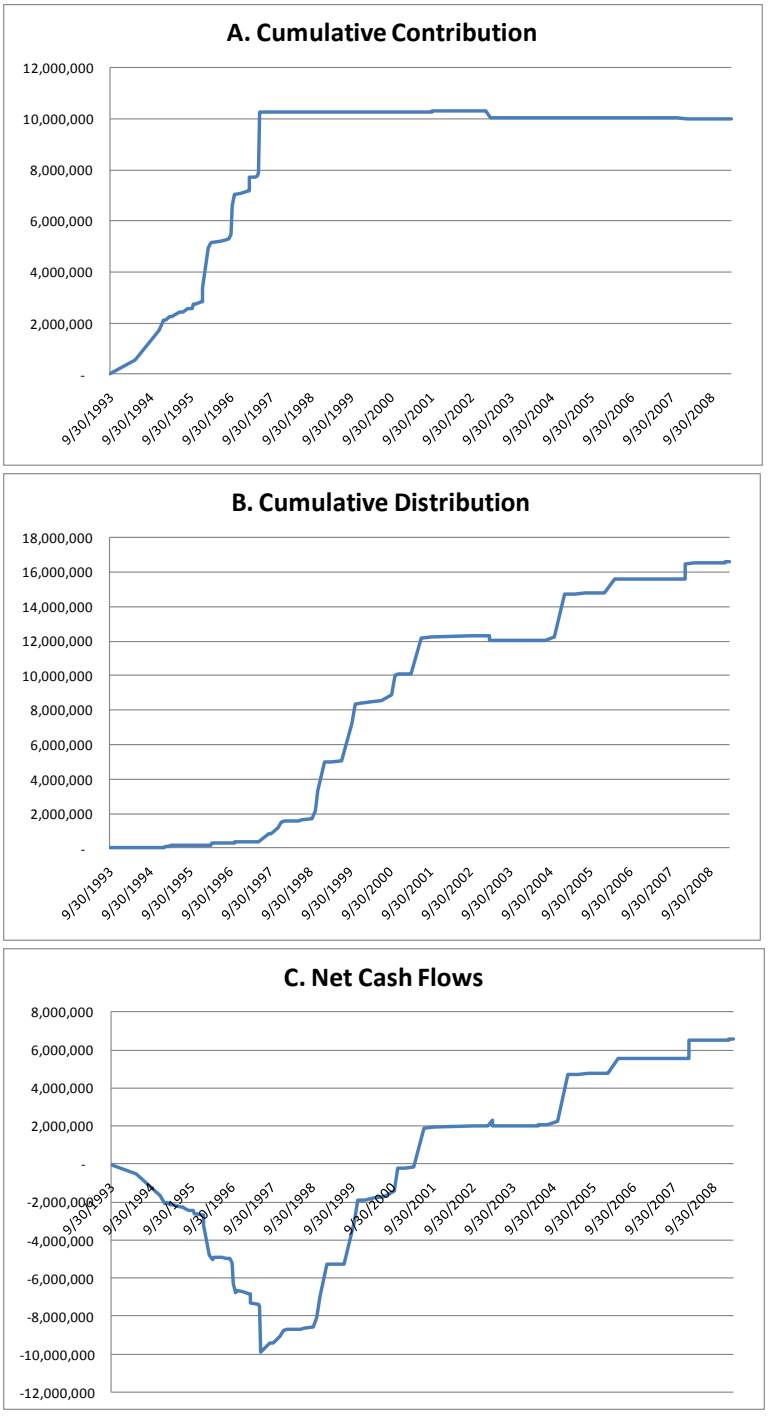

Table 1. Private equity fund performance and fund raising

The table reports the distribution of buyout funds' (Panel A) and venture capital funds' (Panel B) performance and fund size by vintage year. I use as a performance measure the internal rate of returns (IRR) reported by private equity partnerships and collected by Preqin. Fund size is in 1990 dollars. Q1 is the first quantile and Q3 is the third quantile.

Panel A. Buyout Funds

		# Funds	IRR					# Funds	Fund Size				
Vintage	# Funds	w/ IRR	Q1	Mean	Median	Q3	Std Dev.	w/ Size	Q1	Mean	Median	Q3	Std Dev.
before 1990	96	59	12.40	24.34	20.00	31.10	17.42	75	61.86	402.19	143.82	342.56	898.84
1990~1999	614	334	2.70	13.60	11.15	22.40	20.57	556	82.53	397.44	191.08	422.77	603.00
2000~2005	839	329	4.20	16.41	13.80	26.70	21.32	795	73.80	441.38	175.33	401.54	800.45
All	1549	722	4.80	15.76	13.20	25.00	20.85	1426	75.90	422.19	177.64	409.59	735.56
Panel B. Venture Capital Funds													
before 1990	311	182	7.60	16.53	12.95	21.00	19.63	205	22.10	68.14	42.93	86.18	74.59
1990~1999	1201	413	-3.50	27.86	10.30	31.90	76.89	1017	24.99	94.53	54.92	109.85	125.49
2000~2005	1958	424	-7.35	0.43	-1.20	7.50	16.58	1738	19.88	107.47	50.69	131.55	158.41
All	3470	1019	-4.70	14.42	6.10	18.20	52.26	2960	21.31	100.30	51.95	117.68	143.64

Table 2. Transition probabilities from current funds' performance quartiles to follow-on funds' performance quartiles

