Investor Scale and Performance in Private Equity Investments

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October 2013

Abstract

We find that defined benefit pension plans that invest significant amounts in private equity (PE) earn 7.4% per year greater returns than plans that invest small amounts. One third of this outperformance comes from lower costs for larger PE investors that we find are related to economizing on costly intermediation by avoiding fund-of-funds and by investing directly, avoiding LP fees. The bulk of the performance gains come from superior gross returns for larger PE investors. Superior access explains only part of the outperformance. We present evidence supporting a conjecture that the remaining superior return arises from more information and information processing ability of substantial PE investors. Consistent with these return patterns, we find disproportionately more investments in PE by plans with the ability to scale up their PE investments.

JEL classification: G11, G20, G23.
Keywords: private equity, alternative assets, pension funds, investment management, size, economies of scale

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Knowledge of the economics of private equity (PE) is based in large part on studies of limited partner (LP) investments of a typical investor in a private equity partnership (e.g. Metrick and Yasuda (2007)). There are good reasons to go beyond such data to assess PE attractiveness for investors. Many PE investors do not restrict themselves to LP investing, but also invest through fund-of-funds, and a growing amount of money is invested directly in PE, either directly or alongside general partners as a co-investment. The resulting cost differences arising from alternative uses of intermediation services could influence performance. Probably of more importance, PE investors differ in their skills in identifying and getting access to better performing partnerships, and in their ability to monitor performance, potentially producing very different gross returns from their PE investments.

Variation in net returns across PE investors is particularly important if the deviations are not random, but rather are linked to specific investor characteristics. Lerner, Schoar and Wongunswai (2007) provided evidence that one important characteristic in the 1990s was investor type, with annual returns for endowments 21% greater than average PE returns. In this paper we focus on another investor characteristic, the scale of investment in PE, and see whether this characteristic is also associated with differences in returns.

The possibility of scale-related differences in performance has been sidestepped in much of the PE literature, in large part as a result of data availability. Studies that rely on the PE holdings of one investor (e.g. Metrick and Yasuda (2007), Robinson and Sensoy (2012)) cannot speak to potential scale related differences in performance. Likewise, studies of LP returns (e.g. Kaplan and Schoar (2004), Phalippou and Gottschlag (2009)) cannot speak to potential gross return and cost differences across investors' PE portfolios of funds and internal investments.

To study potential scale-related differences in overall returns to PE investing, one needs data on PE portfolios in a sample that includes investors with very different PE holdings. Ideally, this sample will also hold constant investor type to get a clearer identification of a scale effect. We use precisely such data from a large international sample of defined benefit pension (DB) plans made available by CEM Benchmarking Inc. (CEM), a Toronto-based global benchmarking firm. The database includes 874 separate international plans over the years of 1990 to 2009 with significant cross-sectional and time series variation in the scale of their PE investing. At the end of our sample, plan assets are about US$5.5 trillion, including $268 billion in PE holdings. The largest investors in our sample allocate over 10% of their assets to PE, producing PE holdings of as much as $15-25 billion.

Analysing the CEM data, we find that investors with substantial PE investments perform significantly better in PE than investors with small PE investments. Largest quintile PE investors, with $6 billion in PE on average at the end of the sample, have 7.4% per year higher net returns (gross returns minus cost) than the smallest quintile PE investors. This relationship between investor scale in PE and PE performance is monotonic in PE holdings, robust, and consistent across time (e.g., 1990-1999, 2000-2009) and geographies (e.g., US only, Canada only, Australia and Europe only). While a positive size-performance relationship could reflect systematic differences in risk exposures between significant and small investors, additional tests suggest this is unlikely.

We seek to explain this positive scale and performance relationship. At first glance it is surprising as a central insight from theory is that we should not expect any relationship between investment scale and performance if the market for capital investment is frictionless and competitive. This is demonstrated clearly in Berk and Green's (2004) model of mutual funds, where in a setting where fund managers have different abilities, all investors receive the same returns. This happens because skilled managers instantaneously attract inflows and the increasing size of their fund erodes performance. Investors then all expect the same performance, regardless of manager skill, with fund managers appropriating any surplus. These predictions are in line with the stylized facts from the mutual fund literature of no persistence and, if anything, decreasing returns for larger funds (Chen, Hong, Huang, and Kubik (2004)).

However, the economic model described above does not fit PE, creating an opportunity for investor characteristics to affect returns. The non-tradable nature of PE means that funds cannot accept flows nearly as rapidly as mutual funds. Moreover, the PE literature finds that skilled managers do not raise fees on subsequent funds sufficiently to appropriate the whole surplus. Kaplan and Schoar (2005) document outperformance in gross returns and persistence in net returns across different funds raised by top quartile companies; more recent evidence suggests that persistent outperformance may be even more widespread (Harris, Jenkinson and Kaplan (2013), Stucke (2012), Robinson and Sensoy (2012)). Thus, there are rents in PE and these rents are captured by at least some investors.

We explore potential economic factors that could create a relationship between investment scale and performance. We first document significant costs savings for substantial PE investors. We hypothesize that as investors make larger PE investments they will reduce their reliance on costly intermediaries. We find that investors both limit the use of the most costly fund-of-funds and they start to invest directly, avoiding intermediation fees completely (e.g., through co-investments), with the largest quintile PE investors having 10% of their portfolios invested using lowest cost direct investing. We also hypothesize and find evidence consistent with superior negotiating power of large investors, who have lower costs within each investment approach. Taken together, the differences in costs between larger and smaller investors in PE account for up to one third of larger investors' outperformance.

Such cost savings could come at the expense of more poorly targeted and executed investments. We find the reverse. Larger investors also have superior gross returns. Superior access to top performing PE partnerships, experience or 'clout' of larger PE investors could potentially explain this outperformance. Our proxies for access suggest it is important for LP returns, accounting for up to 20% of the outperformance and for overall PE returns. We do not find evidence of a significant impact using our proxies for experience and clout.

We conjecture that the most likely explanation for the remaining superior return is that PE scale is associated with more information and information processing ability. While we have no direct measures of information processing to test this conjecture, it does offer the simplest explanation for three facts we document: larger investors use fewer intermediation services; larger investors deliver superior gross returns in each PE investment approach (fund-of-funds, LP investing and direct investing) consistent with a common capability; and, we find a positive association between skill in internal investing (associated with larger investors) and subsequent performance in fund investing.

We also consider the hypothesis of organizational diseconomies (e.g. Stein (2002), Chen, Hong, Kubik and Stein (2004)) that predicts that scale will eventually reduce performance, as hierarchies emerge and discourage collection of relevant soft information to maximize returns to PE investing. We find some evidence of concavity in the scale and performance relationship. The point estimates imply that at $34 billion in PE further scale starts to reduce performance, a scale of investing somewhat beyond the largest PE investors in the database and substantially beyond the typical scale of DB plans' PE holdings.

These differences in returns, that we have found linked to larger investors' abilities to lower costs and deliver gross returns, provide an explanation for patterns of asset allocation by DB plans. We find asset allocation to PE increases monotonically with plan size, with top quintile plans having six times to the allocation of smallest quintile plans. These results hold also when we control for proxies for differences in risk appetite and liquidity risk across plans. Thus, institutions that can potentially become large PE investors indeed choose to do so, in line with a belief that they have a comparative advantage in PE.

Prior work (Lerner, Schoar and Wongsunwai (2007)) has suggested investor *type* drives returns to LP investing, linking return differences to superior access and experience for endowments. Sensoy, Wang and Weisbach (2013) suggest this effect was limited to the 1990s and went away with the maturing of the private equity industry. Our contribution differs in holding *type* fixed, focusing on differences across investor scale, and using investors' full PE portfolio. We also emphasize different drivers of the performance differences: cost savings tied to scale of investing; a limited role for access in explaining gross returns; and, we introduce a conjecture, and provide evidence consistent with, a comparative advantage of larger investors in information processing capability.

Prior research using endowment data provided some indications that investor scale might be important (e.g. Lerner, Schoar, and Wang (2008)) but scale impacts were not emphasized, and are constrained by endowments' limited size. DB plans are substantially larger providing substantial variation in PE investment scale. Other work explores whether scale of *funds* influences performance, with the most recent studies (e.g. Harris, Jenkinson, and Kaplan (2013)) finding no evidence of a relationship between LP fund size and performance. Thus, if the only difference between large and small PE investors was the scale of the funds in which they invest, we would find no relationship between investor scale and performance.

The rest of the paper is organized as follows. Section I describes our data. Section II examines the impact of investor scale in PE on performance. Section III explores the economic determinants of the performance differences between significant and smaller PE investors. Section IV tests whether investor scale influences asset allocation and Section V concludes.

I - Data

I.1 Datasource

To examine links between the scale of investment in PE and performance we use PE holdings, costs, and returns from an international sample of pension plans provided to us by CEM Benchmarking, Inc. (CEM), a Toronto-based global benchmarking firm. The data is based on survey responses of 874 distinct pension plans and spans the years 1990 to 2009 with 5,406 plan-year observations. Table I provides an overview. In the average sample year, we have 270 funds that account for $2.9 trillion in assets under management (AUM), with the maximum of 368 plans per year and $5.5 trillion in AUM. The average plan manages $10 billion while the median plan size is $2.5 billion, indicating positive skewness in size. PE holdings per year average $705 million over the time period, growing to $1.4 billion per year in the last 3 sample years. US plans (corporate plans) account for 57% (55%) of our observations and include a greater fraction of the largest (smaller) plans.

Particular strengths of the CEM database are that it has performance data for the full PE portfolio (including LP investments, fund-of-fund investments, and direct investments) and that it reports returns separately by each of these approaches. To the best of our knowledge, ours is the first paper that breaks out data on PE holdings managed by internal managers. Plans also report separately the gross returns and costs that produce net returns, and this reporting is subject to validation checks by the data provider. The cost data is based on the dollar amounts investors in our sample paid to managers (including base and performance fees) and the plan's activity-based allocation of fixed costs to that activity.[1]

Alongside these strengths are limitations. CEM performance data are internally reported annual returns by PE investment approach that boards use in assessing performance across all of their various investments. Returns are based on capital distributions from exited investments and on changes in audited net asset value (NAV) for remaining portfolio investments divided by invested capital (including new investments). Thus, returns rely in part on NAV calculations. While the use of NAVs is unavoidable in PE research, it is still a potential concern for assessing performance as recent studies suggest NAVs are conservative with respect to ultimate returns to LP investment.[2]

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[1] External active management costs include "All fees paid to third-party managers including investment management fees, manager-of-managers fees, performance-based fees, commitment fees and 'hidden' fees netted from the returns" and "other internal and external costs that can be directly attributed to specific externally managed holdings." For example, CEM directs respondents in the following way: "the costs of a trading system used by both internal domestic stock and fixed income managers should be allocated to both internal domestic stock and fixed income investment cost based on an estimate of usage. A simpler and acceptable alternative allocation method is to allocate overhead costs based on relative direct head count." Instruction and Footnotes, 2009 US Defined Benefit Pension Fund Survey. http://www.cembenchmarking.com/Surveys/SurveyDownload.aspx

[2] Kaplan and Schoar (2005) for example restricted attention to funds that had substantially exited their investments. Yet even, in this case NAV estimates affected reported returns. See the discussion in Stucke (2012) of the concerns with NAV reporting in Venture Expert. The CEM use of NAVs does not suffer from systematic weaknesses reported with Venture Expert data as it come from the investors themselves. Including data from more recent vintage years which account for the bulk of PE investment requires more reliance on NAVs, as discussed in Harris, Jenkinson, and Kaplan (2013). Recent studies provide some evidence of the extent of conservatism in NAVs, although showing this is least pronounced for annual audited data (e.g. Jenkinson, Sousa, and Stucke (2013)).

