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Is Bigger Better?
Size and Performance in Pension Plan Management

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Abstract

We find substantial positive economies of scale in asset management using a newly available pension plan database: Large plans outperform small ones by 30-40 bps/year. We test whether plans make hypothesized changes on the intensive margin (within asset class) or the extensive margin (across asset classes) as they grow, and find that both channels are important. On the intensive margin, larger plans utilize more internal and passive management, which leads to cost savings that improve net returns by about 13 bps per year. On the extensive margin, larger plans dramatically overweight areas where we expect negotiating power to matter (where costs are high and where there is substantial variation in costs across plans). There are substantial positive economies of scale in both before- and after-cost returns in these areas, particularly in private equity and real estate, where shifting from smallest to largest quintile increases returns by up to 7% per year. We also find evidence of organizational diseconomies of scale, as larger assets at the plan level reduce net returns in an asset class, but not by enough to offset the economies of scale arising from larger investments in the asset class. All in all, diseconomies of scale documented in mutual and hedge fund literature do not necessarily translate to more flexible, multi-asset-class institutions such as pension plans.

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Choosing the size of the firm is a central question when scale has a significant impact on performance. In the realm of asset management significant scale economies would motivate investors to choose larger investment vehicles, encourage managers to aggregate funds, and provide incentives for governments interested in social welfare to facilitate such aggregation. Given the substantial dollars at stake, and the role of asset management in retirement income, the question whether there are scale economies is therefore an important one.

Probably the best evidence we have on scale economies in asset management comes from the mutual fund literature, where the stylized fact that emerges is that there are diseconomies of scale. Concerns that larger funds face more severe price impact of trades, that capital inflows will force managers to pursue poorer investment ideas, and that hierarchies would slow down decision making and dampen incentives figure prominently in the dominant theoretical models (e.g. Berk and Green (2004), Stein (2002)) and are borne out in the data. The diminishing returns to scale at the fund level have been found in cross-sectional studies of mutual funds (e.g., Chen, Hong, Huang, and Kubik (2004)), in hedge funds (e.g., Fung, Hsieh, Naik, and Ramadorai (2008)) and in private equity funds, where in addition to Kaplan and Schoar's (2005) finding of a concave relationship between size and performance more recently Lopez-de-Silanes, Phalippou, and Gottschalg (2010) have found that the more assets managed in parallel in a fund, the worse that fund's performance.

It is unclear, however, whether this evidence from the fund level translates to larger investment vehicles with greater degrees of freedom in resource allocation, for example, pension plans, endowments, or sovereign wealth funds. Two avenues through which larger investment vehicles could avoid size-related disadvantages would be to switch towards less size-sensitive investment approaches within an asset class (e.g., invest more passively) or to shift resources towards approaches and asset classes where there might be more than offsetting positive economies of scale. Such channels are rarely available to investment vehicles studied elsewhere, e.g., to mutual funds, but are available for multi-asset-class managers such as pension plans.

This paper re-examines the question of scale economies by looking at the strategies and performance of defined benefit (DB) pension plans.[1] Using pension plans has a number of advantages for studying economies of scale in asset management. Relative to endowments and sovereign wealth funds, there are many more pension plans with a wider size distribution. Data is more readily available here than for sovereign wealth funds. Moreover, plan size has a significant exogenous element, aiding in the identification of any impact of size on performance. Size is in large part dictated by the sponsor organization size and by inflows or outflows related to contractual commitments. The weak governance attributed to these plans (e.g. Lakonishok, Shleifer and Vishny (1992)) means that size-related performance problems might exist and persist for extended periods of time, which may allow us to capture them in the data.

We exploit a recently available dataset of multi-class defined benefit pension plans from CEM Benchmarking Inc. (CEM), a Toronto-based global benchmarking firm. The database covers a significant fraction of the industry between 1990 and 2008, and includes US as well as international plans. In 2007, for example, the database accounts for more than $4 trillion in assets, and includes plans representing 40% of US defined benefit assets, 70% of Canadian defined benefit assets, as well as $1 trillion in assets from 25 European plans and 11 Australian/New Zealand plans. It includes 842 unique plans of varying sizes, with a mean plan size of $8.9 billion. The dataset has annual information on quite detailed asset class categories (for example, alternatives includes classification by private equity, hedge funds, real estate, REITs, commodities, and other categories) and investment approach (for example, equities are broken down into externally actively managed, externally passively managed, internally actively

[1] Throughout the paper, we use the term "plan" to refer to pension plans (pension funds), and the term "fund" to refer to mutual, private equity, and hedge funds that may manage assets for a pension plan.

managed, and internally passively managed). Within each asset class and style we have detailed holdings and performance data, with separate information on costs, gross returns, and benchmarks. The US data in the database has recently been used by Ken French (2008) in his exploration of the costs of active investing, and by Bauer, Cremers, and Frehen (2010), who investigate scale effects in equity investing for US plans in US equities.

We start our exploration of the relationship between pension plan scale and performance at the overall plan level. Here, our main performance indicator is net returns, defined as the difference between the gross return and the sum of the costs and the benchmark return. We generate the plan-level return by aggregating the net returns at asset class level, where benchmarks are most meaningful.

We find strong evidence of increasing rather than decreasing returns to scale – bigger is better when it comes to pension plans. These scale economies are seen both in summary statistics across size quintiles and in regressions where we control for other factors that may drive returns. The difference in net returns between the largest plans (5^{th} quintile, where average size is $37 billion) and smaller plans (whether looking at the 1^{st} quintile, with the average size is $340 million, or the second quintile, with the average size is $990 million quintile) is 33 to 42 basis points per year. To put this number in perspective, this gain is similar in magnitude to the reported benefits of passive management in US equities (French (2008)).

Having established a relationship between pension plan size and performance we turn to economic theory to help us identify the channels through which this result may arise, and then take these predictions to the data. Taking the asset class as given, a direct way to avoid size diseconomies would be for larger plans to proportionally increase the number of managers, so as to maintain a lower average mandate size. An indirect way would be for larger plans to avoid diseconomies in externally managed funds by relying more on approaches that are less size sensitive (e.g. passive management) or where size-related cost savings may compensate potential diseconomies on the return side (e.g. internal management). There are likely greater fixed costs of setting up the human resources, reporting, and physical infrastructure with internal management, so we predict size will have a greater impact on internal than passive choices.

The second channel plan managers could use is to take advantage of their freedom to reallocate assets across asset classes. Specifically, they could shift assets from classes where scale-related diseconomies are likely to be largest to areas where they are weaker or where there may even be positive scale related economies. A model such as Berk and Green (2004) shuts down one possible way for positive economies of scale to prevail by assuming that all of the bargaining power is held by the external asset managers and/ or there is no surplus. More generally, however, it is conceivable (and in less competitive asset classes also likely) that there is surplus and that buyers of external managers' services may have negating power to appropriate part of that surplus. Larger plans are likely to have buyer power and be able to negotiate lower fee structures in such settings. There might also be scale economies on the return side if larger plans are given special access to attractive deals, are able to attract and retain more skilful managers or are treated differently from other investors and granted special co-investment opportunities or contractual protections (e.g. most favored nation status).

For these effects to combine to improve performance they will have to offset hypothesized organizational diseconomies of scale. With size comes more hierarchical decision making, which can produce costs. In the model of Stein (2002), for instance, scale diseconomies come from the need to transfer soft information up the hierarchy and the distortions in incentives this produces. In pension plans, an example would be the cost for the private equity team to have to appeal to another group within the plan to approve a significant private equity investment, and the cost of the delays and errors in transmission such additional communication may produce in larger and more hierarchical organizations.

We find strong empirical support for almost all of these predictions. Looking first at the within asset class predictions, plans do increase the number of mandates with plan size. However, the increase is less than proportional, which still may expose plans to greater potential diseconomies of scale at the external manager level. What appears to more than compensate for this is the more extensive use of internal and passive management – the difference between the proportion of assets managed internally or passively between the largest and smaller plans is a striking 39% of all plan assets. Such approaches not only allow plans to avoid diseconomies of scale, but they are actually associated with higher plan-level net returns. Moving from the average fraction of internal or passive holdings in the smallest quintile to the average fraction in the largest quintile adds 13 basis points per year (t-stat: 2.24) to net returns, accounting for roughly a third of the overall impact of size on performance. This improvement is driven by cost savings, with no statistically significant deterioration in gross returns.

We next look at the predicted shift of assets towards asset classes where scale and negotiating power could matter. The summary statistics suggest a focus on alternative asset classes, where costs are high on average and where there is substantial variation in costs across plans. We find that larger plans allocate significantly greater amounts to alternatives, and within alternatives to private equity (PE) and real assets, but not to hedge funds. The differences in the alternative asset holdings between the 5th and 1st and 2nd quintile are 6.3% to 4.0% of plan assets at the mean (8.1% to 5.2% at the median). In comparison, the overall average allocation to alternatives is about 6%. Regression results show that these differences are not driven by potential differences in the risk appetite and the need for liquidity between smaller and larger plans. More importantly, this shift in allocation is associated with statistically and economically large positive economies of scale in net returns. Summary statistics indicate that moving from the 1st or 2nd to the 5th quintile is associated with a performance improvement in alternatives of 1.4% to 2.2% per year. Our regression estimates suggest that the greatest positive impact of size is in the private equity component of alternatives, with a move from the 1st or 2nd size quintile to the 5th size quintile associated with up to 7% increase in net returns.

While the popular characterization of these classes suggests a fixed contract structure of "2 and 20," with a 2% fee for assets under management and a 20% carried interest, we find that costs are far from constant, with substantial economies of scale in costs across the alternatives components. More surprising, we also find positive economies of scale in gross returns in the largest components of alternative assets.[2] In private equity our regression estimates suggest that a move from the smallest to the largest quintile of size would improve a plan's gross returns by about 6%. These results are very robust for private equity and real assets, but we find no evidence of any size effect in hedge funds. A potential explanation for this finding is that size provides negotiating power with private equity and real asset fund managers. Larger pension plans may have access to co-investment opportunities that allow for some cherry-picking of investments, better monitoring of external fund managers, as well as the ability to protect themselves in their contracts through most favored nation treatment that is not available to all LPs. Hedge funds do not provide all such channels, and are more likely to face the same liquidity and price impact effects that contribute to decreasing returns in mutual funds.

We find some evidence of these additional benefits in documenting that returns on externally and on internally managed private equity are positively related. We observe a similar relationship in real assets, but not in hedge funds (which are exclusively externally managed), public equities, or fixed income. These spillovers only arise in alternative asset classes in which barriers to building internal management teams are the highest and where the advantage of large plans is the most pronounced.

[2] In private equity, real estate, and REITs investments that add up to 90% of the average plan's alternative holdings.

Finally, we explore more directly questions of organizational diseconomies of scale. To do this, we revisit our previous regressions that look at size within the investment category and include in addition a measure of the pension plan size outside of the given investment category. Consistent with the prediction of organizational diseconomies, this pension plan size measure has a negative and significant effect on performance. In short, bigger is better within a given asset class, but being bigger everywhere has a downside. Since assets outside of an asset class are unlikely to correlate with price impact etc. in that asset class, we view this as persuasive evidence for importance of organizational diseconomies of scale. The economic effect is most pronounced exactly where theories focusing on the importance of soft information and incentives (e.g., Stein (2002)) would predict. We find the greatest negative effect of overall plan size in alternative asset classes such as private equity, then in public equities, and finally the least impact in fixed income. Importantly, this pension plan-level effect does not dominate the within-asset class positive effect for the range of size we have in our sample.

Our finding of positive economies of scale for pension plans has policy implications. It suggests that value will be enhanced by fostering an environment with larger funds that are positioned to capture the economies of scale. One way to achieve this would be to open up larger plans to investments by smaller third parties, as is now being explored in a few settings.[3] Moreover, our results indicate that the current shift from defined benefit to defined contribution plans produces additional costs for the remaining members of shrinking defined benefit plans. All in all, our paper suggests that there is value in giving savers access to funds with sufficient scale and with freedom of action to take advantage of that scale by using various approaches to investment management (e.g., passive, internal) and by investing in multiple asset classes.