I sort all funds for which I have follow-on funds into performance quartiles and calculate the conditional probability that a partnership's 1st through 3rd follow-on funds will either stay in the same performance quartile as its current funds, or that it will move into one of the other three quartiles. The row headings with "Expected" are the expected probabilities that a follow-on fund will be in one of the four quartiles (column headings 1 through 4) under the assumption that the classification into one of the follow-on performance quartiles is purely random. The column heading with "Chi-square" reports Chi-square test statistics testing the null hypothesis of no association between current and follow-on funds performance. The first, second, and third sub-panels of each panel report transition probabilities from current fund to the 1st, 2nd, and 3rd follow-on funds, respectively. Panels A and B report transition probabilities for buyout and venture capital funds, respectively. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Buyout Funds							
		1	2	3	4	Total	Chi-square
Current	Expected	21.14%	28.08%	26.81%	23.97%	317	45.25 ***
to 1st	1	37.08	33.71	16.85	12.36	89	
follow-on	2	20.45	27.27	32.95	19.32	88	
	3	8.05	31.03	33.33	27.59	87	
	4	16.98	15.09	22.64	45.28	53	
Current	Expected	24.46%	25.54%	28.26%	21.74%	184	16.31 *
to 2nd	1	22.41	36.21	31.03	10.34	58	
follow-on	2	30.36	17.86	23.21	28.57	56	
	3	18.75	22.92	37.50	20.83	48	
	4	27.27	22.73	13.64	36.36	22	
Current	Expected	18.87%	28.30%	29.25%	23.58%	106	9.64
to 3rd	1	14.29	25.71	37.14	22.86	35	
follow-on	2	25.00	25.00	16.67	33.33	36	
	3	13.64	40.91	36.36	9.09	22	
	4	23.08	23.08	30.77	23.08	13	

Panel B. Venture Capital Funds							
		1	2	3	4	Total	Chi-square
Current	Expected	26.59%	27.29%	24.94%	21.18%	425	52.10 ***
to 1st	1	35.46	25.46	30.00	9.09	110	
follow-on	2	36.44	25.42	22.03	16.10	118	
	3	20.91	32.73	25.46	20.91	110	
	4	9.20	25.29	21.84	43.68	87	
Current	Expected	26.15%	25.77%	26.54%	21.54%	260	4.31
to 2nd	1	31.34	25.37	25.37	17.91	67	
follow-on	2	28.05	21.95	25.61	24.39	82	
	3	24.24	27.27	28.79	19.70	66	
	4	17.78	31.11	26.67	24.44	45	
Current	Expected	22.02%	27.38%	29.76%	20.83%	168	11.87
to 3rd	1	31.25	27.08	25.00	16.67	48	
follow-on	2	23.64	20.00	32.73	23.64	55	
	3	16.22	29.73	24.32	29.73	37	
	4	10.71	39.29	39.29	10.71	28	

Table 3. Pearson and Spearman correlations between current fund performance and follow-on fund performance

This table reports Pearson (Panel A) and Spearman (Panel B) correlations between current fund performance and follow-on fund performance. The first and second four rows of each panel are for buyout and venture capital funds, respectively. The first row of each sub-panel uses all funds which have IRR data for any of their following funds to compute correlation coefficients. The second through fourth rows of each sub-panel require that a fund raise first through third follow-on funds. The row headings with F~F+t (t=1, 2, or 3) indicate that a fund has IRR data from the current through the t-th follow-on funds. The first three columns report correlations, the second three columns report p-values, and the last three columns report the number of funds used to compute correlations.

		Panel A. Pearson correlation								
		IRR			*p* -value			N		
		F+1	F+2	F+3	F+1	F+2	F+3	F+1	F+2	F+3
Buyout	All	0.35	0.12	0.09	0.00	0.10	0.39	317	184	106
	F ~ F+1	0.35			0.00			317		
	F ~ F+2	0.26	0.11		0.00	0.16		166	166	
	F ~ F+3	0.36	0.05	0.12	0.00	0.64	0.28	82	82	82
Venture	All	0.16	0.02	-0.08	0.00	0.79	0.30	425	260	168
	F ~ F+1	0.16			0.00			425		
	F ~ F+2	0.22	0.01		0.00	0.92		228	228	
	F ~ F+3	0.20	-0.04	-0.09	0.02	0.61	0.29	135	135	135

		Panel B. Spearman correlation								
		IRR			*p* -value			N		
		F+1	F+2	F+3	F+1	F+2	F+3	F+1	F+2	F+3
Buyout	All	0.29	0.17	0.08	0.00	0.02	0.40	317	184	106
	F ~ F+1	0.29			0.00			317		
	F ~ F+2	0.24	0.18		0.00	0.02		166	166	
	F ~ F+3	0.29	0.06	0.14	0.01	0.62	0.22	82	82	82
Venture	All	0.42	0.10	-0.10	0.00	0.12	0.21	425	260	168
	F ~ F+1	0.42			0.00			425		
	F ~ F+2	0.34	0.10		0.00	0.15		228	228	
	F ~ F+3	0.28	-0.05	-0.09	0.00	0.53	0.33	135	135	135

Table 4. Cross sectional regression of current performance on past performance

The table reports the estimates of the following regression: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-\tau} + \gamma_t (\text{Fund Size})_t + \varepsilon_t$, where τ is 1, 2, or 3 and t- τ represents τ-th previous funds. Funds raised after 2005 are excluded from the estimations. The dependent variable is the logarithms of IRRs of current funds. The independent variables are the logarithm of IRRs and the logarithm of fund size of the first, second, and third previous funds in the first, second, and third panels, respectively. In Columns (1) and (3), unadjusted IRRs are used as independent and dependent variables, and vintage year fixed effects are included. In Columns (2) and (4), benchmark adjusted IRRs are used as independent and dependent variables, where benchmark IRRs are the median IRRs of portfolios of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, or buyout). The standard errors are clustered at the PE firm level. Columns (1) and (2) estimate the equation for buyout funds and Columns (3) and (4) for venture capital funds. The numbers in the parentheses are t-statistics. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Current IRR on first previous fund's IRR

	Buyout		Venture Capital	
	IRR	Adjusted IRR	IRR	Adjusted IRR
	(1)	**(2)**	**(3)**	**(4)**
IRR(t-1)	0.444***	0.409***	0.234***	0.278***
	(6.155)	(5.720)	(4.541)	(4.704)
Fund Size (t)	-0.009**	-0.012**	-0.009	-0.025**
	(-2.000)	(-2.512)	(-0.875)	(-2.547)
Constant	0.489***	0.480***	0.630***	0.634***
	(7.533)	(7.762)	(9.316)	(8.600)
Obs.	317	317	425	425
Adjusted R2	0.217	0.133	0.220	0.101