CEM performance data is also at the level of overall holdings for each investment approach (e.g., all external LP positions) rather than fund-level data with specific inflows and outflows for each specific PE investment. This means we cannot provide alternative performance measures such as Public Market Equivalent returns (Kaplan and Schoar (2005) and Harris, Jenkinson, and Kaplan (2013)), we cannot introduce vintage year controls at the fund level, and we cannot break out separately returns by buyout and venture fund investments. We capture some elements of time variation in returns through a variety of controls: we include year fixed effects, explore sensitivity of results by excluding years associated with abnormally strong vintage years, and also report the time series averages of the cross sectional results to reduce the reliance on any specific year. We attempt to address potential differences in returns arising from unmeasured differences in the reliance on buyout by introducing controls to capture the importance of such factors, comparing returns over time, and including non-parametric tests for size-related returns.

Given these data limitations, the CEM performance data is less appropriate for assessments of absolute PE performance than studies that take advantage of fund-level cash flow information. At the same time, data on the overall PE portfolios is what is required to assess if there are different returns between larger and smaller PE investors, particularly because most investors do not limit themselves to LP investing. Moreover, in focusing on differences in returns between large and small investors we expect little impact from potential systematic biases in reporting (e.g. from NAVs or vintage years) that may come with CEM data. Such biases are likely to be widespread across PE investors and independent of investment scale and therefore will have a similar impact on returns for substantial and small PE investors. Where possible, we identify situations where potential biases (e.g., differential risk exposures) might depend upon scale and conduct additional tests to ascertain their potential importance.

We use the provided data as given, with the following changes. Holdings are provided in each plan's local currency. To ensure comparability across plans from different countries we express asset holdings in real (2009) US dollars using interbank exchange rates as of December 31 of each sample year and the CPI deflator from St. Louis Fed.[3] We winsorize cost and return data at the 1st and the 99th percentile to avoid results being driven by a few extreme observations that remain even after the CEM vetting process. For each plan we have an ID, country or region of domicile (e.g., US, Canada, etc.), ownership (corporate, public, other[4]), the fraction of liabilities that are due to current retirees, etc. Our data provider requires us to preserve plan anonymity and does not allow us to match data with alternative data sets.

The dataset is an unbalanced panel over the 1990-2009 period. The mean (median) length of time a plan with a given ID is in the sample is 6.2 (4) years. The relatively short duration in the dataset arises from the increasing number of participants in the

[3] Results are substantially similar if we also express returns in dollar terms. Moreover, our baseline results are identical if nominal holdings size is used (because the CPI adjustment becomes additive when we use log size and is then subsumed in year fixed effects).

[4] The 'other' category accounts for 600 plan-year observations and includes union pension plans, insurance funds, and a few endowments and sovereign wealth funds. Results are robust to excluding this category.

benchmarking service over time,[5] from the fact that CEM assigns new identifiers to plans following a substantial change in the structure of plan membership (e.g. a merger), and from other idiosyncratic reasons that lead plans to cease to participate in the benchmarking service.

The scale of investment in PE differs significantly across plans. Measured over the whole sample, the median plan invests $114 million into PE, while the largest plans average $3 billion in PE investments. We also present data for the last three years in the sample to account for the time trends in PE investments[6] (described in more detail below). In the most recent years, the median PE investment doubles to $242 million, with the 1st quintile PE investors investing $27 million and the 5th quintile $5.7 billion.

I.2 Coverage, Representativeness and Potential Biases

As with any new data source, there are questions about its coverage, representativeness, and potential biases. The CEM database is the most comprehensive database on pension plan asset allocation, performance, and costs that we are familiar with.[7] It has been used in previous papers including French's (2008) presidential address on the costs of active investing, Bauer, Cremers and Frehen's (2011) analysis of US plans'

[5] For example, 168 of the 874 plans appear in the data only in 2006 or later, so these plans can have at most 4 observations. The average plan appears in 57% of years following its addition year.

[6] Harris, Jenkinson, and Kaplan (2013) report $794 billion in PE commitments in 2005-2008, compared to $668 billion in the previous decade of 1996-2004, and $148 bn in the previous 15 years for 1980-1995.

[7] For example, Novy-Marx and Rauh (2010) rely on a sample of 116 state plans, Ferson and Khang (2002) use data on equity holdings of 60 pension plans between 1984 and 1994, Blake, Lehmann, and Timmerman (1999) have 9 years of data on 306 UK pension plans, Coggin, Fabozzi, and Rahman (1993) have 8 years of data on 71 US equity pension plan managers. In comparison, our US sub-sample includes 171 public, 323 corporate, and 50 other (predominantly union) plans and spans the period 1990-2009. There are other papers that occasionally use more plans, but have much less data about each of the plans (e.g. Rauh (2006) uses a larger sample of 1,522 corporate plans from 1990 to 1998 that he could match with IRS data).

investments in US equities, and Dyck, Lins, and Pomorski (2013) study of Canadian and US plans investments in foreign equities.

The database is particularly strong in its coverage of very large plans, aided by the inclusion of international plans. The sample includes on average (max) 26 (104) plans with more than $10 bn a year, 29 (52) plans with more than $25 bn a year, and 5 (11) plans larger than $100 billion per year. While the cost of the benchmarking service is moderate, it is more easily covered by larger plans whose sponsors are more likely to demand the benchmarking as part of their governance of the plan. Our data provider allowed us to compare the list of plans covered to the list of top 1,000 US pension plans published by the trade journal 'Pensions and Investments' for 2007. The CEM database includes at least 215 plans in the top 1000, with a higher percentage of CEM plans among the largest plans (172 plans in the top 500, 110 in the top 200 and 57 plans in the top 100). Testimonials on the CEM website and publicly available statements show that the service is used by many of the largest plans in the world.[8] We have particularly strong representation from US and Canadian pension plans: At the end of the sample US plans account for approximately 45% of assets in US defined benefit pension plans and Canadian plans account for 90% of assets in Canadian plans.

[8] Publicly available information from the CEM website and plan public disclosures show that the participants include the large American plans CalPERS ($199B in assets according to 2009 Pensions and Investment's Databook) and CalSTRS ($130B), the large Canadian plans CPPIB ($122B) and Ontario Teachers ($92B), and the large European plans PFZM/PGGM ($124B) and ABP/APG ($300B).

While the database is quite comprehensive, it does not cover the universe of plans, raising questions whether the omitted plans might have different characteristics than the included ones. This would be a significant concern if, for example, the larger plan strategically reported only in their good years and the smaller plans reported in both good and bad years.

To explore these issues we first compared asset allocation of the US plans in the CEM database with asset allocation in the Pensions and Investments 2007 top 200 US funds list (the sample for which they report asset allocation) and found statistically indistinguishable and economically small differences across the two samples. We next looked at performance of pension plans of publicly-traded US firms that are required to report net plan returns in their annual statements and which Compustat covers since 1996. The time series averages of the equally-weighted cross sectional average (median) returns of such plans in the CEM database are 7.3% (7.0%) (CEM has on average 87 US corporate plans per year with the maximum of 123). There are many more plans reported by Compustat firms (2137 on average), the bulk of which are substantially smaller. The average return of these plans is 6.6% for the whole sample, 6.9% for plans at least as large as the smallest CEM plan ($25m), and 7.4% for the largest 200 corporate plans. Our interpretation of these comparisons is that our US sample is comparable with the population of plans in Compustat, but skewed towards larger plans. We do not have population data and cannot carry out similar analyses for non-US plans. However, the Canadian data is particularly comprehensive (in 2009 for example we capture 90% of all Canadian defined benefit assets), so there are fewer ex ante concerns of bias here.

Another potential bias would be if firms came in and out of the database based on their performance. There is no survivorship bias as the plans that no longer report do remain in the database. We also compared the net returns minus benchmark returns of new plans (plans that enter the database in year *t*) and plans that have reported in the immediately preceding year (have reports in both year *t* and year *t*–1). The difference is essentially zero (-0.002%). Similarly, the difference in the performance of plans that skip a year (enter the database before year *t* and report in year *t*, but not in year *t*–1) and plans that continue reporting (report in both years *t* and *t*–1) is tiny (-0.05%).[9] These results suggest it is unlikely that plans strategically report only in years when their performance is superior.

There is no bias in the reporting of PE holdings and performance, as plans report the holdings and returns to their complete PE portfolio.

II Size and Performance in Private Equity

II.1 Descriptive Data

To begin our exploration of a possible relationship between the scale of investment in PE and performance we turn to the descriptive statistics of Table I. This data is based on

[9] Bauer, Cremers, and Frehen (2011) also use the CEM database and were allowed by the data provider to match the US corporate plans in the database to Compustat, matching 67% of the CEM firms. They find no significant return difference between plans that enter or leave the CEM database and plans that remain in the data.

the full time period of 1990-2009. To limit the effect of any particular year, we sort plans into quintiles in each year based on the previous year's holdings (e.g., 1990 holdings for 1991 data), and report the time series averages. In the far right column we report differences between the largest and the smallest PE investor quintiles. Given the time series pattern of increasing holdings in PE (that we report later in Figure 2), the reported average holding size is likely not to be representative of any specific year. As one way to address this limitation, we also report at the bottom of the panel the patterns in returns for just the final 3 years of the sample, when CEM had the most plans and more plans were likely to have some PE investments.

These data provide early indications of superior returns for substantial compared to the smallest PE investors. Compared to small investors, larger investors have on average a superior gross return of 8.8% per year, lower costs of 201 basis points per year, and superior net returns of 10.8% per year, with the differences in gross and net returns monotonic in size quintiles. At the end of our sample period (2007-2009), a more challenging period for PE, significant differences remain with a 5.9% per year greater return for larger investors.