[3] This is already happening with a number of large European funds (e.g. APG of the Netherlands) and is being considered by large Canadian pension plans such as Ontario Teachers Pension Plan and OMERS (e.g. http://www.omers.com/About_OMERS/OMERS_Investment_Management_Services_available_to_third_parties.htm)

Our paper builds on the growing literature on economies of scale at the fund level, including the papers cited earlier, but differs from these in focusing on scale economies for plans that have greater degrees of freedom.[4] Papers using endowment data similarly find positive economies of scale in returns (e.g. Brown, Garlappi and Tiu (2009)), while Lerner, Schoar and Wang (2008), for example, do not find the size effect to be strong once they control for whether an endowment is from an 'Ivy Plus' university, hypothesizing that the benefit comes from these schools' alumni networks and from the fact that their plans moved more aggressively into alternatives early on. Two possible factors that would reconcile our findings with Lerner et al. (2008) are that scale economies kick in at higher levels of assets (the average endowment size at the end of their sample is $483 million, significantly less than $8.9 billion in our pension plan sample) and/ or that since alumni networks do not exist for pension plans, size plays their role in attracting better talent and governance. Few other papers have used pension data to examine scale economies, but where they have they have focused primarily on specific investments in equities and fixed income finding diseconomies (e.g. Blake, Timmermann, Tonks, and Wermers (2010), who look at UK plan returns on UK fixed income and equities and on international equities, and Bauer, Cremers and Frehen (2010), who look at US plan returns on US equities). In contrast, we use a broader sample of international plans, highlight the impact of size on overall plan returns, and when exploring the channels through which plan-level returns are affected we analyze the full range of assets including alternatives.[5]

[4] An incomplete list of notable papers include Pollet and Wilson (2008), who find that fund inflows predominantly lead to larger positions in existing stocks rather than to new and diversifying investments, consistent with the diseconomies argument. Christoffersen, Keim, and Musto (2006) and Edelen, Evans, and Kadlec 2007) show that the negative economies of scale of US funds are driven by their larger transaction sizes and higher transaction costs.

[5] We note that our finding of positive economies of scale is reconcilable with Bauer, Cremers and Frehen's (2010) finding of the reverse in domestic equity investments of US plans using CEM data. When we restrict attention to US plans' US equity holdings, we find no significant impact of plan size on returns.

The rest of the paper is organized as follows. In Section I we describe our data and provide summary statistics on plans and on the main asset classes. Section II reports results on overall returns at the plan level. Section III explores whether larger pension plans shift resources to investment styles and classes less subject to decreasing returns, focusing on the mandate size, use of internal and passive management, and asset allocation. In Section IV we investigate whether asset classes that larger plans use more intensely are associated with increasing or decreasing returns to scale. Section V discusses organizational diseconomies of scale. We conclude in section VI.

I – Data

I.1 Data Source

We make use of detailed data on pension plan size and performance from 1990 to 2008 provided to us by CEM Benchmarking, Inc. (CEM), a Toronto-based global benchmarking firm. The data is based on information pension plans report on their asset allocation, costs, gross returns, and benchmarks by asset class. CEM performs checks on the data and takes steps to confirm its accuracy and reliability, and produces reports used by management and boards. Asset classes examined include equities (including separately US equities, EAFE equities, and emerging market equities), various fixed income categories, and alternatives (including hedge funds, private equity, and real assets, subdivided into real estate, REITS, natural resources, etc.). Within each of these asset classes, performance is further broken down along two dimensions, internal versus external management, and active versus passive management.[6] The

[6] Hedge funds are exclusively externally managed. Alternative asset classes are always actively managed. Some management styles and asset classes are rarely used, e.g., we only have 20 plan-year observations of internally managed passive emerging market equity.

database also has additional information on other items of interest, e.g. the number of external mandates or costs at the overall plan level, although coverage of such items is less extensive.

We provide summary statistics of the database in Panel A of Table I. The data we use in this paper is based on survey responses of 842 distinct pension plans with 5008 plan-year observations. In each year we calculate the basic summary statistics for the performance measure, with the panel reporting the average value across the years the performance measure is available in our sample, which is 9 for hedge funds (for which performance data is only available since 2000) and 19 for all other asset classes (for which we have data in all sample years, 1990 to 2008). The plans involved are roughly equally split between corporate and non-corporate plans and US and non-US, with corporate plans accounting for 54% of the sample, and US plans accounting for 57% of the sample. The mean length of time a plan is in the sample is 6 years. While the database does not account for all pension plans, its coverage is quite extensive, with the 2007 reporting year for example accounting for more than $4 trillion in assets, and including plans representing 40% of US defined benefit assets, 70% of Canadian defined benefit assets, as well as $1 trillion in assets from 25 European plans and 11 Australian/New Zealand plans. The average plan invests 56% of its portfolio in equity, 34% in fixed income and 6% in alternatives; the remaining 4% are in cash and tactical asset allocation. 19% of these assets are passively managed, and 17% are managed internally.

We have information on the country (e.g., US) or region (e.g., Euro zone) of the plan and a plan ID, but do not have information on specific plan names so we cannot match the data with alternative data sets. We use the provided data as given, with the following changes. The holding and performance data is provided in each plan's local currency. To ensure comparability we express asset holdings in (millions of) US dollars and transform all returns into US dollar returns using interbank exchange rates as of December 31 of each sample year and hence assuming that plan investments are held and returns are earned over the entire calendar year.

(Of course, this assumption is only needed for non-US plans.) We also winsorize costs and return the 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.

As with any relatively new data source, there are natural concerns about potential biases. One concern is that plans only report in years when they did well. This would produce a positively skewed description of performance and may impact our results if this reporting bias were further related to plan size. Fortunately, Bauer, Cremers and Frehen (2010) address this issue with CEM data using their sample of US funds. They match the CEM funds with Compustat data and find no evidence of performance-related biases. A second potential concern is that there might be a bias in the benchmarks plans report to CEM. We address this concern directly in the paper by also presenting results for gross returns with year fixed effects, which act as a common benchmark for a given asset class. More generally though, we have no strong reason to believe that benchmarks are strategically misreported or that if they were, this would be related to plan size. The reports that CEM produces based on the survey data are typically used by top management and boards of directors, and plans would have little reason to misreport and make this service less informative. Moreover, we regressed benchmark returns on size and did not find any evidence of size-related differences that may influence our findings.

I.2 Summary Statistics on Performance across Asset Classes and Styles

As outlined in the introduction, we expect that larger plans may have more negotiating power. The scope for negotiating power to matter will depend on the characteristics of a given asset class. This is illustrated in panel B of Table I, where we report cost and performance measures for different investment categories. Investment categories in the alternative asset class have the highest interquartile range in almost all performance categories, foreshadowing their importance for finding a significant impact of size. The interquartile range in costs is 181 basis points in private equity, 132 basis points in hedge funds, and 58 basis points in real assets, in part reflecting the much higher average costs in alternative asset classes. Alternative investment categories also have the greatest variation in gross returns of 19, 12, and 10%, respectively and in net returns, with variation of 17, 9, and 6%. Equities have lower variation with an interquartile range of just 24-45 basis points in costs, 4-7% in gross returns, and 3-6% in net returns. Fixed income has even lower variation of just 14 basis points in costs, 7% in gross returns, and 1.5% in net returns. In the bottom half of the panel we reproduce these statistics just for the internally managed holdings, finding significantly lower costs (e.g. internal costs for private equity are just 44 basis points, more than 200 basis points less than the overall average), and mixed evidence whether internal management affects gross and net returns.

II Differences in Performance Across Size Categories

We now examine the relationship between size and performance at the pension plan level in the summary statistics in Table II and in the regressions in Table III. In sum, these tables show that rather than facing diseconomies of scale, or constant returns to scale, larger plans experience higher returns. Bigger is better when it comes to pension plans.

Table II shows the variation in plan size across five size quintiles. In each year we have divided the data into five quintiles by size, and the table reports the time-series averages of the cross-sectional average computed in each sample year. Plans in the 1st and 2nd average \$331 and \$962 million in assets respectively (unreported medians are very similar), while the largest quintile plans have \$36.2 billion in assets on average (median=\$21.3 billion). We next look at net returns, defined as the difference between gross returns and the sum of costs and benchmark returns. There is a lot of variation in net returns across these size quintiles. The difference in net returns between the largest plans (5th quintile) and smaller plans (1st and 2nd quintiles) is 33 to 36 basis points (with similar magnitudes at the median). To put this number in perspective, the overall average abnormal return in our sample is 18 basis points. While this univariate finding foreshadows our subsequent results, at this stage it has to be cautiously interpreted, as other factors, e.g., the proportion of corporate or US plans, also vary with size and might drive this difference.

To account for such factors and explore more carefully the potential relationship between plan size and net returns we turn to a regression framework that we employ throughout the paper. We regress overall plan net performance against the log of plan size, with some specifications including year and plan fixed effects. Our net return measure is defined as gross returns minus costs and minus the self-reported benchmark returns. Net returns are computed for each asset class and value-weighted into a plan-level measure. From this measure we subtract the plan-level investment administration costs (e.g., oversight and custodial costs), which are not included in the asset-class-specific cost figures. In the primary tables we present results where the size variable is the average plan size in the current year, and we include in the Appendix similar regressions using a lagged measure of size. We headline contemporaneous size as it is the most appropriate measure for current year costs and because it provides the most power in our tests (using lagged size dramatically reduces the size of our sample, e.g., when predicting overall plan returns, the sample size drops from 4950 to 3829; when predicting returns or costs of individual asset classes, the relative drop in the number of observations is even more severe). This power increases our ability to impose more demanding tests of the data that use plan fixed effects to identify the impact of size on performance. The main downside to this choice is that the same-year relationship between size and performance may be partly mechanical (better performance leads to larger end-of-period size). However, the similarity of lagged size and average current year size results, discussed in the Appendix, indicates that this mechanical relationship does not play an important role in our analysis.

The regression results in Table III tell a similar story as the summary statistics and indicate a statistically and economically significant positive impact of size on performance. The statistically significant coefficient on log size of 0.09 in column (1) (and column (2) where we include year fixed effects) implies a difference in net plan returns between 5th and 1st or 2nd quintile plans from 42 to 33 points measured using mean size data (37 to 28 basis points if medians are used). This is easier to see in column (3) where we introduce dummies for the smallest and largest quintiles, and the difference in coefficients implies a 27-(-9)=36 basis point difference in performance. In column (4) we restrict ourselves to just US plans, the sample that Bauer, Cremers, and Frehen (2010) have shown has no performance-related bias in reporting. The effect is, if anything, more pronounced in the US plans.[7] In column (5) we go back to the full sample, but this time include additional control variables for corporate and non-US plans and find this has little impact on the overall size coefficient. In column (6), the positive and significant coefficient on the interaction between size and corporate plan dummy indicates that the size effect is more pronounced here. The combined coefficient on US corporate plans almost doubles from about 0.09 in specification (1) to 0.17 in specification (6) (F-test=19.96, p-value=0.00), while the coefficient on non-US corporate plans changes to 0.19 (F-test=16.00, p-value=0.00). The impact of size is somewhat lower for public pension plans: The coefficient for US (non-US) public plans is 0.06 (0.08) with t-stat=1.98, p-value=0.048 (F-test=5.63, p-value=0.02). We find some persistence in plan performance in column (7), where we include lagged net return, but this does not affect our finding of positive size economies, particularly for corporate plans.

In column (8) we provide a more demanding test, introducing plan fixed effects in addition to year fixed effects, so that the effect of size on performance comes only from within-

[7] Given that many readers may be interested in the sub-sample of US funds, we present additional analysis for these funds in the Appendix.

plan variation in size. Here we find the predicted sign, although the result is not significant at conventional levels, perhaps suggesting the limited power of plan fixed effects (recall that we have only 6 [4] observations for the average [median] plan). When we add additional controls to the regressions with plan fixed effects in columns (9) and (10), the main effect remains positive and of economically important magnitude, but is again insignificant.

The specifications in Table III relate net returns to log of size. It is possible that the correct functional form is not in fact log-linear and that our specifications might not reveal decreasing returns to scale over some regions of plan size. To address this point, we estimated regressions with log size directly (as in Table III), log size and its square, and log size and its square and cube, and present the results graphically in Figure 1. The figure shows that including the squared term has little impact. It does show a slight attenuation with the inclusion of the cubic term, but importantly we find no evidence that the impact of size becomes negative over the relevant range for most pension plans (the plots are provided for the 5^{th} to 95^{th} percentile of size in our sample). The similarity of shape of the relationship regardless of the specification used suggests that regressing performance on the logarithm of size is a good approximation to the underlying relationship.[8]

In sum, Table III provides evidence that there are positive rather than negative returns to scale in pension plan performance. To understand better the channels through which size influences performance we now turn to more detailed data on investment approaches in section III and the evidence on the performance implications of reallocation across asset classes in section IV. In section V we bring into focus organizational costs which may counteract these positive scale economies were plans to get significantly larger.

[8] In the Appendix we provide additional evidence that our results are not driven by very large or very small plans.

III - Do Larger Plans Take Different Investment Approaches?

