Size, Age, and the Performance Life Cycle of Hedge Funds[*]

Chao Gao[†], Tim Haight[‡], and Chengdong Yin[§]

September 2018

Abstract

This paper examines the performance life cycle of hedge funds. Small funds outperform large funds and small funds maintain good performance over time. One possible explanation for these effects is that expected management fees increasingly outweigh expected incentive fees when funds grow larger over their life cycle. Aside from size, performance life cycle patterns do not vary significantly with a host of fund- and family-level characteristics. Our results suggest that fund growth over time drives performance declines over a hedge fund's life cycle and that performance persistence is more achievable when funds stay small.

Key Words: Hedge Funds, Performance Life Cycle, Fund Size, Fund Age.
JEL Classification: G23.

[*] We thank Lu Zheng for helpful comments and suggestions. All remaining errors are ours.
[†] Krannert School of Management, Purdue University. Email: gao202@purdue.edu.
[‡] College of Business Administration, Loyola Marymount University. Email: thaight@lmu.edu.
[§] Corresponding author at: Krannert School of Management, Purdue University. 403 W. State Street, West Lafayette, IN 47907. Tel.: +1 (765) 494-4431. Email: yin80@purdue.edu.

How to select hedge funds with superior performance is one of the most extensively studied questions in the literature. While this task has always been important in the money management industry, it has been especially challenging for hedge funds in recent years, as hedge fund performance has been lackluster since the 2008-2009 financial crisis. In broad terms, the literature tackles the fund selection question from two different angles. One strand of the literature provides evidence on cross-sectional relations between fund performance and fund characteristics such as fund size, fund age, compensation contracts, and share restrictions.[1] Another strand of the literature examines whether hedge fund performance "persists" over time.[2] While there is scant research connecting these two strands, hedge fund investors are likely to consider characteristic predictors and performance persistence jointly. In particular, investors should be interested not only in identifying funds with superior performance in the cross section, but also in identifying how long superior performance can last, especially given hedge funds' high minimum investment requirements and long share restriction periods.

This study connects the two strands of literature by examining the performance life cycle of hedge funds with various characteristics. By *performance life cycle*, we mean performance at different stages of a hedge fund's existence. The performance life cycle approach offers several advantages over conventional approaches used in prior literature. First, the performance life cycle approach enables analyses of performance persistence over multiple periods, which is rare in the persistence literature. The literature commonly examines persistence over two consecutive periods using portfolio approaches and panel regressions, but the performance life cycle approach allows us to study how hedge fund performance evolves from a multi-period time series perspective. Second, the performance life cycle approach enables analyses of the first few years of a fund's

[1] See Ackermann, McEnally, and Ravenscraft (1999), Liang (1999), Brown, Goetzmann, and Park (2001), Naik, Ramadorai, and Stromqvist (2007), Aragon (2007), Jones (2007), Agarwal, Daniel, and Naik (2009), Getmansky (2012), Schaub and Schmid (2013), Teo (2013), Aiken, Clifford, and Ellis (2015), and Yin (2016), among others.
[2] See Eling (2009) for a review of earlier studies. See also Kosowski, Naik, and Teo (2007), Jagannathan, Malakhov, and Novikov (2010), and Ammann, Huber, and Schmid (2013), among others.

performance record, which is also rare in the persistence literature.[3] Because hedge funds typically have short lives, and because many successful funds maintain performance by closing themselves off to new investors, identifying performance persistence early in a hedge fund's life can be highly valuable for investors. Third, the performance life cycle approach enables performance comparisons of funds with different characteristics at different stages of their life cycles. Thus, the performance life cycle approach allows us to examine whether certain types of funds are more likely to maintain superior performance over time.

One study that is closely related to ours is Aggarwal and Jorion (2010). They find that hedge fund performance peaks during the first few years of a fund's life, but declines thereafter at an average rate of 42 basis points per year. While these findings suggest that hedge fund performance declines with age (on average), the authors do not examine what drives performance declines with age, nor its connection with other fund characteristics. Thus, their findings may have limited implications for investors. Another related study is Boyson (2008), who examines hedge fund performance persistence by sorting funds based on fund size, fund age, and fund past performance. Like other studies in the persistence literature, Boyson (2008) only examines persistence over two consecutive periods, and persistence is not examined during the first few years of a fund's life. In addition, the author does not examine whether fund characteristics facilitate performance persistence independent of the level of past performance.