It is common in the PE literature to adjust performance for exposure to systematic risk by looking at returns in excess of a measure of the market portfolio producing a 'public market equivalent' return. Schoar and Kaplan (2004) use the S&P 500, assuming a beta of one, while Harris, Jenkinson, and Kaplan (2013) also express returns relative to alternative indices (e.g. Russell 3000, Russell 2000 and Russell 2000 Value) and alternative assumptions about beta. Our data do not allow us to use specific cash inflows and outflows to produce such a measure, but we can produce a simpler measure of 'excess' net returns by subtracting S&P 500 returns from annual reported net returns, lagging index returns by one quarter to reflect an expected time lag in PE reporting (e.g., Jegadeesh, Kraussl, and Pollet (2011)). This lowers mean returns to PE investing to 2.6% per year but has no effect on the *differences* across investors in returns. Any corrections for exposure to systematic risk that are common to small and large PE investors drop out when we compute performance differences.

A more important concern is potential differences in the risk profiles of PE portfolios of larger and smaller investors. Below we address this possibility by introducing controls for investment approach, for potential differences in the types of funds between large and small PE investors, and for exposure to risk factors. Here, as a more crude way to address concerns about differential risk exposure possible with summary statistics, we assess performance by subtracting from net returns a benchmark PE return set by plan sponsors (who have full information on their portfolio). If set properly, these benchmarks should capture important cross-sectional and time series differences across portfolios. The data suggests this is a more demanding hurdle than S&P500 returns, with mean net returns minus benchmark of -1.7% per year (versus +2.6% for S&P500). More importantly, the resulting performance difference between large and small plans is 9.7%, substantially the same as without benchmarks.

These summary statistics, while suggestive, are not sufficient to establish a link between size and performance. Domicile (US or non-US) and sponsorship (corporate versus public) also correlate with size and could be driving the relationship, factors other than size may influence returns, and there are better ways to address risk. We address these issues in a regression framework.

II.2. Size and Performance in Private Equity

In Table II we use multivariate regressions of performance on scale of PE investment exploiting simultaneously cross-sectional and time-series variation in size in our sample. In all these regressions we define 'investment scale' as the logarithm of previous year dollar PE holdings. In our primary regressions the dependent variable is the net return (the difference between gross returns and costs).[10]

Having greater dollars invested in PE predicts stronger performance. A simple univariate regression (untabulated) produces a positive and significant coefficient on lag log PE holdings of 1.096 (t-stat of 4.39). More compelling are regressions with controls in Table II. In (1) we arrive at a similar result with controls for sponsorship (corporate or not) and domicile (US or not) that covary with size. In (2) we redefine the performance measure as 'excess' net returns by subtracting the S&P 500 benchmark return, producing again a statistically significant positive coefficient on lag log PE holdings of 1.739. Our

[10] CEM reports that in earlier sample years plans had some difficulty in identifying PE gross returns and costs separately. This may introduce noise to our later analysis when we separately look at gross returns and costs but does not affect the analysis here as we are looking at net returns.

preferred baseline regression is (3) that uses net returns as the dependent variable, the controls in (1), and year fixed effects. Year fixed effects are also equivalent to a common benchmark on returns, so there is no benefit to using excess returns, and capture in a crude way the impact of vintage years. There may be correlation of residuals within a plan across years and within a year across plans. To account for the former, we cluster errors at the plan level. To account for the letter, we follow Petersen (2011), who in settings like ours (a large number of plans per year, but relatively few years per plan) recommends clustering by plan and including year fixed effects.[11]

Again, we find a statistically significant impact of lagged scale on performance (t-stat of 6.8). The effect is economically significant as well. We compute the implied change in performance due to a move from the median level of holdings of the smallest plans (Q1; 20% of plans with the smallest overall size) to the median holdings of the largest plans (Q5), as well as a more conventional one standard deviation change in log holdings, and present these statistics at the bottom of the table. By either measure, the impact of size is substantial: the move from small to large improves net PE returns by 7.4% p.a., and a one standard deviation change moves performance by 4%. To put this magnitude in perspective, the mean net return in PE in Table I is 9.6%.

[11] The results are similarly strong when we double cluster on both year and plan: For example, the resulting t-statistic on size in regression (3) described below is 3.43; the only qualitative change is that the non-US dummy becomes insignificant with double clustering. Another approach to address this issue is to use the Fama-McBeth method, something we do in the robustness section and Table IV, producing similar results.

Factors correlated with investing scale could be driving these returns. If larger investors have invested in PE for a longer period and therefore have a portfolio of older investments than smaller PE investors, then their outperformance could be driven by the well-known j-curve effect – returns are lower in early years while capital is deployed only to yield returns later in the fund life. Larger investors could also assign a larger weight on buyout than venture funds, affecting their returns. Finally, results could be driven by the impact of particularly good vintage years if large PE investors fortuitously overweighted PE in such years.

We explore the j-curve concern directly by exploiting additional information CEM collects on assets used to compute fees. We construct the ratio of PE holdings to the assets used to compute fees. Low values for this ratio are likely driven by committed but not yet deployed capital, as plans PE investments are earlier in the j-curve. We include this variable in (4), restricting attention to plans that have a ratio less than one (where there is a clearer interpretation as a proxy for the position on the j-curve). As expected, we find a positive and significant coefficient on the ratio. More importantly, we find little impact on log lagged holdings with a similar coefficient and level of significance.

Another possible concern is that the results could be driven by a link between the size of PE holdings and the type of funds investors can access, thus making the reported results more driven by luck than by any investor skill. For LP investing it is clear that large PE investors have access to PE funds unavailable to smaller PE investors. As Harris, Jenkinson, and Kaplan (2013) report, the average fund size in buyout (venture) was $782

($191) million in the 1990s and $1400 ($358) million in the 2000s. Average sized funds would be essentially inaccessible to the smaller first and second quintile size PE investors if GPs impose a minimum investment scale of even one twentieth of fund size. Similarly, if large investors want to deploy their capital without making too many separate investments, they may be dissuaded from smaller funds and invest disproportionately in mega funds. This could lead larger investors to focus more on buyouts and less on venture, and in buyouts to a focus on the largest 'mega-funds.'

Without looking at the data, it is hard to assess the empirical importance of these concerns as there are also reasons to believe that tilts in portfolios will be moderated. For example, even if there is a tilt in LP investing towards buyouts by larger investors, this does not necessarily imply the same tilt in fund-of-funds holdings. Investors could use fund-of-funds to moderate or unwind any tilt in their LP portfolios. As we show below, all plans use some fund-of-fund investing and smaller investors are particularly likely to use this approach.

We conduct two tests to address the possibility that portfolio tilts associated with investor scale drive our finding. We indirectly test for the possibility that the results are driven by larger plans being more focused on buyouts by comparing the return to scale in the 1990s and the 2000s. If differences in portfolios were the dominant factor driving returns, then we would expect larger investors to do better than smaller investors in the 2000s compared to the 1990s, for buyout returns are much better than venture returns in the 2000s with the reverse in the 1990s (e.g. see results reported in Harris, Jenkinson, and Kaplan

(2013)). We report results for the 1990s in column (5) and for the 2000s in (6). These results provide little support that such a compositional difference is driving returns. We find a significant coefficient on investor scale in both periods, and inconsistent with the concern that better returns for larger plans come from a buyout focus, in the 2000s when buyouts had greater returns, the coefficient on investor scale is lower than in the 1990s. In untabulated results, we find identical results if we restrict ourselves solely to LP investments, with a significant coefficient on scale in both periods, with a greater coefficient in the 1990s than in the 2000s.

Next, we include in our regressions the interaction of the difference in returns between mega- and small cap PE partnerships with the scale of investments in PE. If large investors outperformance comes from exclusively from years where mega cap partnerships outperform small cap PE partnerships, this variable will load positively and lag holdings will be rendered insignificant. We use data available from Preqin on the returns to mega cap and small cap PE funds.[12] Since Preqin provides this data only since 2001, we conduct this test on this smaller sample. In (7) we include the interaction with relative PE fund returns. The results are consistent with such a tilt in holdings as we find a positive and significant

[12] The performance data is based on an index of quarterly returns for funds of different scales, with the percentage change in quarter = [(NAV at quarter end + distribution during quarter) / (NAV at quarter start + call-ups during quarter)] – 1.

coefficient on the interaction. This lowers the estimated impact of size on performance by 13%, but importantly scale remains statistically and economically significant.[13]

To explore the possibility that results are driven by particularly strong vintage years we identify the relationship between investor scale and performance excluding results associated with particularly good vintage years. Studies have shown that the bulk of fund investing, particularly in strong vintage years, occurs within three year of closing the fund, (e.g., Lopez de Silanes et al. (2011)). Thus, we exclude outstanding vintage years and the two subsequent years following each outstanding vintage year. As an indicator of good vintage years we use data on Public Market Equivalent ratios (PMEs) reported in Harris et al. (2013). We define a good buyout year as a year in which buyout funds performed better than one standard deviation over the average (1990, 1994, and 2003). We identify good venture years in the same way. In (8) we repeat our baseline regression excluding the outstanding buyout vintage years (and subsequent two years) and in (9) we go further and also exclude the outstanding venture years (and subsequent 2 years). In both specifications we continue to find a significant return to scale with only a slightly smaller economic magnitude.

We finish this section by including another powerful way to test whether scale influences performance by using plan fixed effects to estimate the effect of scale on

[13] The coefficient on scale in the 2001-2009 time period without the interaction is 1.139 (untabulated), and the % change is calculated by comparing the coefficient with and without the interaction. In untabulated results we arrive at substantially the same results if instead of (mega cap – small cap) we use (large cap – small cap) or ((mega cap plus large cap)/2 – small cap).

performance using solely the within-plan variation. The fixed effect captures any long-standing plan-specific superior access. The power of this test depends on there being enough time series variation in size within a plan and long enough time series for individual plans. Luckily, we have a number of plans that made dramatic changes in scale over the sample period.[14] The plan fixed effects regressions in column (10) reinforce our finding from column (3), showing an even stronger economic impact of scale on performance that is statistically significant.

II.2.1 Differences in Risk Exposures

Interpretation of these results would be different if there were systematic differences in the risk in the PE holdings of significant and smaller PE investors. (We note that any risk exposure common for all PE investors would not influence the estimated differences in returns.) The magnitude of the performance differences and the robustness of the results across years make this less likely, but do not rule out this possibility. To address this possibility more fully in Table III we conduct some standard asset pricing tests. An important qualification is that these tests have limited power: using lag size limits us to 19 annual return observations.