III.1 Size and the Average Mandate Size

One potential way to avoid diseconomies of scale is for larger pension plans to spread their assets across more investment vehicles. Our data includes information on the number of external active mandates (but not detailed mandate-level information) for a subset of plans. Combining this information with data on the overall assets managed actively by external managers, we produce average mandate size. We treat this quantity as a proxy for the size of the external fund that invests on behalf of a pension plan.[9]

Table IV shows that plans do act as if they are aware of the diseconomies of scale at the fund level. In the regressions in this table the dependent variable is the log of the number of mandates and the independent variable is the log of the external holdings in that asset class, with controls for plan attributes that correlate with size. The coefficient on the log of holdings can be interpreted as an elasticity. Its positive and significant estimates in Table IV indicate that larger plans do increase their number of mandates, but this increase is far from proportional. For example, in column (1) we find that when plans double their equity holdings, they increase the number of mandates by only 34%. Magnitudes are similar in other asset classes, with the most substantial response in number of mandates in private equity, where the estimated elasticity is 54%. The end result is that larger plans have substantially larger mandate sizes, something revealed most clearly in Figure 2, which shows a monotonic relationship between plan size and average mandate size that is persistent over time for equities and the most important sub-components of alternatives. Existing evidence in the mutual fund and private equity literature suggests that such dramatic increases of allocations to a manager

[9] This is an admittedly imperfect proxy. It is more meaningful to the extent that large and small plans interact similarly with external fund managers and larger average mandate size means the fund receiving the mandate takes larger positions in existing investments, as Pollet and Wilson (2008) have found.

may be harmful for performance, making our findings from the previous section even more surprising: Large plans are able to generate better net performance in spite of the fact that they have substantially larger mandate sizes.[10]

III.2 Size and Diversification Away from External and Active Management

Another way for larger plans to avoid exposing themselves to diseconomies associated with external active management is to use less of that investment approach. Passive management produces returns that are less scale-sensitive, and in internal active management there might be sufficiently lower costs so as to produce constant or even increasing returns to scale in net performance. Moreover, it is easier for larger funds to overcome the fixed costs associated with establishing internal management.[11]

The summary statistics in Table II suggest a strong and significant impact of these two channels. That table shows that Q5 plans manage a striking 39% more of their assets internally or passively. These numbers are even greater than the overall average percentage of internal or passive assets of 32%. The regression analysis in Table V illustrates this result, with columns (1) and (2) showing the result for the whole portfolio and columns (3) to (11) confirming it for each of the three major asset classes, with the strongest effects in fixed income (where internal management is perhaps the easiest to set up) and the effect in alternatives driven by internal management (as this asset class is not managed passively). In regressions (5), (8), and (11) we

[10] An alternative possibility (that we do not have the data to test) is that larger plans are able to write different contracts in their mandates, aligning incentives better and limiting the ability of the manager to access additional funds. Canada Pension Plan Investment Board, one of the largest asset managers in Canada, has developed and successfully used a performance contract that substantially differs from industry standards (see Raymond (2008)). CPP IB's success in implementing this contract is related to its size and importance; it is unlikely that a small plan would be able to entice external managers to accept a contract that markedly differs from the usual fee structure.

[11] The existence of scale economies arising from the ability to spread fixed costs of internal management over a larger asset base is very clear at the plan level, with plan-level administrative costs monotonically declining with from 12 basis points in the 1st quintile to just 3 basis points in the 5th quintile in Table II.

include both the asset class holdings and the overall plan size outside the asset class to see if the choice to invest internally arises from the assets devoted to that sector, or more generally from the overall plan size. The data suggests the choice to go internal or passive is driven by both factors in equities, just by the assets in the class for fixed income, and just by the overall plan size for alternatives. This suggests that only the largest plans can devote enough resources to manage alternative asset classes in-house.

If, as we hypothesize, larger plans use internal and passive management to avoid running head-on into areas of decreasing returns, this has ambiguous predictions for returns to these approaches within an asset class, but should improve net returns for larger plans at the plan level. To the extent that plans are optimally allocating resources, they should shift resources across the four styles available to them (internal active, internal passive, external active, external passive) until the risk-adjusted returns are equalized. Plans that do so may avoid diseconomies and produce net return gains at the plan level. We find evidence consistent with both of these contentions.

In untabulated regressions we relate asset class net returns to the proportion of holdings that is not invested in external active management (controlling for size and plan characteristics), and find positive but insignificant results on this variable. In Table VI we show regressions at the plan level, where we add an additional control variable of the fraction of holdings not invested in external active management to the main specifications from Table III. This variable produces positive returns in (1) that are robust to inclusion of control variables in (2). We find in (3) and (4) that this positive result comes from internal management and that it is driven by the impact on costs ((5) and (6)) with no significant impact on gross returns ((7) and (8)). The economic impact of the management style is noticeable (moving from values typical for 1st to those typical for 5th size quintile improves returns by 13 basis points) and reduces the estimated impact of size on performance by about one third compared to Table III.

III.3 Size and Diversification into More Investment Categories

The second mechanism whereby plan managers can avoid diseconomies of scale at the fund level is to expand the number of investment categories in the portfolio and to increase weights on categories that are less subject to decreasing returns to scale. This approach may also have diversification benefits,[12] but we are ignoring these and focusing only on whether it provides positive economies of scale in net returns.

In Table II we report differences in asset allocation across the three broad asset classes of equity, fixed income and alternatives. The impact of size on allocation appears greatest in the alternative asset class, where the differences in portfolio weights on alternatives between the 5th and 1st and 2nd quintile are 6.3% and 4.0% of plan assets, respectively (8.1 to 5.2% at the median). These differences are roughly equal in magnitude to the overall mean asset allocation to alternatives in our sample (about 6%). Of course, these differences in summary statistics are not fully convincing, for a variety of other factors aside from size could influence asset allocation decisions. We therefore turn to a regression framework in Table VII.

The regression framework allows us to at least partly address another potential determinant of allocation decisions: The alternative asset classes are usually associated with higher risk and lower liquidity, and differences in risk appetites or the demand for liquidity might correlate with plan size. Our first proxy for risk appetite/demand for liquidity is the fraction of liabilities tied to current retirees, as a greater percentage implies a greater need for returns in the near term. In our sample its mean value is 46%, with an interquartile range of 55%. Our second proxy is whether a plan is a corporate plan or not. This is an indirect measure of risk appetite, as to the extent that a corporate plan is underfunded, it carries a

[12] The standard deviations of the average returns (average net returns) in the 5th and 1st size quintiles are 0.12 and 0.13 (0.014 and 0.01), respectively, in line with larger plans being better diversified.

larger bankruptcy risk. We include a dummy for a foreign plan as well to make results comparable with previous findings, although we have no strong prior on this variable.

In Table VII we regress the portfolio weight on alternative assets against plan size, and find that larger plans allocate more to alternatives, with the positive and significant coefficient implying an 8% greater allocation to alternatives in moving from the smallest to the largest size quintile. In line with economic intuition, we find in (2) and (3) that plans that likely have the greatest need for safety and liquidity (plans with a high fraction of current retirees among plan members) indeed invest less in alternative assets, but the interaction shows that this has less of an effect on larger funds. Importantly, this does not affect the coefficient on plan size. In specifications (4) to (9) we analyze portfolio weights on the main alternative components, finding that size leads to greater weight on private equity in (6) and (7) and real assets in (8) and (9), but has no effect on allocations to hedge funds in (4) and (5).

IV - Size and Performance in Investment Categories Where Larger Plans Are More Active

The previous section documents that one of the most pronounced differences between larger and smaller pension plans is larger plans' increased focus on alternative assets. In this section we examine whether this difference in allocation is also associated with a differences in performance. It is important to note that in our net return and cost regressions here we are using only the costs associated with a given asset class, rather than plan-level costs linked to audit, oversight, etc., to provide a purer test of performance in that asset class. We did include the plan-level costs in the regressions in Table III, and will again explore them in section V.

IV.1 – Size and Net Returns in Alternatives

Table II suggests a significant impact of size on performance in the alternative asset class. The 1st and 2nd quintile have net returns of -13 and -87 points respectively, while the 5th quintile shows positive returns of 130 basis points. Thus, a move from the 1st or 2nd to the 5th quintile is associated with a performance improvement of 143 to 217 basis points. Differences in gross returns are even more pronounced. Part of this effect could be driven by differences in the choice across investment opportunities in alternatives. To address this issue and to control for other factors, we now analyze separately the investment categories of private equity, real estate, REITs and hedge funds that make up the bulk of the alternative asset category.[13]

We begin our analysis with private equity net returns in Panel A of Table VIII. We find a strong relationship between size and performance. Column (1) presents the univariate regression of net returns on the log of holdings of private equity (with year fixed effects) and is the base regression in our analysis. The coefficient of 1.18 implies that a move from the 1st or 2nd to the 5th size quintile produces a 5 to 7% increase in net returns. This premium is higher than half of the overall average gross return in that asset class. In column (2) we introduce controls for corporate and foreign status, and, in (3), their interactions with size, but they do not change the main effect of our central variable of interest. In columns (4) and (5) we check to see whether these results are driven solely by style choices within the asset class highlighted in the previous section of the paper (the intensive margin). In (4) we control for the percentage of private equity holdings managed internally, and in (5) we add the average mandate size, although this variable is only available for a small subset of our data. In both cases, the overall impact of size remains economically large and significant.

[13] Private equity and real estate account for 83% of alternative asset holdings for the average plan. A few plans provide additional information for other sub-categories of real assets, e.g., infrastructure. Size tends to be positive and economically large in regressions on these sub-categories, but is rarely statistically significant, perhaps because the number of plan-year observations we can use drops to about 200-300.

In Table VIII Panel B we report the coefficient on size for identical regressions for real estate, REITs and hedge funds. We find similar results for real estate as for private equity, with statistically and economically significant coefficients on size. In contrast, for hedge funds we find mostly insignificant results, particularly after we include controls.[14] REITs also show some strong positive results, but we caution the reader about these results as they are not robust to using lagged size as opposed to contemporaneous size. REITs are the only asset class that generates different results when average same-year size is used and when lagged size is employed instead. We present evidence for this in the Appendix.

This difference between hedge funds and the other alternatives categories, both here in net returns, and in the previous section where we found no greater allocation of large plans to this category, supports the argument that larger plans shift resources to areas where they are more likely to have a comparative advantage. This may be because hedge funds have lower capacity for accommodating large inflows, with flows inducing large price impact and forcing managers to exploit weaker ideas. This view is consistent with the evidence in Fung et al. (2008). In private equity and real estate the potential investment universe is much greater and less likely to suffer from such adverse effects. Moreover, it is likely that large pension plans are able to negotiate additional benefits with private equity funds. For example, they may be allowed to co-invest alongside a fund, with such an option reducing their costs, giving them additional insight into the investment, and possibly allowing them to monitor the PE fund better. Larger plans may also have some synergies with private equity funds. To the extent that they have more clout with the policy makers, they may help PE funds in regulatory arbitrage or, say, in winning an infrastructure contract. It is less likely that similar synergies exist when plans interact with hedge funds.

[14] Additional analysis in the Appendix shows no evidence of economies of scale in hedge funds in subsamples of our data (e.g., when non-US or when smallest/ largest plans are excluded, etc.).

Before examining such channels in more detail, we need to convince ourselves that these results are not spurious. There are a number of potential concerns with these results for alternatives, as there are a number of omitted variables that could be driving the returns in addition to size. Three such variables, highlighted by Lerner, Schoar, and Wang (2007), are experience, access, and timing. Perhaps larger pension plans have simply been investing for a longer period of time in the asset class, have greater experience and have established connections with the persistently strong private equity performers identified in previous papers (e.g. Kaplan and Schoar (2005)) that have closed their funds to new investors. In such a case the positive relationship between pension plan allocations to alternatives and net returns is more of a historical accident than a robust relationship between size and performance.

To address this concern we run two additional specifications. First, in columns (6) and (7) we include the lagged net returns, again finding a robust relationship between size and performance. In line with the earlier studies, e.g., Kaplan and Schoar (2005), we find strong persistence in net returns to private equity. Second, in columns (8-10) we include plan fixed effects so that the size effect comes solely off the within-plan variation. The relationship is even stronger with a higher value to the size coefficient and remains statistically significant when we do so. Thus, our findings are not driven by pension plans invested in private equity funds with high recent performance or by the access of larger plans to the best PE managers, to the extent that such access is constant over the sample period and is subsumed in plan fixed effects.

What this analysis does not do is to address the concern about timing arising from both the vintage effect (some years are better for returns than others) and the j-curve effect (it takes time for fund investments to yield returns). If larger plans invested earlier than smaller ones, then we may simply be seeing the effect of the timing of the investments. Such concerns are greatest for private equity. It is comforting, but not fully convincing, that we see similar results for real estate investments, where there is less likely to be a j-curve to investment returns. To tackle this issue directly we went back to the data provider. We asked for and were provided more detailed information for some measures of timing for a subset of the plans in our sample, based on a survey CEM conducted in early 2009. Specifically, we obtained for 15% of plans that invested in private equity in the year 2008 (and which account for 18% of the dollars in private equity) the fraction of private equity investments that were still in the commitment period in 2008 and the average vintage year of their PE portfolios (weighted by the amount invested in each LP position). These are admittedly crude measures to capture differences in both vintage year and j-curve, but are all that is possible given our data.