Panel B. Current IRR on second previous fund's IRR

IRR(t-2)	0.178*	0.150	0.094	0.107
	(1.809)	(1.618)	(1.329)	(1.455)
Fund Size (t)	-0.018**	-0.020***	-0.010	-0.033**
	(-2.476)	(-2.684)	(-0.618)	(-1.978)
Constant	0.772***	0.714***	0.782***	0.813***
	(7.516)	(7.437)	(8.903)	(8.504)
Obs.	184	184	260	260
Adjusted R2	0.072	0.063	0.153	0.026

Panel C. Current IRR on third previous fund's IRR

IRR(t-3)	0.109	0.111	0.079	-0.072
	(1.009)	(1.060)	(1.195)	(-1.116)
Fund Size (t)	-0.005	-0.012	-0.031	-0.045**
	(-0.585)	(-1.313)	(-1.530)	(-2.090)
Constant	0.740***	0.696***	0.941***	1.034***
	(6.621)	(5.872)	(9.125)	(8.735)
Obs.	106	106	168	168
Adjusted R2	0.029	0.011	0.180	0.050

Table 5. Subsequent fund performance (unadjusted IRRs) by quartile portfolios based on current fund performance

Each fund is sorted into quartile rank portfolios in each vintage year based on its IRR. Next, mean and median IRRs are computed for follow-on funds in each quartile. The column headings with F+t where t takes 1, 2, or 3 represent the t-th follow-on fund. F is current funds used to form the initial portfolios. Panel A is for buyout funds and Panel B for venture capital funds. Sub-panel A includes all funds. Sub-panels B through D require that a fund has 1st, 2nd, and 3rd following funds, respectively. The last four columns report the number of funds included in the computation of the mean and median values. The last row of each sub-panel reports t-statistics (for the tests of difference in mean IRRs between portfolios 1 and 4) and Wilcoxon rank sum Z-statistics (for the tests of difference in median IRRs between portfolio 1 and 4). Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Buyout

	Mean				Median				N			
Quartile	F	F+1	F+2	F+3	F	F+1	F+2	F+3	F	F+1	F+2	F+3
A. All funds												
All	15.93	15.45	15.43	15.08	13.85	12.90	13.50	13.50	668	317	184	106
1	39.52	24.40	18.49	12.51	33.00	19.70	16.90	12.90	157	89	58	35
2	19.53	15.73	12.80	16.11	19.70	13.10	13.70	15.20	173	88	56	36
3	10.35	10.71	15.00	16.85	9.30	9.40	11.05	14.40	173	87	48	22
4	-4.44	7.73	14.98	16.15	-2.30	6.20	14.40	12.90	165	53	22	13
Diff(1-4)	19.67***	3.59***	0.5	-0.27	14.38***	-3.82***	-0.73	0				
B. Funds with 1st follow-on funds' IRR available												
All	19.77	15.45			17.90	12.90			317	317		
1	38.47	24.40			32.83	19.70			89	89		
2	20.71	15.73			20.95	13.10			88	88		
3	12.05	10.71			11.60	9.40			87	87		
4	-0.49	7.73			-0.60	6.20			53	53		
Diff(1-4)	12.1***	3.59***			-9.22***	-3.82***						
C. Funds with 1st and 2nd follow-on funds' IRR available												
All	24.09	18.75	14.65		21.30	16.21	13.25		166	166	166	
1	40.85	25.00	17.47		36.45	21.60	16.10		54	54	54	
2	24.11	18.26	11.58		22.75	19.10	13.70		46	46	46	
3	13.19	14.57	14.19		13.80	12.80	10.15		46	46	46	
4	3.89	12.66	15.17		7.55	7.90	14.40		20	20	20	
Diff(1-4)	9.73***	2.38**	0.56		-6.1***	-2.63**	-0.95					
D. Funds with 1st, 2nd, and 3rd follow-on funds' IRR available												
All	30.17	21.65	17.56	14.99	25.75	19.10	16.61	15.00	82	82	82	82
1	45.83	28.09	20.11	14.89	47.30	24.70	17.50	15.00	31	31	31	31
2	26.27	20.08	15.08	14.21	25.70	19.00	15.20	15.20	25	25	25	25
3	18.28	17.74	16.25	15.69	18.00	15.10	16.10	13.70	19	19	19	19
4	7.03	9.40	18.69	16.31	9.90	8.40	15.10	12.90	7	7	7	7
Diff(1-4)	5.11***	4.62***	0.27	-0.21	-3.9***	-3.05***	-0.46	0				

Table 5. (Continued)

Panel B. Venture Capital

	Mean				Median				N			
Quartile	F	F+1	F+2	F+3	F	F+1	F+2	F+3	F	F+1	F+2	F+3
A. All funds												
All	14.01	16.83	21.10	24.88	4.84	4.30	3.40	2.55	884	425	260	168
1	54.35	28.33	31.44	24.28	23.55	8.40	4.20	3.80	210	110	67	48
2	13.51	26.07	17.52	21.91	6.60	8.10	2.26	2.30	226	118	82	55
3	2.27	9.93	24.85	38.10	-1.40	2.90	2.90	0.90	228	110	66	37
4	-11.80	-1.53	6.74	14.28	-11.20	-4.00	1.10	4.02	220	87	45	28
Diff(1-4)	8.72***	3.71***	1.51	0.89	16.05***	-4.7***	-0.89	-0.08				
B. Funds with 1st follow-on funds' IRR available												
All	23.23	16.83			10.00	4.30			425	425		
1	71.62	28.33			39.80	8.40			110	110		
2	18.69	26.07			15.15	8.10			118	118		
3	4.37	9.93			4.69	2.90			110	110		
4	-7.91	-1.53			-8.80	-4.00			87	87		
Diff(1-4)	5.65***	3.71***			-10.19***	-4.7***						
C. Funds with 1st and 2nd follow-on funds' IRR available												
All	29.84	24.70	21.53		15.10	7.95	3.55		228	228	228	
1	77.30	38.25	28.29		63.70	13.00	4.00		61	61	61	
2	24.76	36.20	19.74		23.65	11.25	4.00		70	70	70	
3	7.89	9.27	25.49		8.70	3.70	2.00		59	59	59	
4	-2.92	5.69	7.84		-1.42	0.40	2.70		38	38	38	
Diff(1-4)	8.96***	2.36**	1.2		-6.52***	-2.04**	-0.31					
D. Funds with 1st, 2nd, and 3rd follow-on funds' IRR available												
All	36.84	29.06	30.92	28.79	22.10	16.50	7.00	2.10	135	135	135	135
1	81.10	44.13	34.07	27.20	63.80	26.20	6.85	3.30	41	41	41	41
2	27.58	31.26	21.72	23.69	24.10	19.35	4.75	1.65	46	46	46	46
3	11.40	12.76	48.75	45.44	10.70	10.30	10.00	0.90	29	29	29	29
4	2.58	16.15	19.16	19.16	1.91	8.10	7.60	3.36	19	19	19	19
Diff(1-4)	7.82***	1.17	-0.11	0.42	-4.3***	-0.23	0.82	0.4				