To maximize the number of observations we sort plans on prior year's PE holdings and construct a portfolio long in large PE investors (largest quintile) and short in small PE investors (smallest quintile). All factor returns are lagged one quarter to reflect an expected

[14] For instance, for each plan with at least 3 observations we computed the difference between the maximum and the minimum PE allocation. For the median (average) plan, the difference between the two extremes, standardized by that plan's median allocation, is 2.3 (3.1).

time lag in PE reporting (e.g., Jegadeesh, Kraussl, and Pollet (2011)).[15] In (1) we use the CAPM with the usual CRSP-based market portfolio[16] while in (2) and (3) we follow Harris et al. (2013) and use the Russell 2000 and Russell 2000 Value indices, recognizing that the typical PE portfolio is tilted toward smaller companies and value companies. There is some indication that the larger investors' portfolios may have higher betas in the significant coefficient on the CRSP factor in (1) and the Russell 2000 value factor in (3). More importantly, even with this small number of data points we estimate a large and significant alpha on the long-short portfolio across all specifications, varying from 8% per year (t-stat= 3.05) to 10% (t-stat=2.72). In (4) we estimate the Fama-French model with additional size and value factors producing similar results. Finally in (5) we include both the market return and the difference in returns between mega and small PE partnerships to control for the previously discussed possibility that large investors disproportionately invest in mega funds. Again, we find economically and statistically significant alphas.

An additional argument against a risk explanation for these results is that smaller investors are more likely to invest in venture rather than buyouts. As was noted earlier, the minimum LP size for larger buyouts is simply too high for smaller PE investors. To the extent that smaller PE investors have a greater relative share of venture in our data,[17] this

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[15] The estimated alphas are economically and statistically similar when we use contemporaneous factors in untabulated tests (available upon request).

[16] Sorensen and Jagannathan (2013) provide theoretical support for this assumption suggesting the use of the value-weighted stock market index is equivalent to the log utility investor using the stochastic discount factor to value risky cash flows.

[17] We explored this possibility by asking our data provider for separate breakouts by venture and buyout. The subsample they could provide is not large and not necessarily representative of PE holdings in the larger dataset,

would suggest they had greater risk as studies indicate that VC is the riskier of the two approaches.[18]

Finally, we take advantage of the fact that plans use benchmarks to assess their PE performance. These benchmarks are selected by plan overseers and are employed to monitor and evaluate the performance of the managers they hire. They are not chosen in the same way as mutual fund benchmarks (the latter are chosen by fund managers and may not do a good job of capturing the relevant portfolio characteristics, Sensoy (2009)). Inspection of the benchmarks suggests they are tailored to characteristics of the PE portfolios. For example, they vary by geography, some plans use levered equity as a benchmark, others use broader indices such as Russell 2000.[19] Any gaming of these PE benchmarks, we expect, would work against us as it would be more likely in the smaller pension plans with less resources to devote to oversight. In Table IV (1) we estimate our baseline specification after subtracting benchmark returns from net returns. These controls have only a slight effect in lowering the estimated coefficient on size from (3) in Table II, but it remains significant and implies an economic effect of moving from a small to a large plan of 7.3% per year.

II.3 Robustness of Economies of Scale in PE

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representing only 37 funds for LBO data and 58 funds with VC data, with overall a maximum of 206 observations. This partial data does provide indications that such a tilt could be important, as VC holdings as a percentage of total PE holdings are largest in the smallest size quintile and are monotonic with size quintiles in this subsample.

[18] For example, Cochrane (2005) estimates beta of about 2 for venture capital, Drissen, Lin, and Phalippou (2011) report a beta of 2.7, and Korteweg and Sorensen (2010) find betas of roughly 2.5. In contrast, Drissen, Lin, and Phalippou (2011) and Franzoni, Nowak, and Phalippou (2011) report LBO beta estimates of about 1.3 and Jegadeesh, Kraussl, and Pollet (2011) find a beta of close to one.

[19] Unfortunately, it is difficult to do much more with the benchmark descriptions, as many plans just list benchmark as 'custom', providing no additional information.

We perform a number of additional robustness checks. The pooled estimates in Table II place more weight on later years where we have more observations. In Table IV we re-estimate our regressions using the Fama-MacBeth approach: Regress performance on lag size in each sample year and then average the time series of estimates. The results in (2) and (3), based on averages over 19 years of data, are substantially the same. For example, the size coefficient is 1.7 in (3) (t-stat=3.46), while the analogous estimate in Table II was 1.8 (t-stat=6.84).

Second, we estimated the results by pooling plans across geographic regions. In Table IV we obtain similar results when we estimate our baseline specification separately for the US plans in (4), Canadian plans in (5), and other geographies (Europe, Australia, and New Zealand) in (6). The impact of size is strong in each of these regions and the estimated coefficients are roughly in line with one another. Third, in (7) we investigate whether it is PE holdings or the overall plan size that drives our result. We find that the economies of scale are based on PE holdings rather than pension plan size. In (8) we replace lagged investment size with the percentile of contemporaneous holdings. Using contemporaneous holdings increases the sample size by over 30%, and percentiles lessen (although do not fully eliminate) the concern of a mechanical relationship between contemporaneous size and performance. The resulting statistically significant coefficient produces similar economic magnitude, suggesting an 8% improvement for a move from 25th to 75th percentile.

III What Economic Factors Drive Larger Investors' Superior PE Performance?

III.1 – Organizational Diseconomies Hypothesis

These results are surprising as some theories suggest scale should hurt rather than help performance due to organizational diseconomies arising from hierarchy costs. In Stein's (2002) articulation of the problem, also discussed in Chen, Hong, Kubik and Stein (2004), diseconomies come from lower incentives to gather accurate information that arise in hierarchies that separate information gatherers from ultimate decision makers. This model may have particular relevance for PE, where soft information is thought to be at the heart of the investment process.

The log-linear regressions from the previous section reject this hypothesis of organizational diseconomies. Here we reexamine this hypothesis using more flexible functional forms. First, we redo our main test using dummy variables for the smallest four quintiles of lag PE size in Table IV (9). The reported coefficients indicate performance against the omitted category – the 20% of the largest investors. As in the previous section, there is a positive relationship between investment scale and performance in PE. All four dummy variables are negative and monotonically increase with scale. However, this regression does provide some evidence of attenuation. The dummy variables for the smallest three size quintiles are significant, but there is no significant difference between the 4^{th} and 5^{th} size quintiles. Next, in (10) we revert to the log linear approach but include in addition the square of log size. This regression provides even clearer evidence of attenuation as the squared term is negative and significant. This result provides support for the organizational diseconomies argument, and is comforting as surely there must be diseconomies at some level of investment.

To get a sense of the point at which scale economies are eliminated we plot the implied scale and performance relationship in Figure 1. The estimates imply that most of the performance improvements from scale of investment in PE come from investments below the scale of the fifth quintile PE investor ($5.7 bn at the end of the sample). Above this level, the benefits of scale are more limited and scale is predicted to reduce performance when PE holdings exceed $34 billion. As of 2009, the maximum PE holdings in our sample were $25 billion, putting even the largest investor below that level, and almost all plans substantially below it. Thus, while the existence of a maximum beneficial level of scale in PE is in line with economic intuition, no plans in our sample reach that scale. Consequently, the predominant fact that needs to be explained remains how larger investors are able to improve their performance.[20]

III.2 – Why do Larger Investors Generate Greater Returns: The Importance of Cost Savings

We consider five hypotheses for scale advantages, at least over a range of size. Two of these hypotheses focus on cost savings coming from an ability of larger investors to economize on intermediation costs and/or from negotiating power.

[20] These tests on the portfolio of PE holdings are admittedly a crude test of the organizational diseconomies hypothesis, as scale of investment need not imply deeper hierarchies. Many pension plans exclusively use external managers and, consequently, limit their internal organization to a handful of investment professionals, with perhaps one professional focused on private equities, with significant reliance on external consultants for such expertise.

The typical investment approach in alternatives is an LP position in an externally managed fund that historically has had a '2 and 20' fee structure that reflects the fees on committed capital and the percentage of the carried interest that goes to the GP (e.g. Metrick and Yasuda (2010)). A potentially less costly alternative to the typical externally managed fund is to establish internal capability and make investments, either co-investing alongside GPs or investing directly on one's own. There is a growing body of anecdotal evidence that internal investing is important for some large plans,[21] and some survey evidence that size correlates strongly with co-investment invitations (e.g. DaRin and Phalippou (2010)). However, we are aware of no existing research on how widespread this practice is and how it affects performance.

Larger PE investors have a comparative advantage in investing directly. There are significant fixed costs in building a capability to invest directly, either as a co-investor or on one's own. These costs include the costs of building an IT backbone to monitor investment opportunities and a human resource capacity to attract and retain the requisite talent. With fixed costs, unit costs are lower for plans that have a larger expected volume of transactions.

Another difference in approach that can be linked to scale is the necessity of using a fund-of-funds investment approach. Fund-of-funds is clearly a more costly approach to PE than LP investing as funds-of-funds layer on additional fees over and above those charged by GPs. This approach is particularly attractive for plans with intended PE investments that do

[21] Large Canadian pension plans in particular have used this channel, as described in the annual reports of Ontario Teachers, OMERS, and Canada Pension Plan Investment Board, an HBS case study (case #9-809-073), and "Maple Revolutionaries," *the Economist*, March 3, 2012.

not meet the minimum LP investment levels demanded by GPs, or cannot afford the people and resources to *ex ante* choose and *ex post* monitor and optimize their LP investments and therefore find it helpful to access and pay for this intermediation. Plans with scale in PE, in contrast, can more easily meet minimum investment sizes and thus are not forced to use funds-of-funds to access specific PE partnerships.

We test for the importance of these hypothesized comparative advantages of larger plans by first identifying cost differences investors report for different implementation approaches and then exploring the likelihood of using a given approach as a function of size. As noted above, in addition to overall net returns to PE investing, plans report costs and gross returns separately to CEM, and CEM performs some validation tests on this reporting.[22] It is likely the reported costs and gross returns have more noise than overall returns given potential inconsistencies across GPs in how they report to their LPs, but we have no reason to believe that such noise will be related with the scale of PE investing.