While we add to the literature by examining how the performance life cycle of a hedge fund varies with its fund- and family-level characteristics, we are particularly interested in examining how fund age and fund size affect the performance life cycle. Fund age is naturally associated with the performance life cycle. However, prior studies generally limit their analysis of age effects to using age as a sorting variable in portfolio analysis or as a control variable in panel regressions. Moreover, Jones (2007) and Aggarwal and Jorion (2010) find that younger funds outperform older funds, but as noted earlier, the mechanism driving the age-performance relation

[3] The persistence literature commonly uses fund performance over an evaluation period of 2 to 3 years to predict fund performance over the next period (one quarter or up to a few years in the future). Thus, there is very little evidence on performance persistence in the first 2 to 3 years of a hedge fund's performance record.

is unclear, so it is not well understood why we observe performance declines with age. Fund size may affect fund performance because of diseconomies of scale, a phenomenon that is well known to academics and practitioners.[4] Berk and Green (2004) develop a model in which good performance delivered by skilled managers attracts capital inflows, but the resulting fund growth leads to performance declines over time and a lack of performance persistence. Following Berk and Green (2004), several empirical studies provide evidence consistent with scale diseconomies in the hedge fund industry (e.g., Naik, Ramadorai, and Stromqvist (2007), Teo (2009), Getmansky (2012), and Yin (2016)). Nevertheless, most of these studies document scale diseconomies using panel data sets and thus offer limited insights about how size affects performance at different stages of a hedge fund's life cycle. By exploring size effects on the time-series dimension, we are able to investigate whether fund growth over time contributes to performance declines over a hedge fund's life cycle and we can assess whether size facilitates performance persistence in multi-year settings.

We start with an analysis of fund performance over time. We collect data from the Lipper TASS and the HFR databases, and our main sample consists of non-backfilled funds that have at least five years of data. Non-backfilled funds are funds whose add dates are no more than 6 months after their inception dates. Aggarwal and Jorion (2010) discuss the importance of mitigating backfill bias when looking at age effects on performance, as backfilled funds are more likely to voluntarily report past performance when it is good. In addition, we require funds to have at least five years of data to mitigate a potential bias caused by funds that fail when they are young. Young failures may result from a variety of factors outside of a hedge fund's immediate control, such as adverse shocks to the industry (e.g., financial crises) or bad luck. Inclusion of young failures could drive a negative age-performance relation even when there is no age effect because performance is likely to deteriorate prior to liquidation.[5] Following Aggarwal and Jorion (2010), we group fund-

[4] See Oksana Patron, "Smaller Hedge Funds Firms are Doing Well," July 9, 2017, Sophie Baker, "Smaller Hedge Funds are Able to Turn a Profit with Less than $100 Million AUM—Survey," 2017, and Vishesh Kumar, "Emerging Hedge Funds Outshine Established Peers as Investors Revisit Asset Class," July 10, 2017.
[5] Our results are robust to other sample selection requirements as shown in Section IV.

month observations by event time, with the first event month being the first month performance data is available. Consistent with the literature, we find that fund performance declines with age.

After documenting declining performance with age, we then investigate whether the age-performance relation is driven by funds with certain fund- and family-level characteristics. For example, it is possible that funds with lockup periods are more likely to generate strong performance when they are young because they can invest in less liquid assets. Moreover, there is evidence that fund families have strong incentives to boost performance in their flagship funds to attract capital for the other funds in their family. After performing subset analysis, we continue to observe similar performance patterns across funds with varying characteristics.

Next, we investigate how the performance life cycle varies with fund size. While prior studies examining hedge fund performance document diseconomies of scale in the cross section, we employ an event time approach to examine whether and to what extent scale diseconomies drive performance declines over a hedge fund's life cycle. In a preliminary analysis, we partition hedge funds in our main sample into three size groups at the beginning of each event year, and we observe average monthly portfolio performance over the event year. Results of this analysis indicate that the small group significantly outperforms the large group throughout much of the performance life cycle and that small group performance is quite consistent over time.