Table 6. The effects of time gap on performance persistence

The table reports ordinary least square regression estimates for the following specifications: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-1} + \beta_{1t} (\text{Fund growth})_{t-1} + \beta_{2t} (\text{Time Gap}) + \beta_{3t} (IRR^* \text{ Time Gap}) + \beta_{4t} (\text{Fund size})_t + \varepsilon_t$. The triple interactions of IRR, Time Gap, and the Buyout dummy variable is included in specifications (5) and (6). Time Gap is the difference between the current funds' vintage year and the follow-on funds' vintage year. Buyout is a dummy variable taking 1 if a fund is a buyout fund, 0 otherwise. IRRs and Time Gap are logarithmized and demeaned. The column headings (1) and (2) are for buyout funds, and (4) and (5) are for venture capital funds. In all regression estimations, vintage fixed year effects are included. Standard errors are clustered at the PE firm level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds		Venture Capital Funds		All Funds	
	IRR	Adjusted	IRR	Adjusted	IRR	Adjusted
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
IRR (t-1)	0.387***	0.357***	0.235***	0.232***	0.269***	0.232***
	(5.613)	(5.445)	(5.022)	(5.140)	(6.918)	(6.064)
Time Gap (t-1) to (t)	0.001	0.011	-0.006	0.020	0.019	0.021
	(0.049)	(0.793)	(-0.284)	(0.996)	(1.083)	(1.227)
IRR*Time Gap	-0.419***	-0.389**	0.093	0.136	0.119	0.136
	(-2.776)	(-2.445)	(0.696)	(0.983)	(1.049)	(1.158)
IRR*Buyout					-0.080	0.124
					(-0.753)	(1.210)
Time Gap*Buyout					-0.034	-0.010
					(-1.277)	(-0.405)
IRR*Time Gap*Buyout					-0.674***	-0.527**
					(-2.677)	(-2.030)
Buyout					0.029**	-0.010
					(2.320)	(-0.792)
Fund size (t)	-0.008*	-0.011**	-0.009	-0.013*	-0.009**	-0.012***
	(-1.858)	(-2.366)	(-1.254)	(-1.826)	(-2.037)	(-2.687)
Constant	0.825***	0.762***	0.806***	0.785***	0.805***	0.780***
	(21.933)	(27.325)	(19.912)	(22.661)	(28.947)	(35.344)
Number of observations	317	317	425	425	742	742
Adjusted R2	0.233	0.140	0.217	0.061	0.174	0.084

Table 7. The effects of similar market conditions on performance persistence

The table reports ordinary least square regression estimates for the following specifications: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-1} + \beta_{1t} (MSM)_{t-1} + \beta_{2t} (IRR*MSM) + \beta_{3t}$ $\beta_{3t}(Fund\ size)_t + \varepsilon_t$. MSM is the market similarity measure defined as the absolute value of $((Market\ Condition)_{i,t+1} / (Market\ Condition)_{i,t} - 1)$. The market condition variables are the 1) IPO volume from the fifth to tenth year of a fund's life (the column heading with 'IPO volume'), 2) GDP growth during a fund's life ('GDP growth'), 3) S&P 500 stock returns over a fund's lifetime ('S&P500 returns'), 4) three month Treasury bill yield during first five years of a fund's life ('T-bill'), and 5) the ratio of average S&P 500 price earnings ratio during first five years to that during subsequent five years. IRRs and MSM are logarithmized and normalized with a mean of zero and a standard deviation of one. The first five columns are the estimates for buyout funds, and the last five columns are for venture capital funds. Standard errors are clustered at the vintage year level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds					Venture Capital Funds				
	IPO Volume	GDP Growth	S&P500 returns	T-bill	S&P500 PE ratio	IPO Volume	GDP Growth	S&P500 returns	T-bill	S&P500 PE ratio
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
IRR(t-1)	0.244***	0.263***	0.334***	0.338***	0.255***	0.286***	0.282***	0.317***	0.417***	0.259***
	(3.577)	(3.852)	(5.164)	(6.340)	(4.220)	(3.844)	(4.545)	(5.741)	(4.822)	(2.891)
MSM(t)	0.203**	0.210***	0.181***	0.018	0.130***	-0.085**	-0.234***	-0.271**	-0.109**	-0.107**
	(2.475)	(2.655)	(6.769)	(0.259)	(4.185)	(-2.438)	(-4.318)	(-2.461)	(-2.064)	(-2.042)
IRR*MSM(t)	-0.217**	-0.249***	-0.030**	-0.151***	-0.200***	-0.040*	-0.093***	-0.399**	-0.224**	-0.107
	(-2.017)	(-2.609)	(-2.163)	(-3.527)	(-2.833)	(-1.933)	(-3.316)	(-2.538)	(-2.560)	(-1.455)
Fund Size (t)	-0.068	-0.072	-0.111**	-0.118**	-0.078	-0.141*	-0.141**	-0.134**	-0.104*	-0.135*
	(-1.278)	(-1.263)	(-2.228)	(-2.250)	(-1.509)	(-1.915)	(-1.981)	(-2.227)	(-1.749)	(-1.883)
Constant	0.469	0.473	0.679**	0.702**	0.540*	0.698*	0.689**	0.623**	0.534*	0.663*
	(1.443)	(1.327)	(2.311)	(2.263)	(1.752)	(1.909)	(2.025)	(1.989)	(1.715)	(1.849)
Obs	252	252	317	217	252	358	358	425	425	358
Adjusted R2	0.165	0.174	0.159	0.157	0.107	0.101	0.156	0.174	0.150	0.095