Table V Panel A provides summary statistics on costs; given time trends in costs and more observations in the final years of our sample, they are based on the last three years of the sample. Fund-of-funds is clearly the most expensive approach with annual reported costs of 694 bps, LP investing is about half as expensive at 351 bps, and internal management is

[22] Where CEM has significant concerns about reported costs that they are unable to address after correspondence with reporting plans, they introduce default PE costs. That is, CEM replaced reported costs for these plans with default costs that they calculated. We think this reduces the noise in the data. At the same time, if this is inaccurate this could affect our results. We therefore asked for and were provided a list of plan identifiers where default costs were used. We re-examined our findings excluding these observations and found that they had no quantitative or qualitative impact on these results, or those reported previously in earlier tables.

about one twentieth the cost at just 35 bps. Panel B shows a negative correlation of investor scale in PE and use of funds-of-funds. The likelihood of a largest quintile plan having any fund-of-funds investments is one half that of the smallest quintile plan (for which fund-of-funds investments account for almost half of all holdings). We find that the smallest quintile plans invest 21 percentage points more of their PE portfolio using this approach than the largest quintile plans (p-value<0.01).[23]

The summary statistics also show that the largest PE investors are most likely to use internal investing and have the biggest percentage of their PE portfolio in this approach. For the largest plans, internal holdings represent 10% of all PE holdings. Using finer size classifications, the difference becomes even more pronounced. Over 40% of the top decile investors engage in internal investing, and 28% of their PE holdings are internal. Given the mean size of top quintile (top decile) investments in PE in these years of \$5.7 bn (\$9.1 bn), this implies \$570 million (\$2.5 bn) are invested internally in these plans. Untabulated regression evidence lines up with the summary statistics. The largest size quintile allocation to internal is 11 percentage points higher than that of the smallest plans (p-value<0.01), in line with the summary statistics. Suggestive of the scale needed for internal investing, the largest plans' allocation to internal also exceeds that of the 4th quintile by 6 percentage points (p-value<0.05).[24]

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[23] Based on untabulated regression of the percentage of assets in fund-of-funds on size quintile dummies, with controls for the domicile, corporate status, and year fixed effects (available upon request).

[24] Based on untabulated regressions of percentage internally managed on size quintile dummies, with controls for domicile, corporate status, and year fixed effects (available upon request).

An alternative to lower intermediation costs that may explain how scale influences costs is superior negotiating power with external managers. Larger investors are more likely to be pivotal in the formation and/or successful closing of a fund. They can most easily put up the capital for a major position and have a fuller range of options to go elsewhere with their investments (to other GPs or, as shown in Table V for the very largest, to use internal management). To try to identify the potential impact of negotiating power, as opposed to cost savings from economizing on costly intermediation, we now examine the impact of scale on costs by focusing separately on fund-of-funds, LP, and internal investments.

The cleanest test for the negotiating power hypothesis comes in examining fund-of-funds PE investments. Both large and small investors can access these funds offered by external managers, with the potential for larger investors to negotiate better terms. We also expect some impact of negotiating power in LP investments, as larger investors may be looked on more favourably than smaller investors and could be given preferential terms through side letters or explicit agreements, although there is also pressure to have common terms across investors. At the same time, we acknowledge another reason for size-related cost differences in LP investments that could come from larger investors investing in different size funds that have different costs (e.g. large buyout versus small buyout) that we cannot observe directly. Finally, size-related differences are unlikely for direct investing as this approach is limited to the largest investors.

In Table VI model (1) we test whether scale in funds-of-funds affects costs in funds-of-funds, continuing to control for corporate status, domicile, and year fixed effects. The negative and significant coefficient on scale is economically significant, implying 211 bps lower costs in fund-of-funds for those making top quintile fund-of-funds investments (a 30% cost reduction from mean costs at the end of the sample period). This suggests negotiating power plays an important role in the reported cost savings.

In LP investments in (2) we also find a negative and significant coefficient on scale. Relative to first quintile plans, 5^{th} quintile plans enjoy cost savings of 112 bps. This is consistent with negotiating power, but could also reflect differences between larger and smaller investors in the cost structures of their LP investments. In (3) we examine costs for internally managed PE and, not surprisingly, the scale coefficient is close to zero and insignificant.

To wrap up this section, we size up the cost savings coming from both less costly intermediation and negotiating power. In (4) we use indicator variables for size quintiles based on lag holdings. Using quintiles we find cost savings for larger investors compared to the smallest quintile investors of a sizable and strongly significant 281 bps. Costs are monotonic with investor scale, with second through fourth quintile investors having costs 144 bps, 65 bps and 62 bps greater than the largest PE investors (the omitted category). In (5) we use a log linear specification and the coefficient of -44.7 on scale implies that larger PE investors have lower costs of 180 bps. Thus we find cost savings are an important part of the performance difference, but do not explain all of the performance gain, accounting for between one quarter (using the log linear specification) and one third (using size quintiles) of the 7.4% superior return we found in Table II.

We attempt to provide a decomposition of the cost savings coming from lower cost intermediation and from negotiating power in (6) by repeating this test including the fraction of the portfolio that uses more costly intermediation approaches of fund-of-funds and LP investing. The positive and significant coefficient on scale in (6) is consistent with scale-related savings over-and-above those coming from differences in the use of costly intermediation. Comparing the coefficients in (5) and (6) suggests larger plans save 145 bps in costs controlling for differences in their use of costly intermediation, which reflects a combination of negotiating power and potentially differences in the types of LP funds they invest in.

III.3 – Explaining Superior Gross Returns for Larger PE Investors

In addition to cost savings we find superior gross returns for larger investors. This is made clear in Table VII. In (1) we find that the scale of investment in PE is associated with much stronger annual gross returns, controlling for corporate status, non-US plans, and year fixed effects. The implied economic effect associated with moving from a smallest to largest quintile plan is 5.5% per year. In an untabulated specification that uses quintiles rather than log holdings we obtain even greater estimates, with the largest quintile outperforming the smallest one by 7.99% for the first size quintile, and with outperformance lowering monotonically with investor scale and ending up with no statistically significant difference in gross returns between large (quintile 4) and the largest investors (quintile 5). Column (2) shows the positive and significant coefficient on scale is not an artifact of differences in the approaches to PE, as including controls for the % of investments using fund-of-funds and % internally managed has no appreciable impact on the scale coefficient. This is not surprising in light of the fact that in additional untabulated tests we find no significant difference in gross returns across these different investment approaches.[25] *III.3.1 Superior Access, Experience and 'Clout' for Larger PE investors*

Two possible explanations for this difference in gross returns are that larger PE investors have preferred access to the best performing PE partnerships, and/or they have greater experience in PE. For example, larger pension plans may have established preferred access to top quartile, persistent GPs (e.g. Kaplan and Schoar (2005)). If so, their superior returns could come from this historical accident rather than from some other attribute associated with size. Similarly, their returns could come not from their scale, but rather from having a longer experience in the asset class, and it is this experience, which is correlated with scale, that is really driving their returns. Lerner, Schoar and Wongsunwai (2007) show that access and experience help explain endowments success in private equity in the 1990s.

[25] All untabulated regressions are available from the authors. To test for differences in gross returns across investment approaches of fund-of-funds, LP, and internal holdings we treat them as separate observations (i.e., a given plan may contribute as many as three observations in each year) and regressing them on indicators for each approach, with and without controls for corporate status and domicile, as well as year and plan fixed effects. In all cases, the investment approach indicators are insignificant.

These factors have become less important as the industry has matured (Sensoy, Wang and Weisbach (2013)).

A third possible explanation is that larger investors contribute to PE returns by taking unobserved actions to help portfolio companies of GPs or their own direct investments, for example by easing potential political obstacles to investment. We call this the 'clout' hypothesis.

Note that recent findings that access was important for returns in the 1990s but not in the 2000s (Sensoy, Wang and Weisbach (2013)), makes it less likely that access can drive reported differences in gross returns as we find superior returns to scale of PE investing in both periods. Nonetheless, to explore the importance of access we first exploit the fact that for a number of plans we have evidence from their PE investments for extended periods of time, and observe considerable changes in the scope of these investors' PE programs. This allows us to introduce plan fixed effects in (3) to capture any long-standing preferential access to better performing funds. The coefficient on size captures how performance changes as investors increase in scale, keeping such preferential access constant. We still find a strong and significant impact of scale on performance, suggesting access is not driving all of the returns.

We can arrive at a better decomposition of the relative importance of access and experience, as opposed to something else, by introducing specific controls that capture aspects of access into the main specification. In (4) we proxy for access to the top quartile partnerships by introducing a dummy variable indicating that returns were in the top quartile last period. To capture the potential impact of experience, we include in the regression their measured experience in the asset class, which we define as the fraction of prior years in the database in which the plan had PE holdings.

We find positive coefficients on these proxies for access and experience, with both economically important and statistical significance on the access proxy.[26] More importantly, by comparing the coefficient on lag log holdings without the proxies for access and experience (1), and with the proxies (4), we have an indication of the importance of access for these results. The estimated impact of investing scale is reduced by about 10%.

We also consider the possibility that investor clout impacts returns. We hypothesize that to the extent that clout exists, it will be more linked to the absolute size of the investor than to the scale of their existing PE investments. Thus, in (5) we test this hypothesis by including in the gross return regression the overall scale of the pension plan in addition to the scale of PE investin (while correlated, there is substantial variation in PE investment scale across plans of similar size). Overall plan scale has a negative and insignificant coefficient, inconsistent with the hypothesis that unique capabilities tied to overall scale drive the results, while lag log holdings in PE remains positive and strongly significant.

III.3.2 Conjecture of Better Information Processing for Larger PE investors?

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[26] We obtain similar results with other proxies for access (e.g., when we use the percentile of prior year's returns, rather than top quartile dummy, we estimate a coefficient of 9.71, t-stat=4.67).

What aside from access, experience and clout could account for superior gross returns? Another possibility is that the scale of investment brings with it a superior ability for larger investors, relative to smaller investors, to manage the information asymmetries that need to be bridged for successful PE investing. These asymmetries include the ability to assess the attractiveness of portfolio investments for direct investing and the capabilities of and contracts offered by different fund managers asking for LP investments. The importance of bridging asymmetries is widely recognized (e.g. Lerner and Schoar (2004), Lerner, Schoar, and Wongsunwai (2007), Kaplan and Stromberg (2009), as is the importance of understanding opaque and complex contracts (Metrick and Yasuda (2010), Phalippou (2009)). Differences across investor types in their ability to bridge such asymmetries may have diminished over time with the maturing of the PE market (Sensoy, Wang and Weisbach (2013)), but important asymmetries may remain within type.

One rationale for such an 'information processing' advantage in pension plans for larger PE investors is simply that scale is associated with more investments, each of which generates information not only about the specific fund investment but also about prospects for PE more generally allowing for a better evaluation of alternatives. As important, larger PE investors might have greater information processing ability than smaller PE investors. Small investors typically have no internal PE experts and rely entirely on outside advice. Larger investors need to attract and retain larger teams to manage their more extensive portfolios, and individuals with ability may be more willing to work for larger investors.[27] Larger PE investors are most likely to acquire more information and more processing ability if they engage in internal investing which requires more people with greater ability.

This 'information processing hypothesis' is a conjecture, as we cannot test this directly with our data having no direct measures of information processing. This conjecture though offers the simplest explanation for two facts. First, it provides a simple explanation for the significant differences in approaches to intermediation documented above. With superior information processing ability, larger PE investors can dis-intermediate funds and focus away from fund-of-funds to fund investing and, for the largest, on direct investing.