In Table IX we examine how these measures of PE investment timing influence our estimates of the impact of size on returns. In columns (1-4) we use just the 2008 data, while in columns (5-8) we pool the 2006-2008 data and assume that the cross sectional variation in timing found for 2008 also applies to these earlier years.[15] In columns (1) and (5) we establish a baseline and show that our prior finding of positive returns to scale in private equity is also found in this sub-sample of plans. Not surprisingly, given the small sample size, this is not significant for 2008, but we do find significance in the pooled data. In columns (2-4) and (6-8) we include the timing variables. They have the predicted signs, with more assets in the commitment period reducing returns and older portfolios producing greater returns. Importantly for us, the inclusion of these variables only slightly reduces the estimated coefficient on size.

IV.2 What Drives Positive Net Returns in Alternatives?

To understand better the channel through which the effect on net returns emerges we conduct two analyses, first decomposing net returns into costs and gross returns in Table X and

[15] If a plan has PE investments that are, on average, 5 years old in 2008, we assume they were 4 (3) years old in 2007 (2006). Clearly, this is only an approximation and does not account for investments that were closed down prior to 2008. We cannot similarly extrapolate the fraction of assets in the commitment period and we assume that that variable does not change in the last three years of the sample.

then in Table XI exploring whether the ability of large plans to invest internally in some of these alternative asset classes contributes to these positive returns.

Despite the widespread belief that private equity funds charge similar fees to all clients – the "2 and 20" with 2 percent of assets and 20 percent of carried interest – we find large variation in reported costs and in Table X find that size has a significant power to explain the level of those costs. In column (1) we introduce our base specification and find a coefficient of -27.4 that is highly significant. This implies a 171 to 124 basis point difference in moving from 1st or 2nd quintile allocation to private equity to the 5th quintile allocation. Note that this effect, while substantial, only accounts for a fraction of the impact of size on net private equity returns we found in Table VIII. As we verify below, the overall impact of size on net returns comes through not only the cost channel, but also through gross returns directly.

The negative relationship between size and cost is robust to introduction of controls for the type of pension plan (column (2)). In column (3) we include a control for the percentage allocated through internal management, with an estimated coefficient of -200, which corresponds to the average costs savings (in basis points) that a plan moving from purely external to purely internal management would experience. In column (4) we repeat the analysis using plan fixed effects, again finding significant cost savings.

A potential concern brought to our attention by the data provider is that for a few plans CEM has introduced default private equity costs, as the reported costs were inconsistent with those of other plans. That is, CEM replaced reported costs for these plans with default costs that they calculated. We think this reduces the noise in our data, but since we were concerned about how this may affect our results, we also asked for and were provided with 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.

In Table X we also use a similar setup to explore the impact of size on gross returns. Surprisingly, we find a similarly strong relationship between size and gross returns. Column (5) is the base specification for gross returns and it produces a statistically significant coefficient estimate of 1.24, implying that moving from the 1st (2nd) to the 5th size quintile would improve gross returns by 7.7 (5.6) percentage points, on average.[16] This positive relationship is robust to the controls for plan type in (6) and to the use of internal management in (7). The only indication of weaker results come in the plan fixed effect regression in (8), where the coefficient remains positive, but the result is no longer statistically significant. As we argue above, this might be because we have relatively little power in specifications with plan fixed effects.

What about patterns in other investment categories? In Panel B we find similarly strong statistical relationships between holdings and costs across all investment categories, with smaller but still sizeable economic magnitude. For example, the coefficients on log size in the base specification range from -7.98 in REITs to -7.63 in hedge funds and -5.43 in real estate. In gross returns, we see strong results for real estate, where size is significant also in the plan fixed effects regression, again confounding results for REITS depending on whether contemporaneous or lagged size is used, and no impact of size on performance in hedge funds.

In Table XI we explore the hypothesis that there might be positive spillovers between larger plans' ability to use internal management and these positive returns. For example, internal management teams in private equity might provide skill and experience that improves external manager selection and monitoring and potentially leads to greater returns in external management. Internal capacity could also increase the likelihood of being offered co-investment opportunities with external managers. To test this hypothesis we focus on net returns in the

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[16] Note that year fixed effects in this and subsequent gross return regressions are equivalent to using a common benchmark to correct returns for the overall movements of private equity.

externally managed part of the asset class and see whether we find that having internal active management and skill in that activity (measured by the net return) influences net returns.

We find evidence of such spillovers in the overall alternative asset class in regressions (1) and (2) and in private equity in particular in regressions (3) and (4). This suggests that having effective internal management is associated with greater returns in externally managed funds. We investigate whether a similar effect arises in public equities or in fixed income, but do not find it in regressions (5-8).

V - Organizational Diseconomies and Other Limits to Scale

As we stated earlier, for the asset-class level effects to combine to improve overall plan performance they will have to offset hypothesized organizational diseconomies of scale. In the model of Stein (2002), these diseconomies arise from communication costs in hierarchies that result in weaker incentives. Pension plans seem to fit the model in that larger plans clearly have deeper hierarchies and more structured decision making processes. It is thus surprising that so far we have not found any evidence of such diseconomies. The failure to find them in the previous section could simply be an artifact of our research design. In our main tests, our measure of size (assets in a given investment category) does not capture the impact of all of the other assets in the plan and the apparatus that goes along with those assets.

To explore this potential channel we now revisit the core regressions in Table VIII and X, this time including not only the measure of assets in a given investment category, but also the amount of other assets in the plan (i.e. total assets less the investment category). As before, we start with a detailed analysis of private equity in Panel A and then overview other asset classes in Panel B, in each case showing results for net returns, for costs, and for gross returns.

When we regress private equity net returns on both private equity holdings and the overall remaining plan size (Table XII, column 1), we find an even stronger impact of size on performance (the coefficient goes from 1.29 in Table VIII to 1.83), and, interestingly, a negative and significant impact of plan size outside private equity. This implies that larger size in a given category increases returns, but larger size elsewhere reduces returns on that asset class. The holdings-level effect is robust to introducing standard plan characteristics as controls in regression (2) and plan fixed effects in (3). The plan-level effect still has negative coefficients in these regressions, but they are no longer significant, with t-statistics of -1.61 and -0.81.

The results for costs, presented in columns (4) to (6), are equally striking. There are substantial economies of scale at the level of a given asset class, but plan size outside of that asset class has the opposite effect. In gross return regressions (7) through (9), the effect of holdings remains positive, while plan size outside of private equity does not seem to matter.

Our finding of economies of scale at the asset class level and organizational diseconomies at the plan level carries over to most other alternative asset classes (real estate and REITs) and to equities (overall, and US equities separately).[17] We report these results in panel B of Table XII. In line with our earlier findings, we find no significant effect of holdings on hedge fund performance. There is also no evidence for economies of scale in fixed income. Net returns seem unaffected by size at either the holdings or the overall plan size level. Not surprisingly, we do find some evidence of size effect in costs. We also find that gross fixed income returns correlate positively with holdings size. This seems to be driven by larger plans allocating relatively more to fixed income sub-classes with higher average returns (e.g., emerging markets fixed income, high yield bonds), which explains why the effect is not detectable in overall net returns (higher average returns on sub-components of fixed income are offset by the benchmarks).

[17] In unreported analysis we find that holdings-level results are driven by non-US plans. This is consistent with findings of Ferreira, Miguel, and Ramos (2010) for an international sample of mutual funds.

We interpret the impact of plan size outside of a given asset class as evidence for the importance of organizational diseconomies of scale. First, plan size outside of a given asset class is unlikely to correlate with price impact or investment capacity of ideas within that asset class. Second, the impact of plan size in different asset classes agrees with the theoretical predictions of Stein (2002): Diseconomies of scale are more pronounced in areas where soft information is important. The magnitude of the effect we document in Table XII (strongest for alternatives, particularly private equity, then for equities, then for fixed income) agrees with this prediction.

The co-existence of positive and negative size effects indicates that initially positive economies of scale may eventually turn negative. A potential concern is that this may not show up in our specifications. We may be overstating the benefits of size by just using a log transformation and we might see more attenuation using other functional forms. In Figure 3 we present these regression results graphically, showing the baseline log result, as well as regressions with a squared term and with a cubed term for private equity, real estate, and REITs. Incorporating higher order terms does suggest some attenuation of the size effect, but it never reverses in the relevant range for the bulk of our pension plans (the x-values range from the 5th to the 95th percentile of holdings). Including a squared term reduces the strength of the size impact somewhat for private equity and real estate, and more substantially for REITs. Including a cubic term as well leads to a close to flat relationship above a threshold for private equity and REITS, but actually suggests greater economies in real estate.

All in all, even though we do find that benefits to scale have a limit, we document that even for the largest plans in our sample the effects at most level off, but do not become negative. Thus, plans do not seem to reach size great enough for the negative effect of plan-level size to offset the initially positive economies of scale at the holdings level.

VI Conclusions

We use a novel dataset to examine the relationship between size and performance in asset management. The existing empirical evidence in mutual funds and the growing evidence in hedge funds and private equity funds point to negative economies to scale. Such findings formed the basis of many influential theoretical investigations, e.g., Berk and Green (2004).

Our central result is that the traditional view should not be automatically translated to multi-asset-class managers like pension plans. We document substantial economies to scale in our sample of DB pension plans: Larger plan size is associated with better net performance of the entire pension plan portfolio. To explain this finding, we document that plans react to changes in size both at the intensive margin (within asset class) and the extensive margin (across asset classes). At the intensive margin, larger plans rely more on internal and passive management. While this approach does not affect the gross returns they earn, it yields cost savings large enough to be detectable in overall net returns: Compared to the smallest quintile, largest quintile plans earn about 13 basis points more per year due to this channel. The effect on the extensive margin is even more dramatic. As plans grow, they change their asset allocation and invest much more in alternative assets, and in private equity and real estate in particular. Plans realize substantial economies of scale both in costs and in gross returns in these areas. The overall impact of size on net returns is substantial, with the movement from 1^{st} to 5^{th} size quintile improving net returns on private equity by as much as 7% per year.

Bigger is better when it comes to pension plans. However, bigger is not *always* better. While there are positive economies of scale at the level of a given asset class, plan size elsewhere has the opposite effect for that asset class. For very large plans, this second channel will dominate and will put them at a disadvantage. However, for the range of size in our sample, negative plan-level diseconomies are not enough to offset the economies at the asset class-level.

APPENDIX

The tables discussed in the body of the paper present results using the average current year size as the key independent variable. In Appendix Table AI we re-estimate the main specifications using lagged size to avoid a potential mechanical relationship between size and performance. The table reproduces the main regressions from Tables III and VIII, in which we relate net returns on the overall plan and on different sub-categories of alternative assets to the overall plan size and to holdings of alternatives.

Table AI confirms that the results we present and discuss in the paper are not driven by our choice of the main dependent variable. When lag size is used, there is strong evidence of positive economies of scale at the plan level, particularly for corporate plans, strong economies to scale in private equity and real estate, and the absence of a relation between size and performance for hedge funds. The magnitude of the estimates is similar to that reported in the paper. The only two areas where our evidence is weaker is when plan fixed effects are used (potentially because eliminating an additional year of data per plan lowers the power of these regressions too much; recall that the average [median] plan only has 6 [4] observations in our database) and the results for REITs. As discussed in the text of the paper, REITs is the only investment category in which using contemporaneous and lagged size leads to different results. The results for other asset classes are very similar to those we present in the body of the paper.

Finally, the database we use in our paper contains both US and international pension plans. Some audiences may be interested in analysis that is limited to US plans. We do that in Panel A of Table AII, where we reproduce key specifications from Tables III and VIII. As can be seen from the table, our results are as strong for the US plans as they are for the overall sample. We see strong economies of scale at the plan level and in private equity and real estate and, finally, no evidence of any size economies in hedge funds.

In Panel B of Table AII we summarize key estimation results obtained earlier (for the overall sample featured in the paper, for the overall sample using lagged instead of contemporaneous size, for US plans), as well as additional robustness checks for the sub-sample of corporate plans and for subsamples excluding plans with extreme size. The overall results are quite similar to those presented earlier. Bigger is better at the overall plan level and, in particular, for holdings of private equity and real estate. Moreover, size does not seem important for hedge fund holdings – the few significantly positive estimates we found in the paper turn insignificant or even change sign in different subsamples. Finally, the last three rows present additional evidence that the effect is not driven by very small or very large plans. All in all, these additional results support the evidence we present and discuss in body of the paper.