One drawback to the portfolio approach is that portfolio membership varies across event years as fund size changes over time. To better examine the life cycle of hedge fund performance, we use modified Fama-MacBeth regressions where, for each fund, we run time-series regressions of performance on size and age, and we take cross-sectional averages of coefficients to assess size and age effects. We find that the cross-sectional average coefficient on fund size is negative and statistically significant while the age coefficient is marginally negative at best. Moreover, when we add further controls for fund family characteristics and capital flows, the age effect becomes statistically indistinguishable from zero. These results suggest that diseconomies of scale significantly drive performance declines over a hedge fund's life cycle.

Since our main sample excludes backfilled funds and funds with less than five years of data, it is not clear whether investors can profitably exploit the effects that we document. For example, small and young funds in our sample exclude those that fail within the first five years, but investors in real time cannot observe which small and young funds will succeed and which will fail. Thus, to provide evidence on the exploitability of the effects that we document, we expand our sample to include backfilled funds and non-backfilled funds with less than five years of data, and we repeat our portfolio analysis using nine (3x3) portfolios sorted independently on size and age at the beginning of each calendar year. Our results indicate that small funds outperform large funds in all three age groups. By contrast, we do not find strongly significant differences in performance between young funds and old funds. Thus, our analysis suggests that investors are more likely to earn higher returns by investing in small hedge funds. In addition, we also examine the frequency with which each size-age portfolio generates "winning" performance by ranking the performance of each portfolio in each calendar year. Our results indicate that portfolios that include small hedge funds are more likely to be in the "winner" group (i.e., top tericle of performance) and less likely to be in the "loser" group (i.e., bottom tercile of performance). Therefore, small hedge funds not only generate higher returns on average but also provide consistent performance over our sample period.

Why does asset growth drive down performance over the life cycle of a hedge fund? Possible explanations from the literature include managers' limited abilities, negative price impacts from large block trading, and the hierarchy cost discussed in Stein (2002). More recent studies provide another possible and testable explanation, namely that the standard compensation contract in the hedge fund industry is not effective at aligning managers' incentives with investors' interests. Lan, Wang, and Yang (2013) show that the present value of managers' future management fees is much higher than the present value of future incentive fees. Yin (2016) shows empirically that the management fee comprises a larger portion of total compensation when funds grow large and thus a fund's optimal size from a compensation perspective exceeds the size that is optimal for performance.[6] These studies suggest that diseconomies of scale may reflect compensation arrangements that are weighted more toward management fees than incentive fees

[6] Yin (2016) presents cross-sectional evidence of scale diseconomies but does not examine the time-series trend.

when funds grow sufficiently large. Consistent with this line of reasoning, we find that the contribution of future management fees to total future fees is higher for larger funds and that the contribution becomes even higher as funds grow larger over time. Thus, when funds grow over their life cycle, managers are likely to have diminishing performance incentives because most of their compensation comes from the asset-based management fee.

Last, one other possible explanation for declining performance with age is that young funds are willing to take on more risk. If these risks pay off, young funds can attract capital inflows and ultimately collect more fees. However, our results do not support this explanation. Using measures such as *VaR*, expected shortfall, and tail risk, we find that younger funds do not have higher downside risk. As argued in Aggarwal and Jorion (2010), managers of young funds may have more innovative ideas and trading strategies relative to old funds.[7] Consequently, young funds might be able to generate good performance without taking extra risk.

This study contributes to the hedge fund literature in the following key ways. First, our study is one of the very few that examines the performance life cycle of hedge funds. We find that, on average, hedge fund performance declines over its life cycle and that fund growth over time significantly drives this decline. We do not find that performance declines over the life cycle is associated with a variety of other fund- and family-level characteristics, nor do we find that is related to young funds assuming higher downside risk. Second, our study contributes to the performance persistence literature. Our results suggest that fund growth and diseconomies of scale contribute to the lack of performance persistence in the hedge fund industry. Thus, funds that maintain a small size may provide higher performance persistence. Third, we are the first study to examine how hedge fund managers' incentives vary over time as a function of fund size. We show that the relative importance of the management fee to managers' compensation arrangements increases with fund size over the life cycle. These findings provide further evidence that the standard compensation contract in the hedge fund industry does not align managers' incentives with investors' best interests.

[7] We examine innovation over the performance life cycle in Section IV, B.5.