Second, as we show in further tests on gross returns in Table VII, the conjecture of superior information processing provides a simple explanation for our finding that larger investors have superior gross returns in *all* three approaches to PE investing of LP investing, fund-of-fund investing and direct investing. In (6-7) we repeat our prior analysis of the overall PE portfolios focusing just on LP investments, with the first regression without controls for access and experience and the second with those controls. In (8-9) we do the same focusing on fund-of-fund investments. In (10) we explore returns to internal investing. Looking at the coefficient on lag log holdings in (7), (9) and (10), we find that even with proxies for access and experience, scale of investing remains statistically significant and economically important across all three styles. As expected access is more important with LP

[27] Larger PE investors might also have governance structures that allow for decentralized decision making, leading to more PE investing, attracting more talent and better outcomes. When provided the data for this paper, the dataprovider did not allow us to match with governance or proxies for management ability.

investing (7) than fund-of-fund investing (9), and including these proxies reduces the estimated impact of scale for LP investing in (7) by close to 20%. The positive and significant coefficient on lag holdings for fund-of-fund investing (9) is particularly important for the information processing conjecture as there is no clear alternative hypotheses to explain this result.

Finally, the information processing conjecture suggests a channel through which larger investors generate positive spillovers by harvesting information from one approach to PE investing (e.g. internal) and harvesting that in another form (e.g. fund investing). It suggests the information spillover will be stronger from internal to external investing than the converse as internal investing requires developing more capabilities. It leaves open the question whether it is access to more information or information processing capability that is more important.

In VIII we explore these three implications/questions. First we test whether larger plans that are much more likely to invest internally, generate gains from this internal investing for their future returns in fund investing. The dependent variable in (1-2) is gross and net returns for externally managed holdings (LPs and fund-of-funds) with the standard controls for domicile, corporate status, and year fixed effects. To capture the potential impact of past internal investing and past ability in internal investing for performance of their fund portfolios, we include an indicator variable if plans in the prior period had more than a trivial amount (we use 5% of all PE investment) of internal investment, and another indicator variable if based on previous history there was evidence plans had top quartile internal teams.[28] To explore whether the strength of the spillover is different from external to internal investing we repeat these regressions using internal investing returns as the dependent variable in (3-4) and testing if past skill in external investing translates into better future performance in internal investing.

In (1-2) we find a positive coefficient on the past internal investing dummy, but this is not significant. We find further that lagged top quartile internal return dummy is both positive and statistically significant in both specifications. This suggests that while information alone may be helpful to generate positive spillovers it is not enough to take advantage of information gained from internal investing, plans must have superior ability in that investing. In (3-4) we report results from the converse test of past returns to external investing on current returns to internal investing. We find a positive but much smaller and insignificant coefficient on lag top quartile external dummy in both specifications, suggesting the greatest spillovers come from investing in internal investing capabilities.

IV - Implications of Scale-Based Differences in Returns: Allocation to Private Equity

The comparative advantage in returns for larger PE investors provides a motivation for plans with the ability to scale up their PE investments to do so. A straightforward proxy for being able to allocate more is the overall size of the plan, so the prediction here is that investors with larger overall size should allocate proportionately more to PE. Figure 2 presents

[28] To identify top quartile internal teams we computed the percentile of internal gross returns in the overall return distribution (internal or external) over the previous three years. 'Top quartile' performers are those for which the average of the percentiles exceeds 75.

PE allocations as percentage of portfolios by size quintiles from 1990 to 2009, showing that large plans (top 20%) consistently invest proportionately more to PE than medium plans (middle 20%) and small plans (bottom 20%). This gap has grown substantially over time. Figure 3 illustrates the differences in allocation across a more complete range of size (20 size buckets) for the most recent period (2007-2009) when PE investing has been greatest. Again it shows a positive and near monotonic relationship between plan scale and PE allocation, with particularly greater allocations for very large plans.

In Table IX we formally test whether larger plans allocate more to alternatives by regressing the portfolio weight of alternative assets on the log of plan size and controls. Since the dependent variable is constrained between zero and one, we use Tobit to estimate the regressions. To reflect the time trends presented in Figure 2, we add year fixed effects to all specifications. A particular advantage of the regression framework is that we can introduce a proxy for cross-sectional and time-series variation in risk appetite and demand for liquidity, an important competing explanation for changes in asset allocation. In our database, the best variable to capture these characteristics is the fraction of liabilities tied to retirees.[29] Plans with a greater fraction of liabilities tied to retirees have greater near term needs for liquidity and are expected to have reduced demand for risky assets.

As in the figures, we find size is associated with much more significant allocation to PE and more generally to alternatives. We first test for the impact of plan size on overall

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[29] Other potentially useful variables, e.g., underfunding, are not collected by the data provider.

allocation to alternatives in a simple univariate specification (1), with controls for sponsorship and domicile in (2), and with a proxy for appetite for risk and liquidity in (3). In line with economic intuition, plans that likely have the greatest need for safety and liquidity indeed invest less in alternative assets, and the interaction shows that this has less of an effect on larger plans. The addition of these variables lowers the coefficient on plan size, but it remains positive and is highly statistically significant. In (4) we focus directly on PE and find that larger plans allocate more to PE, controlling for other factors that affect risk appetite and demand for liquidity. We get similar results of scale and allocation in real estate in (5), but not in hedge funds in (6).

V Conclusions

Using data on PE investments of DB pension plans we find that investors with substantial PE holdings outperform investors with smaller PE holdings. When holdings of PE increase from small plan to large plan median, net returns improve by up to 7.4% per year. This shows that investment scale is a first-order determinant of investor performance in PE.

We seek to explain this result by appealing to economic explanations for the impact of scale on performance. We find that cost advantages for larger plans are important contributors to the superior performance, accounting for up to one third of the performance gain. Our tests also highlight a new fact of substantial internal investment by some of the largest PE investors, at substantially lower costs. Further, we document superior gross returns for larger investors in PE. Superior access accounts for a portion of the gains.

With these patterns in performance, we predict that plans that have the capacity to become large PE investors will do so. This is precisely what we find, with substantially larger percentage of portfolio allocations to PE by the largest plans. Moreover, the difference between large and small plans has grown significantly over 1990-2009, consistent with large plans learning about their relative strengths over time.

We believe these findings have several implications. For pension plans, the results on internal investing show substantial cost savings, with no reduction in gross returns, and positive information spillovers for external investing. This raises questions whether more internal investing may be appropriate. For pension plan beneficiaries, the weaker returns to investors with limited PE holdings bring into question the sustainability of such investments. This suggests that investors with insufficient assets to make considerable investments in PE on their own may reconsider the attractiveness of the asset class or seek asset management vehicles with more capacity for scale. We note that in a number of countries, including the United Kingdom, the Netherlands, and Canada, governments as plan sponsors of some of the sub-scale investors are considering pension reforms that promote re-allocation of pension contributions to more scaled pooled asset management vehicles, in part motivated by the possibilities of capturing such returns.[30] To the extent that investors do alter their approach to PE, this has important implications for funds more generally.

[30] In the UK, the National Employment Savings Trust (NEST) presents one effort to create a scaled investment vehicle. In the Netherlands and Canada there are efforts to allow existing large pension plans to open themselves up to other members, and large plans that have moved to take advantage of this opportunity include APG (Netherlands), Ontario Teachers Pension Plan (Canada) and OMERS (Canada). See, for example,

Finally, we conjecture that a possible explanation for gains to scale comes from superior information processing capability of larger PE investors and present suggestive evidence consistent with the conjecture. This conjecture points also to the potential importance of differences across plans in their ability to attract and retain talent to oversee and run PE portfolios, and of governance structure. We leave these questions for future research.

http://www.omers.com/About_OMERS/OMERS_Investment_Management_Services_available_to_third_parties.htm). In Ontario, Canada, the provincial government is considering proposals to force smaller plans into mega plans to capture such advantages (The Morneau Report, "Facilitating Pooled Asset Management for Ontario's Public Sector Institutions," October 2012).

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Figure 1. Private equity scale-performance relationship. This figure uses coefficient estimates from Table IV model (10) to plot the implied relationship between lag log holdings and net returns. The specification includes log lag holdings, the square of log lag holdings, corporate and non-US indicators, and year fixed effects. The solid line covers the range of PE holdings in our sample. Outside this range, the dash-dotted segment and dotted segment respectively show slight positive and then negative impact of scale.

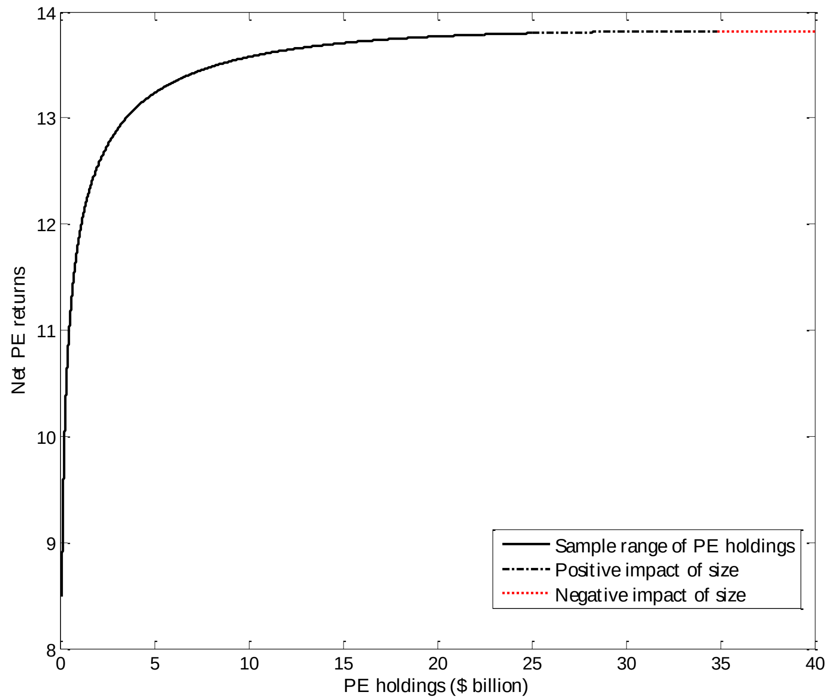


Figure 2. Time trends in allocations to private equity. This graph presents the average portfolio weight of private equity in each sample year, for the smallest quintile of plans, the middle quintile, and the largest quintile of plans.