References

Bauer, Rob M.M.J., Martijn K.J. Cremers, and Rik G. P. Frehen, 2010, "Pension Fund Performance and Costs: Small is Beautiful," working paper, Maastricht University.

Berk, Jonathan and Richard Green, 2004, "Mutual Fund Flows and Performance in Rational Markets," Journal of Political Economy, Volume 112, No. 6, 1269-1295.

Bernstein, Shai, Josh Lerner, and Antoinette Schoar, 2009, "The Investment Strategies of Sovereign Wealth Funds," NBER Working Paper No. 14861.

Blake, David, Allan Timmermann, Ian Tonks, and Russ Wermers, 2010, "Decentralized Investment Management: Evidence from the Pension Fund Industry," working paper, City University.

Brown, Keith C., Lorenzo Garlappi, and Cristian Tiu, 2009, "Asset Allocation and Portfolio Performance: Evidence from University Endowment Funds," working paper, University of Texas at Austin.

Chen, Joseph S., Harrison G. Hong, Ming Huang, and Jeffrey D. Kubik, 2004, "Does Fund Size Erode Mutual Fund Performance? The Role of Liquidity and Organization," American Economic Review, Volume 95, No. 5, 1276-1302.

Christoffersen, Susan E.K., Donald B. Keim, and D.K. Musto, 2006, "Valuable Information and Costly Liquidity: Evidence from Individual Mutual Fund Trades," working paper, University of Toronto.

Edelen, Roger M., Richard Evans, and Gregory B. Kadlec, 2007, "Scale Effects in Mutual Fund Performance: The Role of Trading Costs," working paper, University of California, Davis.

Ferreira, Miguel A., Antonio F. Miguel, and Sofia B. Ramos, 2010, "The Determinants of Mutual Fund Performance: A Cross-Country Study," working paper, Universidade Nova de Lisboa.

French, Kenneth R., 2008, "Presidential Address: The Cost of Active Investing," Journal of Finance, Volume 63, No. 4, 1537-1573.

Fung, William, David A. Hsieh, Narayan Y. Naik, and Tarun Ramadorai, 2008, "Hedge Funds: Performance, Risk, and Capital Formation," Journal of Finance, Volume 63, No. 4, 1777-1803.

Kaplan, Steven and Antoinette Schoar, 2005, "Private Equity Performance: Returns, Persistence and Capital Flows," Journal of Finance, Volume 60, 1791-1823.

Lakonishok, Joseph, Andrei Shleifer, R.W. Vishny, 1992, "The Structure and Performance of the Money Management Industry," Brookings Papers on Economic Activity: Microeconomics, 339-391.

Lerner, Josh, Antoinette Schoar and Jialan Wang, 2007, "Smart Institutions, Foolish Choices?: The Limited Partner Performance Puzzle," Journal of Finance, Volume 62, 731-764.

Lerner, Josh, Antoinette Schoar and Jialan Wang, 2008, "Secrets of the Academy: The Drivers of University Endowment Success," Journal of Economic Perspectives, Volume 22, 207-222.

Lopez-de-Silanes, Florencio, Ludovic Phalippou, and Oliver Gottschalg, 2010, "Diseconomies of Scale in Private Equity," working paper, University of Amsterdam.

Naik, Narayan Y., Tarun Ramadorai, and Maria Stromqvist, 2007, "Capacity Constraints and Hedge Fund Strategy Returns," European Financial Management, 13, 239-256.

Pastor, Lubos and Robert F. Stambaugh, 2010, "The Size of the Active Management Industry," working paper, University of Chicago.

Pollet, Joshua M. and Mungo Wilson, 2008, "How Does Size Affect Mutual Fund Behavior?" Journal of Finance, Volume 63, 2941-2969.

Raymond, Donald M., 2008, "Paying (Only) for Skill (Alpha) – A Practical Approach," CFA Institute Conference Proceedings Quarterly, Volume 25, No 2, 51-59.

Stein, Jeremy C., 2002, "Information Production and Capital Allocation: Decentralized versus Hierarchical Firms," Journal of Finance, Volume 57, No. 5, 1891-921.

Figure 1. Relationship between overall plan size and plan-level net returns. This figure presents the relationship between the overall plan size and net plan returns. The solid (dotted, dash-dotted) line illustrates the fitted values of the linear (quadratic, cubic) regression of net returns on log plan size. The values on the x-axis are in billions of dollars and go from the 5th to the 95th percentile of plan size in our sample. The values on the y-axis correspond to the net returns, in percentages, fitted for a given value of size. The intercept is chosen so that a fund with the median size has zero return.

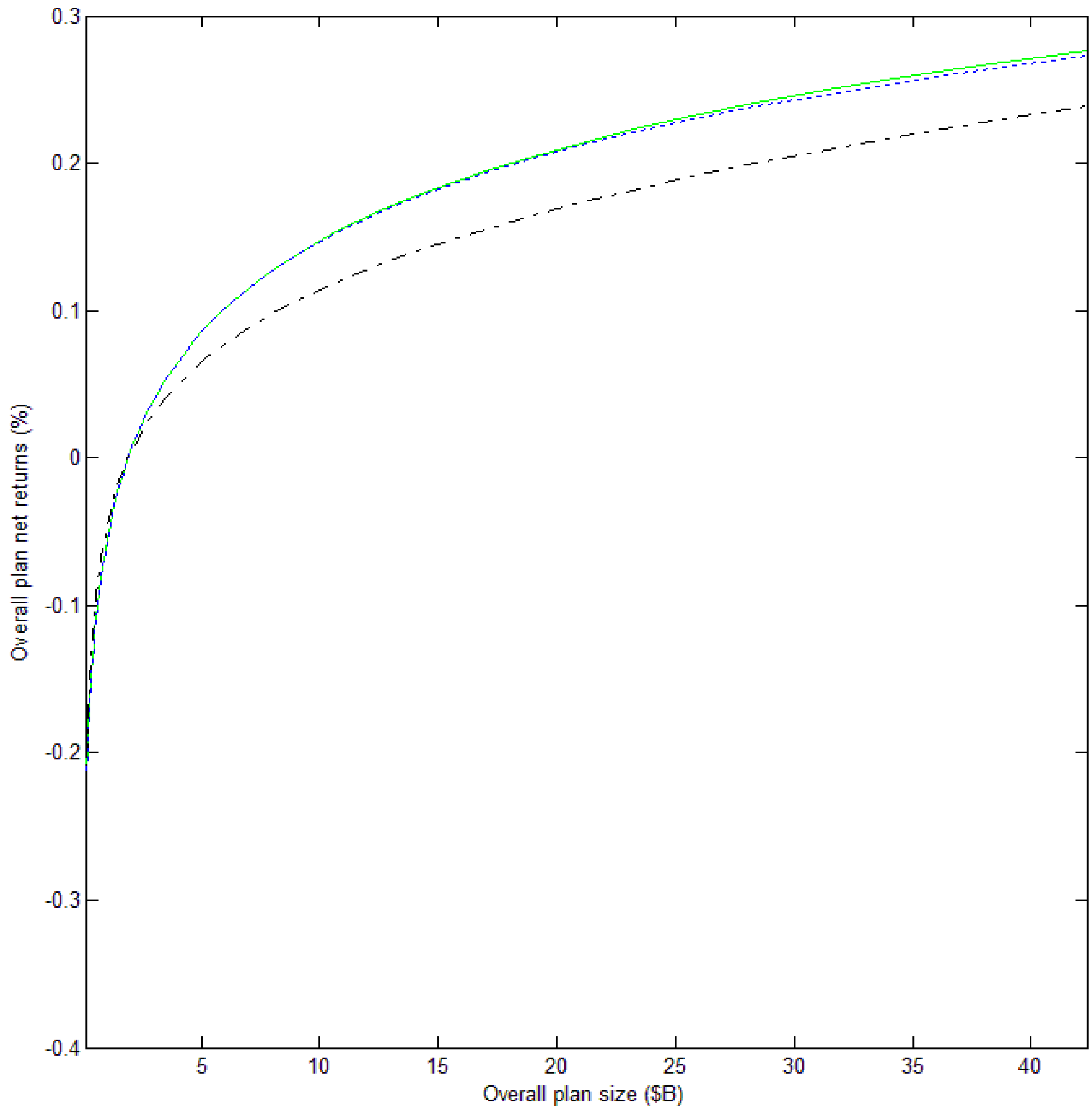

Figure 2. Average external mandate size over time. This graph presents the average external mandate size, in millions of dollars, for largest (dash-dotted line), medium (dotted line), and smallest (solid line) third of pension plans. In each case, mandate size is computed as the ratio of external holdings of a given asset class and the number of external mandates plans report. While we have holdings data for the entire sample period for most asset classes (except for hedge funds, where holdings start in 2000), the data on the number of mandates are only available at the end of our sample for most asset classes.

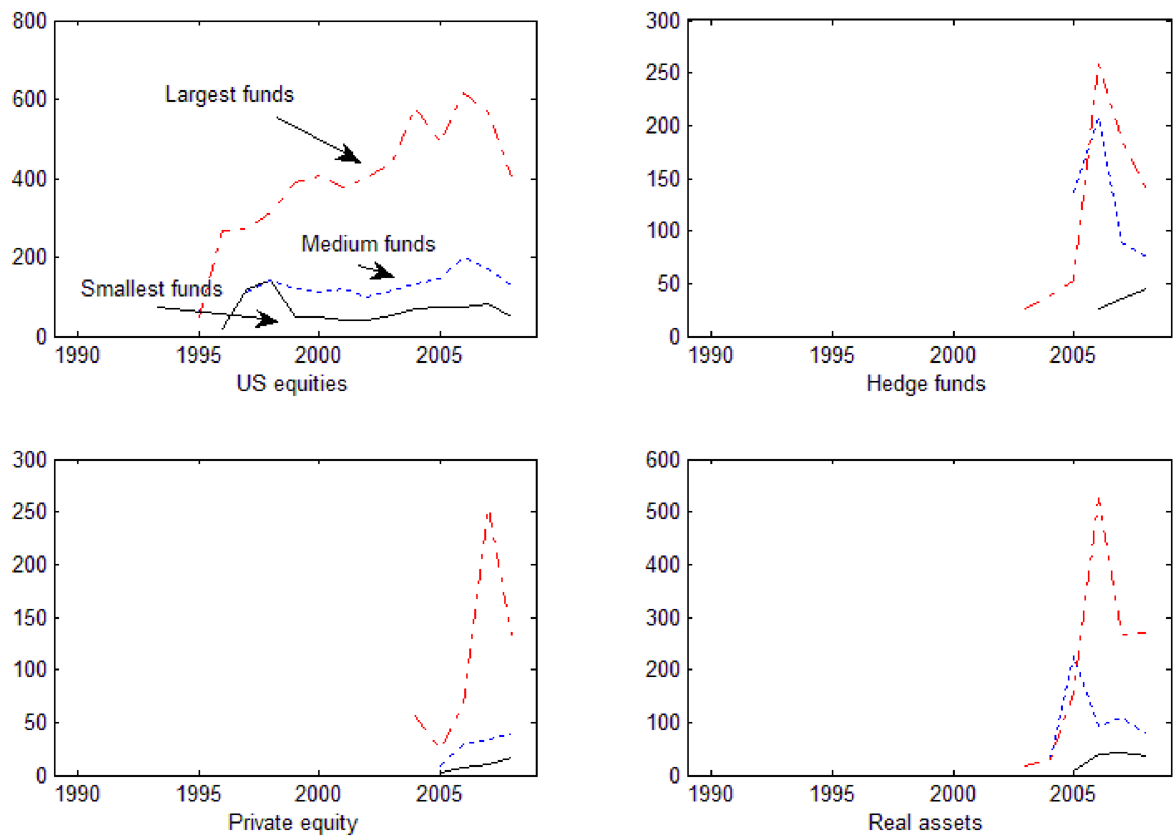

Figure 3. Relationship between holding size and net returns on alternative assets. This figure presents the relationship between holdings size and net returns for different categories of alternative assets. Within each plot, the solid (dotted, dash-dotted) line illustrates the fitted values of the linear (quadratic, cubic) regression of net returns on log holdings of a given asset class. The values on the x-axis are in millions of dollars and go from the 5^{th} to the 95^{th} percentile of holdings of a given asset in our sample. The values on the y-axis correspond to net returns, in percentages, implied by a given value of size and regression coefficients. The intercept is chosen so that a fund with the median holdings size has zero net return.