Table 8. Current fund performance and follow-on fund growth

The table presents ordinary least square regression estimates of the following specifications: $(\text{Fund Growth})_t = \alpha_t + \beta_t (\text{IRR})_{t-1} + \gamma_t (\text{Fund Size})_{t-1} + \varepsilon_t$. Fund growth (from the current to the 1st follow-on fund), IRRs, and fund size are logarithmized. In Columns (5) and (6), I also include the buyout fund dummy variable (taking a value of 1 if a fund is a buyout fund, 0 for a venture capital fund) and the interaction term between the buyout dummy variable and IRRs. Columns (1), (3), and (5) show the estimates of the regression of fund growth on unadjusted IRRs, and Columns (2), (4), and (6) for the regression of fund growth on benchmark adjusted IRRs. Benchmark IRRs are the median IRRs of the portfolio of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, and buyout). In all regression estimations, I exclude funds raised after 2005. In Columns (1), (3), and (5), I include vintage fixed year effects. The numbers in the parentheses are t-statistics. Standard errors are clustered at the PE firm level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds		Venture Capital Funds		All Funds	
	IRR	Adjusted IRR	IRR	Adjusted IRR	IRR	Adjusted IRR
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
IRR(t-1)	0.596**	0.583**	0.379***	0.432***	0.409***	0.428***
	(2.125)	(2.319)	(2.794)	(3.465)	(3.245)	(3.442)
Buyout=1					-0.097	0.154
					(-0.409)	(0.767)
Buyout*IRR					0.491	0.176
					(1.580)	(0.613)
Fund size(t-1)	-0.166***	-0.153***	-0.155***	-0.128***	-0.161***	-0.140***
	(-6.259)	(-6.730)	(-6.730)	(-7.235)	(-9.339)	(-9.699)
Constant	1.396***	1.465***	1.226***	1.162***	1.226***	1.220***
	(5.156)	(6.779)	(8.682)	(9.498)	(9.551)	(10.547)
Number of observations	383	383	529	529	912	912
Adjusted R2	0.232	0.196	0.208	0.148	0.221	0.179

Table 9. Fund growth and follow-on fund performance

The table reports the ordinary least square regression estimates of the following specifications: $(IRR)_t = \alpha_t + \beta_t (\text{Fund growth})_{t-1} + \gamma_t (IRR)_{t-1} + \delta_t (\text{Fund Size})_t + \varepsilon_t$. Fund growth, IRRs, and fund size are logarithmized. In Columns (5) and (6), I also include buyout fund dummy variable (taking the value of 1 if a fund is a buyout fund and 0 for a venture capital fund) and the interaction term between the buyout dummy variable and fund growth. Columns (1), (3), and (5) show the estimates of the regression of fund growth on unadjusted IRRs, and Columns (2), (4), and (6) show the same for the regression of fund growth on benchmark adjusted IRRs. Benchmark IRRs are the median IRRs of the portfolio of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, and buyout). In all regression estimations, I exclude funds raised after 2005. In Columns (1), (3), and (5), I include vintage fixed year effects. The numbers in the parentheses are t-statistics. Standard errors are clustered at the PE firm level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds		Venture Capital Funds		All Funds	
	IRR	Adjusted IRR	IRR	Adjusted IRR	IRR	Adjusted IRR
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Fund Growth (t-1) to (t)	0.001	-0.009	-0.064***	-0.069***	-0.074***	-0.069***
	(0.092)	(-0.568)	(-3.555)	(-4.662)	(-4.062)	(-4.132)
IRR (t-1)	0.443***	0.417***	0.250***	0.257***	0.330***	0.281***
	(5.727)	(5.585)	(5.569)	(4.810)	(6.741)	(5.852)
Buyout=1					-0.036	-0.067***
					(-1.555)	(-2.814)
Buyout*Fund Growth					0.069***	0.065***
					(3.081)	(2.890)
Fund size (t)	-0.009*	-0.010*	-0.001	-0.006	-0.014***	-0.008
	(-1.900)	(-1.894)	(-0.061)	(-0.725)	(-2.629)	(-1.569)
Constant	0.489***	0.471***	0.644***	0.630***	0.627***	0.622***
	(7.520)	(8.048)	(9.601)	(9.398)	(10.434)	(11.145)
Number of observations	317	317	425	425	742	742
Adjusted R2	0.214	0.127	0.237	0.086	0.129	0.099

Table 10. The effects of fund growth on performance persistence

The table reports the ordinary least square regression estimates for the following specifications: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-1} + \beta_{1t} (\text{Fund growth})_{t-1} + \beta_{2t} (\text{IRR*Fund Growth}) + \beta_3(\text{Fund size})_t + \varepsilon_t$. The triple interactions of IRR, Time Gap, and the Buyout dummy variable is included in Specifications (5) and (6). Fund growth is the growth rate from the current to the follow-on fund. IRRs and Fund growth are logarithmized and demeaned. Buyout is a dummy variable taking 1 if the fund is a buyout fund, 0 otherwise. The column headings (1) and (2) are for buyout funds, and (4) and (5) are for venture capital funds. In all regression estimations, vintage fixed year effects are included. Standard errors are clustered at the PE firm level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds		Venture Capital Funds		All Funds	
	IRR	Adjusted	IRR	Adjusted	IRR	Adjusted
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
IRR (t-1)	0.441***	0.432***	0.383***	0.370***	0.424***	0.371***
	(6.472)	(6.610)	(7.449)	(7.339)	(9.863)	(8.595)
Fund Growth (t-1) to (t)	-0.000	-0.002	-0.053***	-0.060***	-0.058***	-0.055***
	(-0.002)	(-0.177)	(-2.739)	(-3.164)	(-3.613)	(-3.419)
IRR*Fund Growth	0.024	-0.143	-0.392***	-0.351***	-0.412***	-0.358***
	(0.188)	(-1.066)	(-5.338)	(-4.626)	(-6.518)	(-5.536)
IRR*Buyout					-0.149	0.012
					(-1.451)	(0.123)
Fund Growth*Buyout					0.044*	0.044*
					(1.805)	(1.847)
IRR*Fund Growth*Buyout					0.471**	0.279
					(2.446)	(1.389)
Buyout					0.023*	-0.025**
					(1.894)	(-2.045)
Fund size (t)	-0.009*	-0.010**	-0.004	-0.008	-0.007	-0.005
	(-1.820)	(-2.147)	(-0.591)	(-1.117)	(-1.428)	(-0.984)
Constant	0.828***	0.757***	0.782***	0.760***	0.794***	0.741***
	(21.595)	(26.520)	(19.650)	(21.925)	(29.103)	(27.193)
Number of observations	317	317	425	425	742	742
Adjusted R2	0.212	0.128	0.286	0.128	0.228	0.165