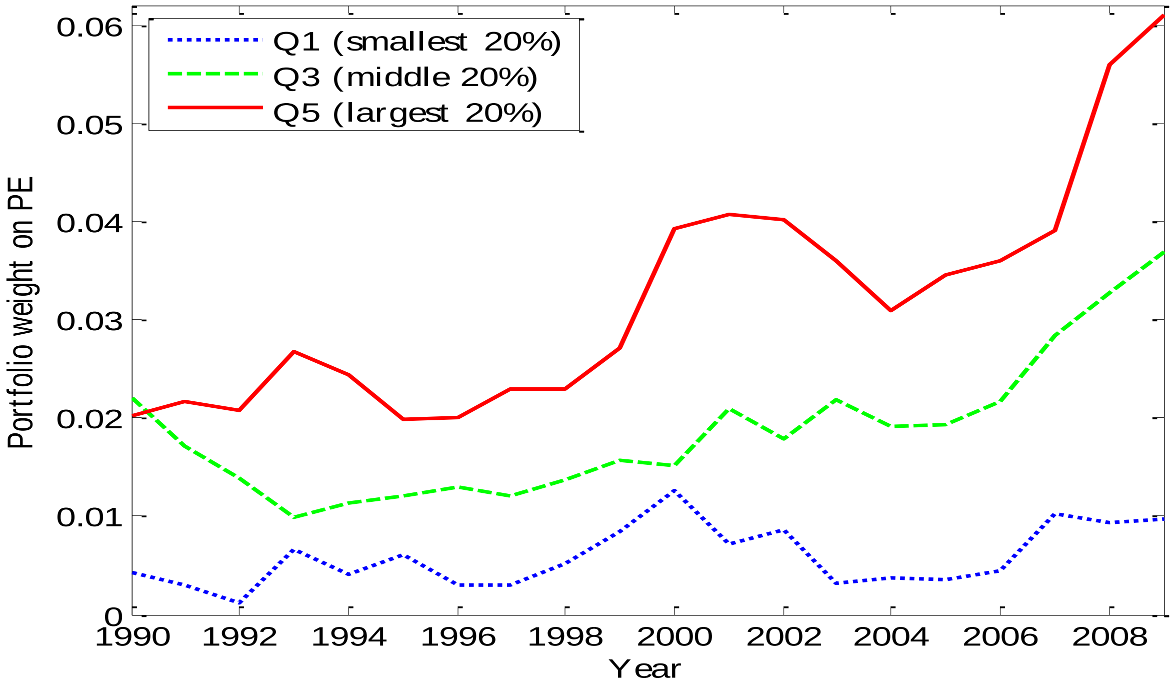
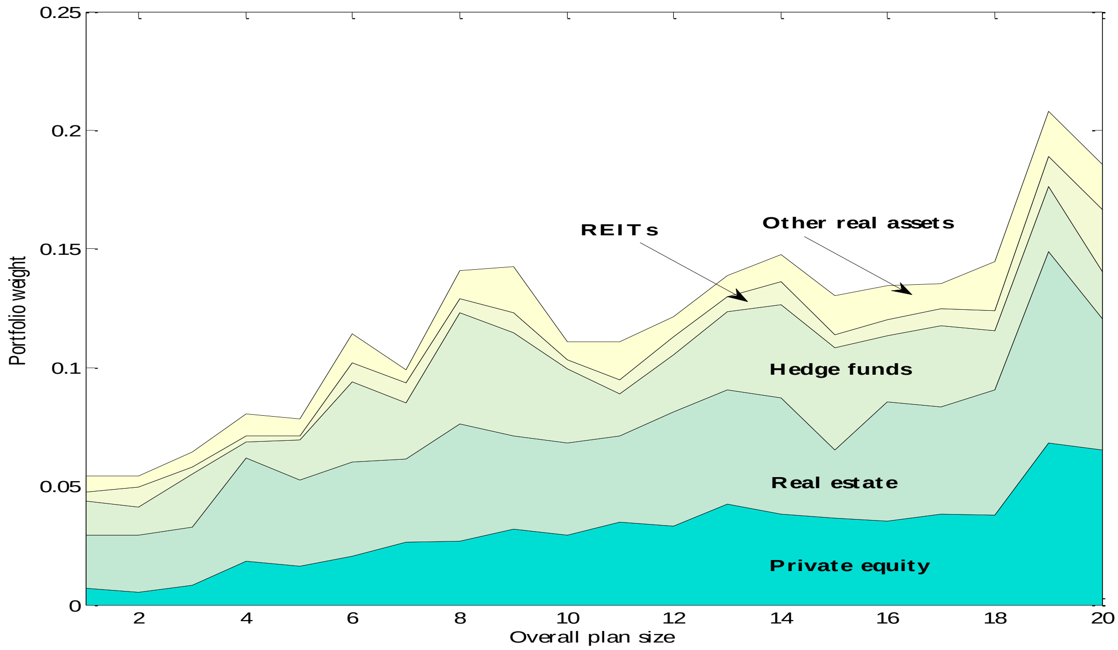


Figure 3. Asset allocation to alternatives across size deciles. In each of the latest three sample years (2007-2009) plans we sort investors into 20 size buckets, based on overall plan size. This graph presents time series averages of portfolio weights of the main components of alternative assets.



0.25
0.2
0.15
0.1
0.05
0
Portfolio weight
2
4
6
8
10
12
14
16
18
20
Overall plan size
REITs
Other real assets
Hedge funds
Real estate
Private equity

Table I: Summary statistics of the CEM database. The table presents overall plan characteristics and key performance measures for PE holdings. The statistics are time series averages, with plans sorted into size quintiles defined in each year over 1991-2009 based on lagged holdings. S&P500 returns are lagged one quarter to reflect an expected time lag in PE reporting (e.g., Jegadeesh, Kraussl, and Pollet (2011)). Benchmark returns are plan-specific PE benchmark returns. The last section of the table presents performance data in the most recent sample years of 2007-2009. Gross and Net returns are reported in percentages, Costs in basis points.

	Mean	St.dev.	25th %	Median	75th %	Max
Sample and plan characteristics						
# plans/year	270	71	269	286	298	368
Total dollars (USD trillion)/year	2.89	1.39	1.75	2.83	3.88	5.46

	Mean	**Median**	**IQR**	**Q1 (small)**	**Q2**	**Q3**	**Q4**	**Q5 (large)**	**Large minus small**
				Plans sorted on overall plan size					
Overall plan size ($B)	10.26	2.47	6.89	0.42	1.22	2.55	6.45	41.10	40.68
% non-US	43%			75%	48%	37%	25%	29%	-46%
% corporate	55%			65%	60%	65%	52%	30%	-35%
% liabilities related to retirees	46	46	15	48	46	46	47	50	2
Private Equity									
	1991-2009			*Plans sorted on lag PE holdings*					
average holdings/plan ($M)	705.3	114.0	459.4	10.4	44.6	126.7	398.2	2999.3	2988.9
Gross returns	12.3	10.5	20.4	7.4	9.3	12.1	15.2	16.2	8.8
Costs	259	197	185	386	275	231	232	185	-201
Net returns	9.64	8.10	20.50	3.52	6.57	9.83	12.83	14.36	10.84
Net returns minus S&P 500	2.61	1.07	20.50	-3.51	-0.46	2.80	5.80	7.33	10.84
Net returns minus benchmark	-1.66	-2.53	21.74	-7.13	-4.12	-1.71	0.92	2.52	9.65
	Only 2007-2009			*Plans sorted on lag PE holdings, only 2007-2009*					
average holdings/plan ($M)	1361.4	242.7	915.7	27.0	105.9	255.4	820.6	5666.3	5639.3
Gross returns	3.4	3.3	13.9	2.1	4.1	0.4	4.9	5.5	3.4

Costs	371	290	256	517	410	361	302	264	−253
Net returns	−0.28	−0.96	15.05	−3.09	0.01	−3.25	1.87	2.82	5.91

Table II. Scale and net returns in private equity. The dependent variable is net returns (gross returns minus costs) on a plan's overall PE holdings (in (2), net return minus S&P500 return lagged one quarter). The main independent variable is lag of log PE holdings. In (4) we use plans where the ratio of holdings to assets used to compute fees is less than one. Regressions (5-9) use data from indicated years. The difference in returns between mega- and small-cap private equity funds is obtained from Preqin. Regressions are estimated with year and plan fixed effects, as indicated. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Economic effects illustrate the implied change in PE net returns from a one standard deviation increase in log holdings, as well as moving from the median holdings of small plans (bottom quintile of plans sorted on overall size) to the median holdings of large plans (largest quintile).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		Net ret minus SP500			1990-1999	2000-2009	Only 2001-9	Exclude 1990-2, 1994-6, 2003-5	Only 2000-2, 2006-9	
lag log PE holdings	1.031***	1.739***	1.836***	2.018***	2.295***	1.604***	2.013***	1.545***	0.993***	2.946***
	(3.92)	(6.88)	(6.84)	(8.10)	(4.55)	(4.68)	(6.59)	(4.27)	(3.14)	(2.67)
ratio holdings/assets used to compute fees				1.984**						
				(2.09)						
lag log size * (Rmega − Rsmall)									0.106***	
									(4.12)	
Corporate plan dummy	3.609***	2.057*	2.475**	2.215**	1.100	3.356**	4.091***	4.055***	2.394**	
	(3.14)	(1.87)	(2.29)	(2.01)	(0.59)	(2.56)	(2.97)	(2.66)	(2.09)	
Non-US plan dummy	-3.272***	-3.164***	-2.356**	-1.676	-6.038***	-0.117	0.136	1.582	-0.566	
	(-2.65)	(-2.70)	(-1.99)	(-1.41)	(-2.85)	(-0.08)	(0.09)	(0.96)	(-0.44)	
Observations	2127	2127	2127	1941	760	1367	1371	988	1,250	2127
R-squared	0.018	0.033	0.303	0.322	0.162	0.319	0.325	0.331	0.366	0.434
Year FE	NO	NO	YES	YES	YES	YES	YES	YES	YES	YES

Fund FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES
Economic effects										
One standard deviation change	2.25	3.80	4.01	4.40	5.01	3.50	4.40	3.37	2.17	6.44
Q1 to Q5 change	4.15	6.99	7.38	8.09	9.23	6.45	8.09	6.21	3.99	11.85[+]

[+] The economic effect is 6.84% when it is computed using the 75th percentile of the change in the holdings of private equity (for each plan, the difference between the maximum and minimum allocation is computed, and the 75th percentile of that variable is used).

Table III: Return differences and risk. In this table we construct a spread portfolio on net returns that is long in large PE investors' PE positions (top size quintile based on lagged PE holdings) and short in small investors' PE positions (bottom quintile) to explore if there is alpha after controlling for exposures to asset pricing risk factors. Risk factors include returns on CRSP, Russell 2000, and Russell 2000 Value indexes, and the Fama-French size and value factors. Model (5) includes as an additional variable the difference of returns between mega and small PE funds, obtained from Preqin. All risk-factor returns are lagged by one quarter relative to private equity returns, and expressed in percent per year.