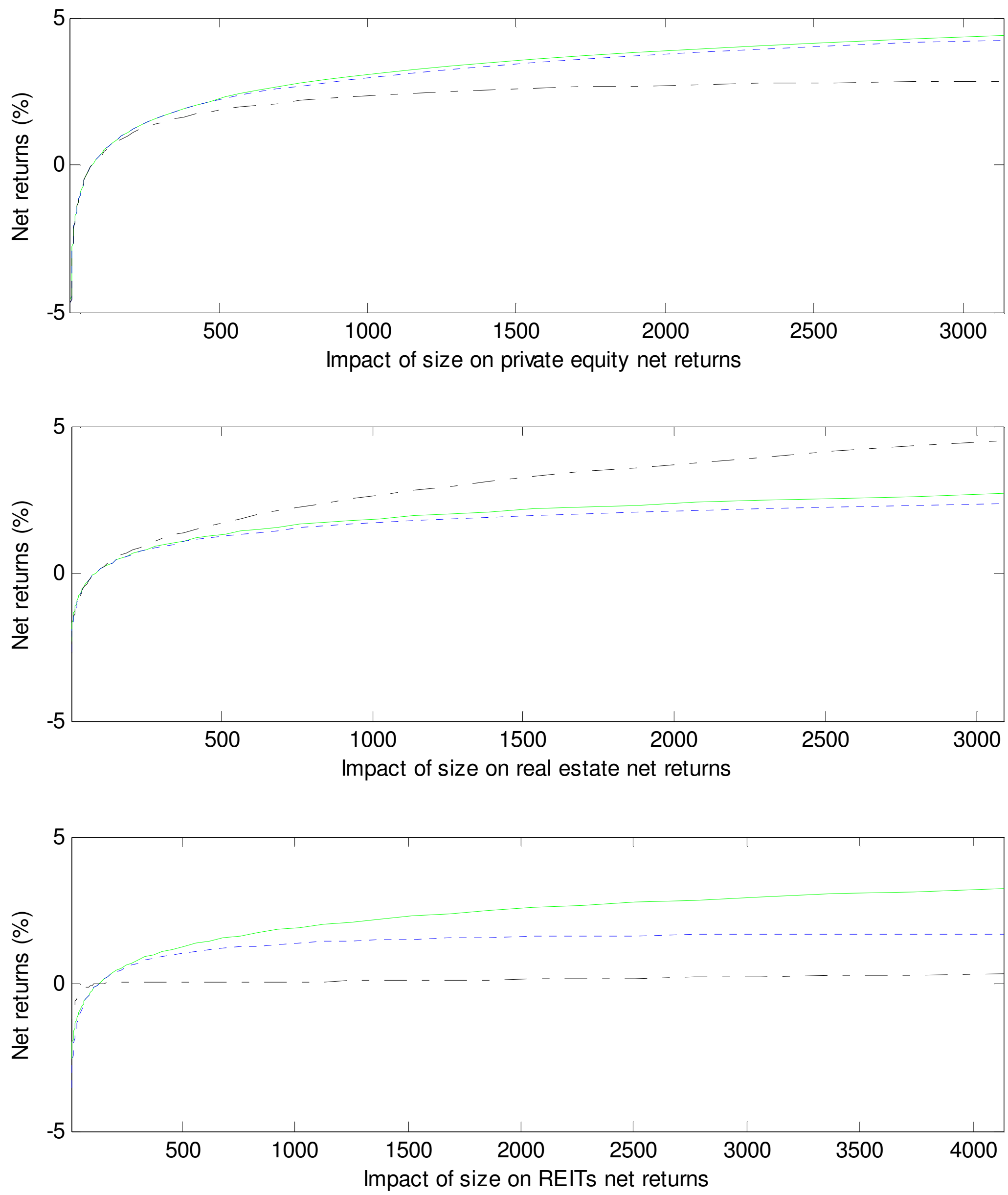

Table I. Summary statistics. This table presents summary statistics from the CEM Benchmarking, Inc. database of defined benefits pension plans. Panel A provides key summary characteristics at the plan level. Panel B presents performance data by asset class and by investment approach (for overall holdings and separately for internal holdings), with different asset classes ranked by interquartile range in performance. Statistics are estimated using a Fama-MacBeth approach: In each year, cross-sectional statistics are computed for the plans/ asset classes with data in that year; the table presents time-series averages of these cross-sectional estimates. Net returns in panel A are defined as gross returns minus costs minus benchmark returns and are computed for each asset class and value-weighted to compose a plan-level measure. Net returns and costs in Panel A include both plan-level costs of investment administration and asset class level costs. Net returns and costs in panel B only include asset class level costs.

Panel A: Summary statistics for plans.

	# obs	Mean	St.dev.	25th %	Median	75th %
Number of unique plans	842					
Number of plan year observations	5008					
Number plans/year	19	264	68	269	285	296
Number observations/ plan	842	5.95	5.40	1	4	10
Total dollars in sample (US $ billion)	19	2502	1652	1013	2482	3892
% pension plans	19	97%				
% corporate plans	19	54%				
% US plans	19	57%				
% liabilities due to current retirees	18	47%	16%	37%	47%	56%
Overall plan size (US $ million)	19	8871	21010	769	1958	6144
Overall plan gross returns (in %)	19	9.22	4.95	5.55	8.87	12.70
Overall abnormal returns (gross-cost-benchmark)	19	0.18	2.62	-0.99	0.04	1.21
% in equities	19	56%	12%	50%	57%	63%
% in fixed income	19	34%	12%	27%	34%	40%
% in alternatives	19	6%	6%	1%	5%	10%
% internally or passively managed	19	32%	30%	6%	23%	51%
% passively managed	19	19%	20%	1%	12%	29%
% internally managed	19	17%	29%	0%	0%	18%

Table I, Panel B: Summary statistics for asset classes.

	Costs (in bps)				Gross returns (in %)				Net returns (in %)			
	Mean	St.dev.	Median	avg x-plan IQR	Mean	St.dev.	Median	avg x-plan IQR	Mean	St.dev.	Median	avg x-plan IQR
OVERALL HOLDINGS:												
Fixed income												
Total	16	3	17	14	8.2	6.9	7.4	7.3	0.04	0.80	0.24	1.46
Public equities												
US equity	27	7	27	24	9.7	19.1	12.8	3.9	-0.06	1.70	0.29	3.44
EAFE equity	42	8	43	31	7.9	20.2	12.9	7.1	0.98	2.73	0.31	5.24
Emerging markets equity	70	13	71	45	13.1	35.0	5.5	6.3	0.79	2.22	0.08	5.61
Alternative assets												
Real assets	68	16	72	58	8.1	10.5	8.7	10.0	0.05	1.39	0.24	5.95
Hedge funds	188	13	188	132	4.7	10.9	7.1	12.3	-1.66	4.89	-0.96	8.77
Private equity	252	116	218	181	12.8	14.2	18.5	19.3	0.10	8.27	-0.31	17.10
INTERNAL HOLDINGS ONLY:												
Fixed income												
Total internal	5	1	5	5	7.8	7.7	7.0	8.4	-0.45	1.65	0.00	2.06
Public equities												
Internal US equity	7	2	7	8	9.5	18.6	11.7	4.0	-0.22	2.02	0.36	3.71
Internal EAFE equity	12	6	11	12	8.2	19.8	14.3	8.8	0.78	1.93	0.58	5.45
Internal emerging markets equity	20	7	19	17	10.2	28.7	5.0	13.0	1.69	12.87	-1.90	9.73
Alternative assets												
Internal real assets	24	5	25	28	8.3	13.0	8.7	13.1	0.96	2.73	1.13	8.41
Internal hedge funds	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Internal private equity	44	9	44	48	12.5	13.6	15.6	19.5	2.99	6.35	2.51	15.01

Table II. Summary statistics for plans sorted on size. Each year we sort plans based on their size (overall pension plan holdings) into quintiles and compute the average of main plan characteristics within each quintile. This table present the time-series averages of these cross-sectional means, computed across 19 years of data in our sample. . For each asset class, net returns are defined as the difference between gross returns and the sum of costs of that asset class and benchmark returns. Plan-level net returns are value-weighted averages of asset-class net returns, and also include plan-level costs of investment administration. Asset class level net returns and costs only include asset class level costs.

	smallest Q1	Q2	Q3	Q4	largest Q5	Q5-Q1
Fund size ($US million)	342	994	2101	5300	37391	37049
% US funds	24%	52%	64%	75%	72%	47%
% corporate funds	64%	57%	65%	52%	31%	-34%
% liabilities due to current retirees	46	47	47	47	48	2
Gross fund returns (%)	9.3	8.8	9.3	9.3	9.4	0.2
Overall asset-class-level costs (bps)	45	43	39	33	25	-20
Plan-level administrative costs (bps)	12	8	6	4	3	-9
Net fund returns (%)	0.10	0.06	0.21	0.32	0.42	0.33
% assets in equities	56%	56%	58%	55%	54%	-3%
% in fixed income	36%	34%	33%	34%	34%	-2%
% assets in alternatives	3%	6%	6%	7%	10%	6%
% assets internally or passively managed	17%	23%	27%	35%	56%	39%
Equity holdings	191	546	1199	2854	19522	19331
% assets internally or passively managed	15%	21%	28%	36%	58%	43%
Average equity mandate size	58	142	190	324	776	718
Fixed income holdings	116	321	636	1734	12173	12057
% assets internally or passively managed	20%	26%	26%	35%	59%	39%
Average fixed income mandate size	88	188	249	494	1973	1886
Alternative asset holdings	13	64	147	396	3715	3702
% assets internally or passively managed	13%	13%	14%	17%	25%	12%
Average alternative asset mandate size	29	51	74	304	390	361
Gross return on equity (%)	9.0	8.8	9.1	9.5	9.2	0.2
Costs of equity investments (bps)	37	36	31	27	16	-20
Net equity returns (%)	0.41	0.35	0.32	0.48	0.35	-0.06
Gross return on fixed income (%)	8.7	8.0	8.3	8.0	8.0	-0.7
Costs of fixed income investments (bps)	20	19	18	14	9	-11
Net fixed income returns (%)	-0.14	-0.13	0.09	0.20	0.21	0.35
Gross return on alternative assets (%)	8.3	7.4	8.9	9.7	10.6	2.3
Costs of alternative assets investments (bps)	93	130	119	120	115	23
Net alternative assets returns (%)	-0.13	-0.87	0.11	0.08	1.30	1.43

Table III: Size and net returns at the pension plan level. This table presents estimates of regressions of year t plan-level net returns on log of plan size and controls. The main dependent variable is the overall net plan return in year t, computed as the value-weighted average of net returns on each of the asset classes the plan invests in, minus the plan-level investment administration costs (including audit, oversight, custodial, and consulting costs). For each asset class, we compute net returns as gross returns minus costs minus plan-specific benchmark for a given asset class. Regressions are estimated over the pooled sample and, where indicated, with year and plan fixed effects. Regression (4) is estimated for the sub-sample of US plans, while the remaining regressions use all available data. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log of average year t plan size	0.09***	0.09***		0.10***	0.11***	0.06**	0.06*	0.37	0.26	0.51
	(4.15)	(4.13)		(3.64)	(4.86)	(1.98)	(1.78)	(1.42)	(0.85)	(1.43)
Plan size in bottom 20% dummy			-0.09							
			(-0.93)							
Plan size in top 20% dummy			0.27***							
			(3.38)							
Non-US plan dummy					0.09	-0.02	0.16			
					(1.16)	(-0.06)	(0.43)			
Corporate plan dummy					0.19**	-0.64*	-0.60			
					(2.56)	(-1.88)	(-1.63)			
Non-US plan dummy * size						0.02	-0.003		0.15	-0.09
						(0.42)	(-0.08)		(0.65)	(-0.36)
Corporate dummy * size						0.11**	0.10**		0.04	0.02
						(2.57)	(2.16)		(1.24)	(0.71)
Net plan return in year t-1							0.08***			-0.04
							(2.59)			(-1.17)
Observations	4950	4950	4950	2888	4950	4950	3789	4950	4950	3789
R-squared	0.003	0.168	0.167	0.223	0.169	0.170	0.190	0.321	0.321	0.346
Year FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Table IV. Plan size and the number of mandates. The regressions in this table relate plan holdings in actively managed external funds in different asset classes to the number of external mandates in those asset classes. The dependent variable is the log of the number of external mandates in the asset class specified in the top row of the table. The main independent variable is the log of the externally managed holdings plans have in a given asset class. "Equities" ["Fixed income"] regression uses observations on all equity [fixed income] sub-classes (e.g., US equity, EAFE equity) that have data on the number of mandates; different sub-classes enter the regression as separate observations. The last two rows reports the results of the F-test for the null hypothesis that the coefficient on log holdings is equal to one. Regressions are estimated over the pooled sample and, where indicated, with year and plan fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)
Asset class:	Equities	Fixed income	Hedge funds	Private equity	Real assets
log external holdings of a given asset class	0.34***	0.33***	0.44***	0.53***	0.36***
	(22.35)	(13.96)	(11.35)	(12.00)	(7.90)
Non-US plan dummy	-0.12***	0.08	-0.12	-0.27	-0.41***
	(-2.62)	(0.46)	(-0.88)	(-1.37)	(-3.01)
Corporate plan dummy	0.06	0.23***	-0.14	-0.22	-0.21*
	(1.54)	(3.70)	(-1.04)	(-1.07)	(-1.70)
Observations	6783	1961	238	301	514
R-squared	0.512	0.473	0.442	0.454	0.347
Year FE	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO
F-test (H_0: log holdings = 1)	1863.31	833.81	202.06	109.12	189.35
p-value	0.00	0.00	0.00	0.00	0.00