Appendix A. Transition probabilities from current fund performance quartiles to follow-on funds' performance quartiles (using benchmarked IRRs)

I sort all funds for which I have follow-on funds into performance quartiles (by benchmarked IRRs) and calculate the conditional probability that a partnership's 1st through 3rd follow-on funds will either stay in the same performance quartile, or move into one of the other three quartiles. The row headings with "Expected" are the expected probabilities that a follow-on fund will be in one of the four quartiles (column) under the assumption that the classification into one of the follow-on performance quartiles is purely random. The column heading with "Chi-square" reports Chi-square test statistics testing the null hypothesis of no association between current and follow-on funds performance. The first, second, and third five rows of each panel report transition probabilities from the current fund to the 1st, 2nd, and 3rd follow-on funds. Panels A and B report transition probabilities for buyout and venture capital funds, respectively. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Buyout Funds

		1	2	3	4	Total	Chi-square
Current	Expected	21.14%	27.13%	29.65%	22.08%	317	35.69 ***
to 1st	1	34.83	29.21	25.84	10.11	89	
follow-on	2	19.32	30.68	34.09	15.91	88	
	3	13.64	27.27	31.82	27.27	88	
	4	13.46	17.31	25.00	44.23	52	
Current	Expected	24.46%	24.46%	28.26%	22.83%	184	13.27
to 2nd	1	27.59	25.86	36.21	10.34	58	
follow-on	2	25.00	25.00	19.64	30.36	56	
	3	17.02	25.53	34.04	23.40	47	
	4	30.43	17.39	17.39	34.78	23	
Current	Expected	20.75%	24.53%	30.19%	24.53%	106	7.83
to 3rd	1	17.14	34.29	28.57	20.00	35	
follow-on	2	30.56	19.44	22.22	27.78	36	
	3	13.04	21.74	43.48	21.74	23	
	4	16.67	16.67	33.33	33.33	12	

Panel B. Venture Capital Funds

		1	2	3	4	Total	Chi-square
Current	Expected	25.41%	27.06%	25.41%	22.12%	425	38.52 ***
to 1st	1	37.27	27.27	24.55	10.91	110	
follow-on	2	30.51	28.81	25.42	15.25	118	
	3	16.82	30.84	25.23	27.10	107	
	4	14.44	20.00	26.67	38.89	90	
Current	Expected	26.15%	25.77%	25.00%	23.08%	260	7.62
to 2nd	1	34.78	24.64	20.29	20.29	69	
follow-on	2	28.05	25.61	24.39	21.95	82	
	3	23.81	23.81	26.98	25.40	63	
	4	13.04	30.44	30.44	26.09	46	
Current	Expected	22.62%	26.19%	29.17%	22.02%	168	18.49 **
to 3rd	1	36.74	22.45	28.57	12.24	49	
follow-on	2	19.64	19.64	26.79	33.93	56	
	3	10.26	30.77	35.90	23.08	39	
	4	20.83	41.67	25.00	12.50	24	

Appendix B. Pearson and Spearman correlations between current fund performance and follow-on fund performance using benchmark adjusted IRR

This table reports Pearson (Panel A) and Spearman (Panel B) correlations between current fund performance and follow-on fund performance (benchmark adjusted IRR). The benchmark adjusted IRRs are raw IRRs minus the median IRRs of the portfolios of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, or buyout). The first and second four rows of each panel are for buyout and venture capital funds, respectively. The second through fourth rows of each sub-panel require that a fund raise first through third follow-on funds. The row headings with F~F+t (t=1, 2, or 3) represents that a fund has benchmark adjusted IRR data from current through t-th follow-on funds. The first three columns report correlations, the second three columns report p-values, and the last three columns report the number of funds used to compute correlations.

		Panel A. Pearson correlation								
		IRR			*p* -value			N		
		F+1	F+2	F+3	F+1	F+2	F+3	F+1	F+2	F+3
Buyout	All	0.34	0.11	0.09	0.00	0.13	0.36	317	184	106
	F ~ F+1	0.34			0.00			317		
	F ~ F+2	0.24	0.10		0.00	0.22		166	166	
	F ~ F+3	0.35	0.09	0.12	0.00	0.42	0.28	82	82	82
Venture	All	0.13	0.01	-0.06	0.01	0.89	0.43	425	260	168
	F ~ F+1	0.13			0.01			425		
	F ~ F+2	0.20	0.00		0.00	0.95		228	228	
	F ~ F+3	0.20	-0.04	-0.08	0.02	0.67	0.39	135	135	135

		Panel B. Spearman correlation								
		IRR			*p* -value			N		
		F+1	F+2	F+3	F+1	F+2	F+3	F+1	F+2	F+3
Buyout	All	0.30	0.15	0.10	0.00	0.04	0.29	317	184	106
	F ~ F+1	0.30			0.00			317		
	F ~ F+2	0.25	0.15		0.00	0.06		166	166	
	F ~ F+3	0.33	0.14	0.17	0.00	0.20	0.12	82	82	82
Venture	All	0.28	0.09	0.00	0.00	0.14	0.99	425	260	168
	F ~ F+1	0.28			0.00			425		
	F ~ F+2	0.26	0.06		0.00	0.41		228	228	
	F ~ F+3	0.30	0.04	0.02	0.00	0.66	0.82	135	135	135