	(1)	(2)	(3)	(4)	(5)
Alpha	8.01***	9.36***	10.34**	11.05***	7.72**
	(3.05)	(3.16)	(2.72)	(3.44)	(2.90)
CRSP market	0.43***			0.29	0.42*
	(2.99)			(1.66)	(2.34)
Russell 2000		0.25			
		(1.64)			
Russell 2000 Value			0.36*		
			(1.80)		
SMB				-0.30	
				(-1.14)	
HML				-0.26	
				(-1.31)	
$R_{mega} - R_{small}$					0.01
					(0.02)
Observations	19	19	14	19	9
R-squared	0.345	0.136	0.212	0.444	0.625

Table IV: Scale and net returns in private equity: robustness. In model (1) the dependent variable is 'excess' net returns defined as net returns minus plans' chosen PE benchmark return. In all other models, the dependent variable is net returns as in Table II. In models (2) and (3) we use the Fama-MacBeth approach and estimate the coefficients from 19 years of cross-sectional regressions. In models (4 - 6) we present results estimated separately for US, Canadian, and European/Australian plans, respectively. As alternative measures of investor scale, in (8) we use contemporaneous size percentile and in (9) lag size quintile (the omitted category are funds in the top 20% of lag holdings size). All regressions include year fixed effects. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Economic effects illustrate the implied change in PE net returns from a one standard deviation increase in log holdings, as well as moving from the median holdings of small plans (bottom quintile of plans sorted on overall size) to the median holdings of large plans (largest quintile).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable:	‘excess’ net returns									
Sample/Estimation:	All	F-M	F-M	US only	Can only	Euro&Aus	All			
lag log holdings	1.821***	1.919***	1.685***	1.691***	1.480***	2.107**	2.294***			3.255***
	(7.49)	(4.26)	(3.46)	(5.02)	(3.15)	(2.52)	(5.78)			(3.82)
log overall plan size							-0.930*			
							(-1.69)			
Percentile of size								15.817***		
								(6.54)		
Holdings in Q1									-10.896***	
									(-5.92)	
Holdings in Q2									-7.177***	
									(-5.05)	
Holdings in Q3									-4.835***	
									(-3.30)	
Holdings in Q4									-1.889	
									(-1.48)	
(lag log holdings)^2										-0.156**
										(-2.04)
Corporate plan dummy	3.173***		1.735	2.956**	1.437	2.286	1.956*	4.594***	2.418**	2.386**
	(2.84)		(1.38)	(2.27)	(0.62)	(0.61)	(1.75)	(3.45)	(2.25)	(2.19)
Non-US plan dummy	0.469		-3.224*				-2.334*	0.671	-2.243*	-2.178*
	(0.39)		(-1.83)				(-1.96)	(0.40)	(-1.88)	(-1.81)

Observations	2123	2127	2127	1435	509	183	2127	2821	2127	2127
R-squared	0.204	0.009	0.015	0.360	0.171	0.457	0.304	0.219	0.301	0.304
Economic effects										
One st. deviation change	3.98	4.19	3.68	3.69	3.23	4.60	5.01			7.11
Q1,2 to Q5 change	7.32	7.72	6.78	6.80	5.95	8.47	9.22			13.09

Table V: Costs and scale-based differences in PE investment approaches. Panel A illustrates costs (in basis points per year) of different PE investment approaches (external fund-of-funds, external LP investments, internal investments). Panel B shows differences across PE holdings size quintiles in the likelihood of having a given investment approach, as well as the fraction of overall PE holdings in that approach. The table presents the time series average based on annual results using the last three sample years (2007-2009).

Panel A: Costs (bps) by investment approach

	#obs	Mean	St.dev.	25th %	Median	75th %	IQR
Funds of funds	329	694	1518	290	443	653	363
External	502	351	509	168	240	362	194
Internal	75	35	50	2	19	44	43

Panel B: Reliance on different PE investment approaches

PE holdings quintile:	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**
% with any internal holdings	6%	3%	5%	7%	24%
% overall assets in internal	2%	1%	0%	2%	10%
% with fund-of-fund holdings	52%	51%	55%	48%	26%
% overall assets in FOFs	48%	37%	35%	22%	11%

Table VI: Cost savings from investment approaches and negotiating power. The dependent variable is costs in bps. The main independent variable is lag log PE holdings for a given investment approach. Model (1) only includes holdings invested using via fund-of-funds (FOF). Model (2) only uses LP investments. Model (3) only uses direct investments made by plan managers. All regressions use year fixed effects. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Economic effects illustrate the implied change in costs in bps from a one standard deviation increase in log holdings in that investment approach, as well as moving from the median holdings of small plans (bottom quintile of plans sorted on overall size) to the median holdings of large plans (largest quintile).

	(1)	(2)	(3)	(4)	(5)	(6)
Investment approach	Fund-of-funds	LP	Internal	All	All	All
lag log holdings	-90.6***	-23.8***	-0.5		-44.7***	-36.0***
	(-3.47)	(-3.98)	(-0.24)		(-6.32)	(-5.26)
Holdings in Q1				280.6***		
				(6.32)		
Holdings in Q2				143.6***		
				(5.07)		
Holdings in Q3				65.4***		
				(3.15)		
Holdings in Q4				62.0***		
				(3.39)		
% in fund-of-funds(FOF)						367.5***
						(8.83)
% in LP						149.7***
						(4.87)
Corporate plan dummy	-167.7**	-118.4***	-5.6	-121.2***	-120.6***	-107.2***
	(-2.54)	(-6.21)	(-0.48)	(-5.01)	(-4.88)	(-4.81)
Non-US plan dummy	71.8	-38.8*	13.3	-80.7***	-77.5***	-28.1
	(0.80)	(-1.73)	(1.41)	(-2.99)	(-2.75)	(-0.95)
Observations	479	1695	302	2163	2163	2163
R-squared	0.234	0.140	0.051	0.158	0.161	0.212
Economic effects						
One standard deviation change	-174	-48	-1		-98	-79

Q1 to Q5 change	−211	−112	−2		−180	−145

Table VII: Explaining gross returns. The dependent variable is gross returns (in percentage per year) on holdings of PE for the investment approach indicated in the top row. Regressions include controls for corporate status, non-US dummy, year and plan fixed effects, as indicated. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively. Economic effects illustrate the implied change in gross returns from a one standard deviation increase in log holdings in that investment approach, as well as moving from the median holdings of small plans (bottom quintile of plans sorted on overall size) to the median holdings of large plans (largest quintile).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Subset of PE holdings:	Overall PE holdings					LP holdings		Fund-of-fund holdings		Internal
lag log holdings	1.370***	1.348***	1.949*	1.234***	1.562***	1.180***	0.998***	1.833***	1.956***	2.385***
	(5.34)	(4.92)	(1.80)	(4.62)	(4.14)	(4.25)	(3.43)	(4.43)	(4.84)	(2.76)
% in fund-of-funds		0.591			0.545					
		(0.42)			(0.39)					
% internally managed		2.206			2.298					
		(0.70)			(0.72)					
Lag returns in top quartile				5.981***			5.360***		0.876	
				(4.94)			(4.52)		(0.40)	
% past years with PE				2.926			4.473		-2.169	
				(1.19)			(1.64)		(-0.52)	
lag log overall plan size					-0.442					
					(-0.81)					
Observations	2,131	2131	2,131	2,109	2131	1,695	1,695	410	365	302
R-squared	0.291	0.292	0.418	0.305	0.292	0.309	0.321	0.490	0.494	0.175
Corporate and Non-US controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO
Economic effects										
One standard deviation change	2.99	2.94	4.26	2.70	3.41	2.36	1.99	3.51	3.75	5.41
Q1 to Q5 change	5.51	5.42	7.84	4.96	6.28	5.54	4.68	4.27	4.56	10.28

Table VIII. Spillovers between internal investing and performance of externally managed PE investments. The dependent variable is gross and net returns on external LP positions (including both fund-of-funds and LP investment approaches) in (1) and (2), respectively, and gross and net returns on internal holdings in (3) and (4), respectively. The main independent variables are an internal holdings indicator (taking the value one whenever a plan manages at least 5% of its PE holdings internally), top quartile internal indicator (taking the value one whenever a plan achieves top quartile performance on its internal holdings), and a similar top quartile indicator for external holdings. To identify top quartile plans, we compute the percentile of internal performance in the overall performance distribution (internal or external) based on three previous years of data. All regressions are estimated with year fixed effects. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	Performance in LP positions		Performance in internal holdings	
	Gross returns	*Net returns*	*Gross returns*	*Net returns*
has any internal	1.033	0.248		
	(0.67)	(0.16)		
lag top quartile internal	6.010**	5.891**		
(based on prior three years)	(2.21)	(2.03)		
top quartile external			0.430	0.399
(based on prior three years)			(0.09)	(0.08)
lag log external holdings	1.214***	1.680***		
	(4.74)	(6.19)		
lag log external holdings			2.381***	2.386***
			(2.75)	(2.75)
Corporate plan dummy	0.672	1.847*	7.635*	7.691*
	(0.64)	(1.71)	(1.74)	(1.77)
Non-US plan dummy	-3.955***	-3.374***	-1.875	-2.012
	(-3.31)	(-2.74)	(-0.57)	(-0.61)
Observations	2007	2007	302	302
R-squared	0.322	0.336	0.195	0.176

Table IX. Asset allocation as a function of size. In these Tobit regressions the dependent variable is the portfolio weight (i.e., holdings of the respective (sub)asset class divided by overall plan size). Control variables include the percentage of liabilities tied to retirees by itself and interacted with log plan size, as well as the non-US plan and corporate plan dummies. Alternatives include private equity holdings, real estate holdings, hedge fund holdings and other (e.g., infrastructure). Note that the time series of hedge fund holdings starts in 2000. All specifications include year fixed effects. Standard errors are clustered at the plan level and t-stats are reported in parentheses below the coefficient. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Weight on:	(1)	(2)	(3)	(4) Private Equity	(5) Real Estate	(6) Hedge Funds
	Overall alternatives					
Log plan size	0.020***	0.019***	0.014***	0.010***	0.012***	-0.005
	(9.74)	(8.50)	(2.82)	(3.18)	(2.95)	(-0.68)
% liability due to retired members			-0.132*	-0.084*	0.019	-0.329***
			(-1.88)	(-1.68)	(0.33)	(-3.00)
% liabilities * ln size			0.017*	0.011*	-0.002	0.039***
			(1.91)	(1.82)	(-0.22)	(2.97)
Non-US plan dummy		-0.011	-0.009	-0.018***	0.004	-0.011
		(-1.60)	(-1.43)	(-4.74)	(0.78)	(-0.86)
Corporate plan dummy		-0.001	-0.002	0.013***	-0.009**	0.006
		(-0.22)	(-0.40)	(3.08)	(-2.16)	(0.43)
Constant	-0.086***	-0.071***	0.009	-0.057**	-0.059*	0.020
	(-5.14)	(-3.44)	(0.24)	(-2.26)	(-1.92)	(0.34)
Observations	5406	5406	4453	4453	4453	2698