Table V. Large plans' increased reliance on internal and passive management. This table presents regressions of the fraction of plan assets that are managed internally or passively (i.e., assets that are *not* external active), at the level of the overall plan (specifications 1 and 2) or in a specific asset class (overall equities, specifications 3 to 5, overall fixed income, specifications 6 to 8, alternative assets, specifications 9 to 11). The main dependent variables are the log of a plan's overall size and log of a plan's holdings in a given asset class. Regressions are estimated over the pooled sample with year fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Asset class:	Overall plan		Equities			Fixed income			Alternative assets		
Log plan size	0.08***	0.09***	0.09***	0.10***		0.08***	0.10***		0.03***	0.06***	
	(11.83)	(13.41)	(14.08)	(13.89)		(7.80)	(10.49)		(3.20)	(5.90)	
Log holdings of asset class					0.05***			0.10***			0.01
					(2.76)			(2.95)			(0.68)
log (plan size – holdings)					0.04**			-0.003			0.05***
					(2.20)			(-0.11)			(3.20)
Non-US plan dummy		0.14***		0.06**	0.06**		0.25***	0.23***		0.30***	0.29***
		(6.40)		(2.52)	(2.46)		(8.77)	(8.15)		(9.31)	(8.91)
Corporate plan dummy		-0.02		-0.002	-0.002		-0.04	-0.03		-0.002	0.003
		(-0.96)		(-0.08)	(-0.10)		(-1.51)	(-1.10)		(-0.06)	(0.09)
Observations	5008	5008	4989	4989	4978	4990	4990	4981	3976	3976	3971
R-squared	0.204	0.257	0.240	0.248	0.244	0.109	0.207	0.217	0.034	0.211	0.213
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table VI. Impact of non-external-active holdings on returns. This table presents estimates of regressions of year *t* plan-level net returns (in %, specifications (1) through (4)), plan-level costs (in basis points, specifications (5) and (6)), and plan-level gross returns (in %, specifications (7) and (8)) on year *t* fraction of plan holdings that are internally or passively managed (i.e., not external active), log of plan size and controls. Plan-level returns and costs are computed as the value-weighted average of returns and costs on each of the asset classes the plan invests in. Regressions are estimated over the pooled sample with year fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Net returns				Costs		Gross returns	
% holdings that are not external active	0.33**	0.33**			-26.25***		-0.27	
	(2.24)	(2.18)			(-13.46)		(-0.71)	
% holdings that are internally managed			0.44***	0.47***		-16.99***		-0.61
			(2.92)	(2.89)		(-8.02)		(-1.49)
% holdings that are passively managed			0.04	0.05		-27.27***		0.24
			(0.26)	(0.33)		(-9.96)		(0.57)
Log of avg year t plan size	0.06**	0.08***	0.05**	0.07**	-2.81***	-3.07***	0.13**	0.16**
	(2.43)	(2.88)	(2.04)	(2.27)	(-7.38)	(-7.80)	(1.99)	(2.27)
Non-US plan dummy		0.04		0.01	-9.71***	-11.04***	0.84***	0.92***
		(0.53)		(0.07)	(-7.66)	(-8.18)	(4.76)	(5.08)
Corporate plan dummy		0.19***		0.20***	4.54***	4.37***	0.35**	0.34**
		(2.66)		(2.78)	(3.82)	(3.68)	(2.22)	(2.14)
Observations	4950	4950	4950	4950	4950	4950	4950	4950
R-squared	0.169	0.170	0.170	0.171	0.404	0.397	0.851	0.851
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO	NO	NO	NO

Table VII. Determinants of investments in alternative assets. The regressions in this table illustrate the impact of size on plans' portfolio weight on overall alternative assets (holdings of alternative assets over plan size, regressions 1 to 3) and portfolio weight on components of alternative assets (holdings of hedge funds, private equity, and real assets over plan size, regressions 4 to 9). Regressions are estimated over the pooled sample with year fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Portfolio weight on:	All alternative assets			Hedge funds		Private equity		Real assets	
Log plan size	0.01***	0.01***	0.01***						
	(8.68)	(3.16)	(2.92)						
Log holdings size				0.0004	-0.002	0.01***	0.003*	0.01***	0.01***
				(0.64)	(-1.03)	(7.40)	(1.71)	(7.35)	(3.13)
% liabilities due to retirees		-0.09**	-0.09**		-0.04*		-0.06***		-0.003
		(-2.05)	(-1.99)		(-1.78)		(-2.79)		(-0.09)
% liabilities due to retirees * size		0.01*	0.01*		0.004		0.01***		0.0004
		(1.86)	(1.80)		(1.51)		(2.64)		(0.08)
Non-US plan dummy			-0.01		-0.01*		-0.01***		0.01**
			(-1.03)		(-1.66)		(-5.63)		(2.10)
Corporate plan dummy			-0.001		0.002		0.01***		-0.01***
			(-0.11)		(0.72)		(3.41)		(-2.99)
Observations	5008	4202	4202	2683	2440	5008	4202	5008	4202
R-squared	0.195	0.249	0.251	0.045	0.055	0.110	0.205	0.135	0.183
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	NO	NO	NO	NO	NO	NO	NO

Table VIII. Economies of scale in net returns in alternative assets. Panel A presents regressions of private equity net returns in year t (in %) on log of average year t holdings of private equity and controls. Panel B summarizes similar regressions for other components of alternative assets: real estate, REITs, and hedge funds, and reports the coefficients on log holdings of these asset classes from regressions with the same controls as those in Panel A. Regressions are estimated over the pooled sample and, where indicated, with year and plan fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Regressions of net returns on private equity on holdings of private equity and controls.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log of avg year t holdings	1.18***	1.29***	1.29***	1.18***	1.50***	1.03***	1.04***	2.51***	2.96***	2.15*
	(5.50)	(5.61)	(3.64)	(5.46)	(2.82)	(4.14)	(3.82)	(2.91)	(2.66)	(1.88)
Non-US plan dummy		0.62	0.15				-1.26			
		(0.60)	(0.08)				(-1.16)			
Corporate plan dummy		3.35***	3.83*				2.23**			
		(3.53)	(1.87)				(2.24)			
Non-US plan dummy * holdings			0.11						-0.30	
			(0.28)						(-0.23)	
Corporate dummy * holdings			-0.11						-0.89	
			(-0.26)						(-1.04)	
% holdings internally managed				2.59			3.28*			12.00**
				(1.37)			(1.83)			(2.01)
Average mandate size					0.003					
					(0.94)					
Net return in year t-1						0.12***	0.11***			-0.03
						(3.56)	(3.43)			(-0.64)
Observations	2497	2497	2497	2497	258	1844	1844	2497	2497	1844
R-squared	0.152	0.157	0.158	0.153	0.071	0.173	0.178	0.345	0.345	0.339
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Table VIII, Panel B: Size coefficients in regressions of net returns on holdings of other alternative asset classes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Real estate	0.75***	0.84***	0.78***	0.71***	1.05***	0.51***	0.54***	0.92***	0.71	0.52
	(7.11)	(7.53)	(4.74)	(6.87)	(2.61)	(5.17)	(5.04)	(2.97)	(1.64)	(1.10)
REITs	0.93***	0.91***	0.99*	1.33***	-1.38	0.55	0.74*	3.16***	3.39***	0.40
	(2.87)	(2.60)	(1.95)	(3.89)	(-1.01)	(1.45)	(1.91)	(2.93)	(2.79)	(0.27)
Hedge funds	0.71**	0.67**	0.57	0.71**	0.20	0.20	0.20	-0.01	0.51	0.15
	(2.49)	(2.46)	(1.28)	(2.49)	(0.28)	(0.65)	(0.66)	(-0.01)	(0.44)	(0.09)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO	NO	NO	YES	YES	YES

Table IX. Economies of scale in private equity: controlling for vintage and j-curve effects. This table presents OLS regression analysis of net returns on externally managed private equity on log of size of external holdings of private equity and controls for the vintage of the investments: the fraction of assets still in the commitment period and the average age of the investment, computed as the invested-amount-weighted average age (current year minus the vintage year of a particular LP position). The vintage data are only available for a limited number of plans for the year 2008. We estimate the regressions on the cross-section of plans in 2008, as well as on the panel of plans in years 2006 to 2008 (plans with the average investment age of less than one (two) years are not included in the regressions that use 2006 (2007) data). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	2008 data only				2006-2008 data (3 years of data)			
Dependent variable:	net returns on external private equity				net returns on external private equity			
Log external private equity holdings	2.11	1.63	1.27	1.41	1.82*	1.77*	1.49	1.51
	(1.22)	(0.99)	(0.69)	(0.79)	(1.93)	(1.87)	(1.43)	(1.43)
% assets in commitment period		-25.21**		-22.94		-3.25		-2.10
		(-2.14)		(-1.70)		(-0.48)		(-0.29)
Average age of private equity investment			2.42	0.76			1.37	1.29
			(1.26)	(0.36)			(1.34)	(1.21)
Constant	-6.56	14.33	-8.40	11.88	-8.94	-6.34	-9.87	-8.28
	(-0.63)	(1.03)	(-0.80)	(0.76)	(-1.57)	(-0.81)	(-1.59)	(-1.00)
Observations	30	30	30	30	78	78	71	71
R-squared	0.050	0.188	0.103	0.192	0.047	0.050	0.072	0.073

Table X. Economies of scale in costs of and gross returns on alternative assets. Panel A presents regressions of private equity year t costs (in bps) and gross returns (in %) on log of average year t holdings of private equity and controls. Panel B summarizes similar regressions for other components of alternative assets: real estate, REITs, and hedge funds, and reports the coefficients on log holdings of these asset classes from regressions with the same controls as those in Panel A. Regressions are estimated over the pooled sample and, where indicated, with year and plan fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Regressions of costs (in bps) and gross returns (in %) on private equity on holdings of private equity and controls.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Costs				Gross returns			
Log of avg year t holdings	-27.42***	-33.17***	-30.23***	-82.11***	1.24***	1.20***	1.22***	1.09
	(-5.22)	(-5.98)	(-5.53)	(-4.64)	(5.30)	(4.95)	(5.04)	(1.21)
Non-US plan dummy		-61.57**	-8.52			-1.29	-0.99	
		(-2.45)	(-0.30)			(-1.24)	(-0.92)	
Corporate plan dummy		-108.27***	-101.85***			1.75*	1.78**	
		(-5.24)	(-5.06)			(1.94)	(1.97)	
% holdings internally managed			-200.34***				-1.16	
			(-7.61)				(-0.51)	
Observations	2497	2497	2497	2497	2497	2497	2497	2497
R-squared	0.124	0.154	0.179	0.589	0.350	0.352	0.352	0.499
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	YES	NO	NO	NO	YES

Table X, Panel B: Size coefficients in regressions of costs and gross returns on holdings of other alternative asset classes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable:	Costs				Gross returns			
Real estate	-5.43***	-7.33***	-6.03***	-5.79**	0.72***	0.76***	0.77***	1.20***
	(-6.29)	(-9.13)	(-7.64)	(-2.57)	(6.61)	(6.72)	(6.68)	(3.36)
REITs	-7.98***	-7.47***	-3.80***	-8.99**	1.17***	1.25***	1.43***	3.30***
	(-5.84)	(-5.16)	(-2.73)	(-2.28)	(3.55)	(3.71)	(3.96)	(2.82)
Hedge funds	-7.63**	-6.96**	-6.96**	10.30	0.25	0.30	0.30	-1.16
	(-2.31)	(-2.24)	(-2.24)	(1.31)	(0.95)	(1.15)	(1.15)	(-0.94)
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	YES	NO	NO	NO	YES