Appendix C. Subsequent fund performance (benchmark adjusted IRRs) by quartile portfolios based on current fund performance

Each fund is sorted into quartile rank portfolios in each vintage year based on its benchmark adjusted IRR. Benchmark adjusted IRRs are raw IRRs minus median IRRs of a portfolio of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, and buyout). Next, mean and median benchmark adjusted IRRs are computed for follow-on funds in each quartile. The column headings with F+t where t takes 1, 2, or 3 represent the t-th follow-on fund. F is the current funds used to form the initial portfolios. Panel A is for buyout funds; Panel B for venture capital funds. Sub-panel A includes all funds. Sub-panels B through D require that a fund has 1st, 2nd, and 3rd following funds, respectively. The last four columns report the number of funds included in the computation of the mean and median values. The last row of each sub-panel reports t-statistics (for the tests of differences in mean IRRs between portfolios 1 and 4) and Wilcoxon rank sum Z-statistics (for the tests of difference in median IRRs between portfolios 1 and 4). Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Buyout

	Mean				Median				N			
Quartile	F	F+1	F+2	F+3	F	F+1	F+2	F+3	F	F+1	F+2	F+3
A. All funds												
All	2.63	2.98	2.96	2.87	0.63	0.55	1.63	0.88	668	317	184	106
1	26.23	11.39	5.17	0.74	20.45	5.25	1.98	0.95	157	89	58	35
2	6.07	3.15	0.59	4.12	5.25	1.03	2.38	0.62	173	88	56	36
3	-2.98	-0.69	3.38	5.01	-2.93	-2.03	-0.85	2.10	174	88	47	23
4	-17.66	-5.50	2.33	1.24	-14.43	-5.03	4.25	-5.55	164	52	23	12
Diff(1-4)	20.87***	3.51***	0.35	-0.42	14.55***	-4.03***	-0.81	0.3				
B. Funds with 1st follow-on funds' IRR available												
All	5.52	2.98			2.60	0.55			317			90
1	24.51	11.39			17.85	5.25			89			31
2	6.32	3.15			5.23	1.03			88			28
3	-2.51	-0.69			-2.60	-2.03			88			21
4	-14.75	-5.50			-12.05	-5.03			52			10
Diff(1-4)	13.27***	3.51***			-9.35***	-4.03***						
C. Funds with 1st and 2nd follow-on funds' IRR available												
All	8.69	5.37	2.22		6.10	2.20	1.18		166	166		82
1	26.22	11.72	4.20		20.80	7.40	1.80		54	54		31
2	8.22	4.48	-0.78		6.70	2.15	1.03		46	46		25
3	-2.15	1.41	2.95		-2.60	-0.60	-0.15		44	44		18
4	-11.67	-0.40	2.21		-11.15	-4.70	2.75		22	22		8
Diff(1-4)	13.01***	2.41**	0.56		-6.37***	-3.09***	-0.95					
D. Funds with 1st, 2nd, and 3rd follow-on funds' IRR available												
All	12.98	7.82	3.68	2.27	8.15	5.65	2.15	0.88	82	82	82	82
1	29.29	15.04	6.25	2.82	29.05	10.00	2.10	2.95	31	31	31	31
2	9.06	6.27	1.35	0.86	6.75	2.10	2.20	-0.15	25	25	25	25
3	0.14	3.54	1.41	2.39	-1.20	2.83	1.73	-1.48	18	18	18	18
4	-9.04	-5.67	6.12	4.22	-7.75	-5.53	4.23	1.33	8	8	8	8
Diff(1-4)	8.41***	6.02***	0.08	-0.26	-4.18***	-3.59***	-0.19	0.02				

Appendix C. (Continued)

Panel B. Venture Capital

	Mean				Median				N			
Quartile	F	F+1	F+2	F+3	F	F+1	F+2	F+3	F	F+1	F+2	F+3
A. All funds												
All	8.07	11.41	16.62	20.90	0.07	0.50	0.18	0.36	884	425	260	168
1	47.76	22.93	27.85	31.54	20.50	4.05	3.40	3.30	211	110	69	49
2	7.35	20.05	12.08	8.64	4.07	3.70	-0.15	-1.48	224	118	82	56
3	-3.41	1.34	20.47	2.82	-3.17	0.00	-0.60	0.00	229	107	63	39
4	-17.33	-2.04	2.60	57.19	-13.80	-3.28	-0.91	4.00	220	90	46	24
Diff(1-4)	8.85***	3.12***	1.56	-0.71	16.51***	-3.96***	-0.92	1.14				
B. Funds with 1st follow-on funds' IRR available												
All	14.70	11.41			1.60	0.50			425			149
1	62.10	22.93			29.40	4.05			110			44
2	9.62	20.05			5.95	3.70			118			51
3	-3.57	1.34			-3.60	0.00			107			35
4	-14.87	-2.04			-13.65	-3.28			90			19
Diff(1-4)	5.52***	3.12***			-10.75***	-3.96***						
C. Funds with 1st and 2nd follow-on funds' IRR available												
All	17.31	16.88	17.12		3.73	1.68	0.18		228	228		135
1	61.30	29.34	25.08		42.05	6.10	2.40		63	63		43
2	12.29	28.82	13.55		8.08	5.38	-0.02		70	70		46
3	-3.45	-0.22	21.37		-3.65	-0.35	-0.79		57	57		30
4	-15.22	-0.08	4.10		-12.90	-1.20	0.53		38	38		16
Diff(1-4)	9.7***	2.28**	1.18		-7.01***	-1.83*	0.01					
D. Funds with 1st, 2nd, and 3rd follow-on funds' IRR available												
All	22.13	17.07	24.51	24.79	8.10	5.35	1.30	0.00	135	135	135	135
1	61.61	31.22	30.32	35.48	42.05	12.90	2.40	3.40	43	43	43	43
2	12.88	20.72	13.38	8.25	8.85	8.70	-0.02	-2.25	46	46	46	46
3	-2.13	-2.44	38.92	4.12	-1.69	-1.18	0.20	0.08	30	30	30	30
4	-11.95	5.11	13.83	82.36	-7.43	4.18	0.50	-0.35	16	16	16	16
Diff(1-4)	8.27***	1.74*	0.05	-0.84	-4.52***	-0.43	0.87	1.53				