Table XI. Spillovers between internal and external holdings. Regressions in this table illustrate spillovers between internally and externally managed investments. The dependent variable is the net return on external active holdings of overall alternatives, private equity, overall equities, and overall fixed income (in columns (1) and (2), (3) and (4), (5) and (6), (7) and (8), respectively). The main independent variables are the log of external active holdings of a given asset class and the net return on internal active holdings of the same asset class. Regressions are only run for plans that have both internally and externally managed holdings of a given asset class. Additional controls include US plan and corporate plan indicators and year fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Asset class:	Alternatives		Private equity		Equities		Fixed income	
Log ext holdings	0.67***	0.58**	1.52***	1.62***	0.45***	0.44**	0.06	-0.06
	(2.85)	(2.26)	(3.23)	(3.21)	(2.83)	(2.40)	(0.57)	(-0.44)
Internal active net return	0.08*	0.08*	0.33***	0.32***	0.00	0.01	0.01	0.01
	(1.79)	(1.78)	(4.27)	(3.96)	(0.10)	(0.12)	(0.26)	(0.18)
Non-US plan dummy		-1.24		1.16		0.01		-1.22***
		(-1.06)		(0.42)		(0.02)		(-2.84)
Corporate fund indicator		0.78		3.33		-0.28		0.89**
		(0.65)		(1.44)		(-0.49)		(2.50)
Observations	609	609	197	197	790	790	626	626
R-squared	0.145	0.147	0.374	0.379	0.217	0.218	0.260	0.278
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	NO	NO	NO	NO	NO	NO

Table XII. Organizational diseconomies of scale: impact of the size of holdings and of the overall plan size. Panel A presents regressions of private equity year t net returns (in %), costs (in bps), and gross returns (in %) on log of year t average holdings of private equity and the log of the difference between overall plan size and holdings in private equity. Panel B summarizes estimated coefficients on log holdings and log of the remaining plan size (the difference between the overall plan size and the holdings of a given asset class) for the remaining asset classes. Regressions in Panel B have the same controls as the corresponding regressions in Panel A. Regressions are estimated over the pooled sample and, where indicated, with year and plan fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Private equity returns and costs regressed on holdings of private equity and fund size outside of private equity.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:		Net returns			Costs			Gross returns	
Ln avg year t holdings	1.83***	1.63***	2.63***	-62.59***	-63.25***	-87.43***	1.34***	1.18***	0.87
	(5.66)	(4.71)	(2.93)	(-6.06)	(-5.99)	(-4.80)	(4.19)	(3.46)	(0.97)
Ln(plan size - holdings)	-1.03**	-0.69	-2.82	65.75***	57.06***	44.27	-0.26	0.001	0.66
	(-2.32)	(-1.61)	(-0.81)	(4.52)	(3.89)	(0.64)	(-0.63)	(0.004)	(0.19)
Non-US plan dummy		0.71			-60.99**			-1.16	
		(0.68)			(-2.29)			(-1.15)	
Corporate plan dummy		2.97***			-80.16***			1.71*	
		(3.14)			(-3.76)			(1.94)	
Observations	2497	2497	2497	2639	2639	2639	2568	2568	2568
R-squared	0.020	0.158	0.345	0.176	0.192	0.592	0.346	0.348	0.490
Year FE	NO	YES	YES	YES	YES	YES	YES	YES	YES
Plan FE	NO	NO	YES	NO	NO	YES	NO	NO	YES

Table XII, Panel B: Summary of results for remaining asset classes.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:		Net returns			Costs			Gross returns		
Real estate	ln holdings	1.04***	1.06***	0.96***	-10.25***	-9.39***	-5.24**	1.12***	1.13***	1.17***
		(5.58)	(5.46)	(3.02)	(-5.90)	(-5.55)	(-2.18)	(5.64)	(5.70)	(3.12)
	ln(plan-holdings)	-0.50**	-0.36	-0.76	7.77***	3.38	-7.90	-0.63***	-0.60**	2.24*
		(-2.30)	(-1.61)	(-0.68)	(3.39)	(1.50)	(-0.80)	(-2.67)	(-2.49)	(1.86)
REITs	ln holdings	1.95***	1.90***	3.33***	-5.88***	-5.09**	-9.26**	1.93***	1.94***	3.00**
		(3.41)	(3.37)	(2.93)	(-2.64)	(-2.29)	(-2.29)	(3.49)	(3.56)	(2.54)
	ln(plan-holdings)	-1.48***	-1.45***	-4.31	-3.07	-3.53	3.90	-1.07*	-0.99*	6.96
		(-2.66)	(-2.66)	(-1.29)	(-1.37)	(-1.60)	(0.64)	(-1.90)	(-1.71)	(1.42)
Hedge funds	ln holdings	0.09	0.29	-0.02	-0.28	1.78	11.07	-0.43	-0.38	-1.18
		(0.29)	(0.93)	(-0.02)	(-0.08)	(0.48)	(1.44)	(-1.29)	(-1.15)	(-0.99)
	ln(plan-holdings)	0.62*	0.57*	0.17	-11.42***	-13.74***	-35.55	1.06***	1.04***	2.80
		(1.79)	(1.69)	(0.05)	(-3.11)	(-3.49)	(-1.15)	(2.91)	(2.79)	(0.62)
US equity	ln holdings	0.44***	0.44***	0.61***	0.22	-5.83***	-4.33***	0.26***	0.37**	0.78***
		(5.73)	(3.23)	(2.86)	(0.35)	(-6.33)	(-3.39)	(3.44)	(2.52)	(2.93)
	ln(plan-holdings)	-0.33***	-0.42***	0.06	-4.66***	0.97	3.43**	-0.28***	-0.36***	0.46
		(-4.27)	(-3.22)	(0.15)	(-6.91)	(1.06)	(2.03)	(-3.41)	(-2.66)	(1.05)
Overall equity	ln holdings	0.27**	0.25**	0.23	-0.32	-3.83***	-3.58***	0.24	0.45**	1.00*
		(2.52)	(2.24)	(1.14)	(-0.31)	(-3.73)	(-2.94)	(1.36)	(2.31)	(1.81)
	ln(plan-holdings)	-0.25**	-0.21**	-0.59**	-4.29***	-1.48	1.72	-0.26	-0.39**	1.08*
		(-2.37)	(-1.98)	(-2.28)	(-4.44)	(-1.57)	(1.40)	(-1.51)	(-2.09)	(1.87)
Overall fixed income	ln holdings	-0.01	0.10	0.16	-6.71***	-4.67***	-3.54***	0.87***	0.65***	3.28***
		(-0.08)	(1.17)	(0.89)	(-12.57)	(-8.95)	(-4.54)	(5.90)	(3.95)	(7.67)
	ln(plan-holdings)	0.02	-0.05	-0.09	4.09***	1.59***	2.71***	-1.00***	-0.61***	1.01**
		(0.25)	(-0.53)	(-0.51)	(7.80)	(3.19)	(3.84)	(-6.49)	(-3.65)	(2.14)

Table AI. Relationship between net returns and lagged size. This table is constructed analogously to Tables III and VIII, with the difference that size variables are now lagged relative to net returns. That is, the dependent variable is net return in year *t* (in %), while the main regressor is log of year *t*-1 holdings of the asset class indicated in the first row of the table. Regressions are estimated over the pooled sample with, where indicated, year fixed effects and plan fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Dependent variable:	Overall plan net returns							Private equity net returns			
Log of year t-1 plan size	0.06***	0.08***		0.10***	0.04	0.06**	-0.31				
	(2.68)	(3.27)		(3.75)	(1.20)	(2.18)	(-1.10)				
Log of year t-1 holdings								1.30***	1.33***	1.42***	2.14***
								(5.46)	(5.32)	(4.10)	(2.71)
Plan size in bottom 20% dummy			0.02								
			(0.23)								
Plan size in top 20% dummy			0.33***								
			(3.76)								
Non-US plan dummy				0.09	-0.10	0.06			-0.32	-2.17	
				(1.07)	(-0.25)	(0.71)			(-0.29)	(-0.92)	
Corporate plan dummy				0.15*	-0.65*	0.15*			2.46**	5.17**	
				(1.84)	(-1.68)	(1.93)			(2.33)	(2.11)	
Non-US plan dummy * size					0.03					0.40	
					(0.58)					(0.87)	
Corporate dummy * size					0.10**					-0.59	
					(2.20)					(-1.27)	
Net plan return in year t-1						0.08***					
						(2.60)					
% holdings that are not external active						0.30**					
						(2.10)					
Observations	3829	3829	3829	3829	3829	3789	3829	1897	1897	1897	1897
R-squared	0.002	0.181	0.181	0.182	0.183	0.190	0.342	0.167	0.170	0.171	0.336
Year FE	NO	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	YES

Table AI, continued.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable:	Real estate net returns				REITs net returns				Hedge fund net returns			
Log of year t-1 holdings	0.69***	0.77***	0.71***	0.31	0.51	0.41	-0.25	0.59	0.07	0.05	-0.39	-1.50
	(5.63)	(5.96)	(3.63)	(0.61)	(1.31)	(1.09)	(-0.48)	(0.41)	(0.23)	(0.17)	(-0.56)	(-1.17)
Non-US plan dummy		0.75*	-0.43			1.06	-3.90			-1.60	-5.87*	
		(1.70)	(-0.34)			(0.90)	(-0.97)			(-1.48)	(-1.68)	
Corporate plan dummy		0.88**	1.36			-0.40	-2.33			0.64	0.81	
		(2.01)	(1.02)			(-0.43)	(-0.65)			(0.62)	(0.24)	
Non-US plan dummy * size			0.26				0.97				0.83	
			(1.10)				(1.32)				(1.20)	
Corporate dummy * size			-0.11				0.43				0.01	
			(-0.43)				(0.63)				(0.02)	
Observations	2499	2499	2499	2499	615	615	615	614	406	406	406	406
R-squared	0.058	0.062	0.063	0.291	0.039	0.041	0.046	0.299	0.204	0.212	0.216	0.517
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	YES

Table AII. Relationship between net returns and size: robustness checks. This table re-estimates the key specifications from Tables III and VIII for subsamples of the data. Panel A presents estimation results for the subsample of US plans. Panel B summarizes similar specifications for various subsamples of the data. All regressions include year fixed effects. T-statistics based on robust standard errors (clustered at the plan level) are reported in parentheses. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Key specifications estimated for US plans only.

	(1)	(2)	(4)	(5)	(7)	(8)	(10)	(11)
Asset class:	Overall plan		Private equity		Real estate		Hedge funds	
Log of avg year t plan size	0.10***	0.13***						
	(3.64)	(4.40)						
Ln(holdings)			1.13***	1.19***	0.80***	0.86***	0.27	0.26
			(3.53)	(3.74)	(6.16)	(6.35)	(0.80)	(0.75)
Non-US plan dummy		N/A		N/A		N/A		N/A
		N/A		N/A		N/A		N/A
Corporate plan dummy		0.28***		3.95***		1.19**		0.95
		(3.10)		(3.61)		(2.54)		(0.85)
Observations	2888	2888	1699	1699	2049	2049	386	386
R-squared	0.223	0.225	0.210	0.218	0.066	0.071	0.178	0.181
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	NO	NO	NO	NO	NO	NO	NO	NO

Table AII, Panel B: Coefficients on plan size/ holdings size for various sub-samples of the data.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Overall plan		Private equity		Real estate		Hedge funds	
All plans, as in the paper	0.09***	0.11***	1.18***	1.29***	0.75***	0.84***	0.71**	0.67**
	(4.13)	(4.86)	(5.50)	(5.61)	(7.11)	(7.53)	(2.49)	(2.46)
All plans, using lag size	0.08***	0.10***	1.30***	1.33***	0.69***	0.77***	0.07	0.05
	(3.27)	(3.75)	(5.46)	(5.32)	(5.63)	(5.96)	(0.23)	(0.17)
US plans only	0.10***	0.13***	1.13***	1.19***	0.80***	0.86***	0.27	0.26
	(3.64)	(4.40)	(3.53)	(3.74)	(6.16)	(6.35)	(0.80)	(0.75)
Corporate plans only	0.16***	0.16***	1.11***	1.05***	0.75***	0.78***	0.41	0.27
	(4.29)	(4.06)	(3.47)	(2.67)	(4.57)	(4.57)	(1.22)	(0.75)
Excluding plans in the largest quintile	0.07**	0.09**	1.24***	1.21***	0.87***	0.95***	0.66	0.33
	(1.99)	(2.28)	(3.43)	(2.88)	(4.84)	(5.22)	(1.49)	(0.76)
Excluding plans in the smallest quintile	0.11***	0.14***	1.23***	1.36***	0.80***	0.87***	0.18	0.17
	(4.04)	(4.92)	(4.98)	(5.30)	(6.95)	(7.14)	(0.74)	(0.71)
Excluding plans in the two extreme quintiles	0.12*	0.14**	1.26***	1.30***	0.93***	0.97***	-0.37	-0.63*
	(1.93)	(2.19)	(2.87)	(2.66)	(4.53)	(4.69)	(-1.07)	(-1.82)