Appendix D. Cross sectional regression of current performance on past performance (funds with vintage year before 1996)

The table reports the estimates of the following regression: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-\tau} + \gamma_t (\text{Fund Size})_t + \varepsilon_t$, where τ is 1, 2, or 3 and t- τ represents τ-th previous funds. Funds raised after 1995 are excluded from the estimations. The dependent variable is the logarithms of IRRs of current funds. The independent variables are the logarithm of IRRs and the logarithm of fund size of the first, second, and third previous funds in the first, second, and third panels, respectively. In Columns (1) and (3), unadjusted IRRs are used as independent and dependent variables, and vintage year fixed effects are included. In Columns (2) and (4), benchmark adjusted IRRs are used as independent and dependent variables, where benchmark IRRs are the median IRRs of portfolios of funds with same vintage year, geographic focus, and investment type (early stage, venture capital, or buyout). The standard errors are clustered at the PE firm level. Columns (1) and (2) estimate the equation for buyout funds and Columns (3) and (4) for venture capital funds. The numbers in the parentheses are t-statistics. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, *, respectively.

Panel A. Current IRR on first previous fund's IRR

	Buyout		Venture Capital	
	IRR	Adjusted IRR	IRR	Adjusted IRR
	(1)	(2)	(3)	(4)
IRR (t-1)	0.494***	0.418***	0.636***	0.666***
	(4.652)	(3.428)	(3.236)	(3.589)
Fund size (t)	-0.003	-0.004	-0.007	-0.000
	(-0.668)	(-0.423)	(-0.284)	(-0.003)
Obs	53	53	107	107
Adjusted R2	0.403	0.153	0.339	0.149

Panel B. Current IRR on second previous fund's IRR

IRR (t-2)	0.135	0.269*	0.502	0.576
	(0.672)	(1.678)	(1.127)	(1.439)
Fund size (t)	-0.022*	-0.021	0.004	0.011
	(-1.951)	(-1.614)	(0.111)	(0.285)
Obs	50	50	92	92
Adjusted R2	0.238	0.095	0.044	0.050

Panel C. Current IRR on third previous funds' IRR

IRR (t-3)	0.101	0.174	0.060	-0.162
	(0.642)	(1.261)	(0.305)	(-0.826)
Fund size (t)	-0.017	-0.014	-0.053	-0.047
	(-1.509)	(-1.233)	(-1.250)	(-1.118)
Obs	48	48	83	83
Adjusted R2	0.060	0.014	0.052	0.008

Appendix E. The effects of similar market conditions on performance persistence (using benchmark adjusted IRRs)

The table reports ordinary least square regression estimates for the following specifications: $(IRR)_t = \alpha_t + \beta_t (IRR)_{t-1} + \beta_{1t} (MSM)_{t-1} + \beta_{2t} (IRR*MSM) + \beta_{3t}$ $\beta_{3t}(Fund\ size)_t + \varepsilon_t$, IRRs are benchmark adjusted. Benchmark adjusted IRRs are raw IRRs minus median IRRs of a portfolio of funds with same vintage year, geographic focus, and investment type (early stage, venture capital or buyout). MSM is the market similarity measure defined as the absolute value of ((Market Condition)$_{i,t+1}$ / (Market Condition)$_{i,t}$ -1). Market condition variables are the 1) IPO volume from the fifth to tenth year of a fund's life (the column heading with 'IPO volume'), 2) GDP growth during a fund's life ('GDP growth'), 3) S&P 500 stock returns over a fund's lifetime ('S&P500 returns'), 4) three month Treasury bill yield during first five years of a fund's life ('T-bill'), and and 5) the ratio of average S&P 500 price earnings ratio during first five years to that during subsequent five years. IRRs and MSM are logarithmized and normalized with a mean of zero and a standard deviation of one. The first five columns are the estimates for buyout funds, and the last five columns are the same for venture capital funds. Standard errors are clustered at vintage year level. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

	Buyout Funds					Venture Capital Funds				
	IPO Volume	GDP Growth	S&P500 returns	T-bill	S&P500 PE ratio	IPO Volume	GDP Growth	S&P500 returns	T-bill	S&P500 PE ratio
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
IRR(t-1)	0.223***	0.230***	0.327***	0.336***	0.233***	0.254***	0.266***	0.278***	0.321***	0.226***
	(2.864)	(3.376)	(4.753)	(7.201)	(3.335)	(3.834)	(4.716)	(5.692)	(3.666)	(2.721)
MSM(t)	0.133	0.135*	0.197***	-0.073	0.161***	-0.086*	-0.166***	-0.179**	-0.056	-0.056**
	(1.482)	(1.655)	(7.133)	(-1.413)	(3.650)	(-1.926)	(-3.198)	(-2.436)	(-1.234)	(-1.965)
IRR*MSM(t)	-0.225*	-0.260**	-0.024**	-0.135***	-0.316***	-0.042***	-0.084***	-0.341***	-0.131	-0.072
	(-1.867)	(-2.446)	(-2.426)	(-4.107)	(-2.826)	(-3.840)	(-3.475)	(-2.919)	(-1.467)	(-1.337)
Fund Size (t)	-0.057	-0.060	-0.093*	-0.104**	-0.066	-0.093	-0.092	-0.095*	-0.077	-0.084
	(-0.976)	(-0.978)	(-1.799)	(-1.965)	(-1.217)	(-1.334)	(-1.356)	(-1.687)	(-1.377)	(-1.263)
Constant	0.347	0.354	0.570*	0.635*	0.410	0.455	0.447	0.451	0.378	0.411
	(0.945)	(0.917)	(1.760)	(1.906)	(1.199)	(1.278)	(1.321)	(1.522)	(1.274)	(1.194)
Obs	252	252	317	317	252	358	358	425	425	358
Adjusted R2	0.114	0.122	0.152	0.149	0.098	0.065	0.093	0.098	0.071	0.055