I. Data and Methodology

A. Data

We collect hedge fund data from the Lipper TASS and Hedge Fund Research (HFR) databases. Following the literature, we only consider funds that report monthly net-of-fee returns in US dollars (USD). Fund-month observations with missing information about fund returns, assets under management, or investment styles are deleted. We also exclude funds in the Fund of Funds style because they invest in other hedge funds rather than securities. To mitigate survivorship bias, we retain defunct funds in our sample. Because defunct fund data are available starting in 1994, our sample period begins in January 1994 and spans through December 2016. In addition, because Lipper TASS and HFR use different investment style classifications, we follow Agarwal, Daniel, and Naik (2009) and consolidate reported styles into the following four general styles: Directional Traders, Relative Value, Security Selection, and Multi-Process.

To identify and remove duplicate funds across databases, we first identify management firms that report to both databases. We match management firms by name and by reported address. Within matched management firms, we calculate return correlations between funds in TASS and funds in HFR. For each pair of funds with correlation≥0.999, we confirm the pair's duplication status based on fund name and fund returns. In addition, as pointed out in Aggarwal and Jorion (2010), management firms may report multiple share classes, including master-feeder structures, to a database. To eliminate duplicate share classes, we calculate the return correlation between each pair of funds within the same management firm. For each pair of funds with correlation≥0.999, we retain the one with the longer performance record or with larger assets under management.

As is well documented in the literature, hedge fund performance in commercial databases suffers from backfill bias. There are three key dates that are relevant to this bias: the inception date, the performance start date, and the add-date. The inception date is when the legal fund structure was established. The performance start date is the date of the first reported monthly return. The add-date is the date when a fund chooses to start reporting to a commercial database. Backfill happens when the performance start date precedes the add-date. Because hedge funds are more likely to report performance data when performance is good, backfilled data are likely to be upward biased. To mitigate the impact of backfill bias on our analysis, we exclude backfilled funds from our main sample. Following Aggarwal and Jorion (2010), we define a fund as "backfilled" if the period between its inception date and its add-date exceeds 6 months.[8]

Turning to the remaining non-backfilled funds, we require funds to have inception dates after 1994 and to have at least 5 years of data.[9] As discussed in the Introduction, funds that fail because of adverse industry shocks or bad luck are likely to experience poor performance just prior to liquidation. By excluding these funds, we mitigate a potential bias that could lead us to observe a negative age-performance relation even when there are no actual age effects on performance. Lastly, we require funds to start with at least \$1 million in assets under management (AUM). We choose \$1 million because it is the most common minimum investment requirement over our sample period, as shown in the Internet Appendix Table IA.II. Moreover, Internet Appendix Table IA.III shows that \$1 million is at about the 25th percentile of fund starting size over our sample period. Thus, the \$1 million starting size requirement does not eliminate too many funds from our sample. Note that our results are not biased by these criteria, as shown in Section IV.

To facilitate our analysis, we construct a reference sample using all backfilled funds and non-backfilled funds that do not survive the filters above. For the reference sample, we require funds to have at least \$5 million in AUM, and we exclude observations before their add-dates. If the add-dates are not available, we remove the first 18 months of data. Finally, to mitigate the impact of outliers and reporting errors, we winsorize fund returns in both the main sample and the reference sample at the 0.5% and 99.5% levels.

[8] One potential issue with this procedure is that the TASS database stopped updating add-date information around 2011. As a result, some funds without backfilled data are excluded from our main sample because their add dates are missing. To address this issue, we follow the procedure in Jorion and Schwarz (2017) to estimate add-dates for TASS funds with inception dates after 2011. Implementing this procedure adds only one additional fund to our main sample, probably because we require 5 years of data to be included in our main sample. Unsurprisingly, the results are robust to implementing this additional procedure (see Internet Appendix Section B.3).

[9] We choose 5 years because the median life span of defunct funds in our sample is 58 months, which is approximately 5 years (see Internet Appendix Table IA.I). As an additional consideration, institutional investors commonly require hedge funds to have a three to five year performance record before investing in them.

B. *Performance Measures*

In this study, we use two measures of fund performance: (1) net-of-fee raw returns, as reported in TASS and HFR, and (2) style-adjusted returns. Style-adjusted returns are defined as the difference between fund monthly returns and the average return of all funds in the same investment style. Thus, for fund *i* in month *t*, its style-adjusted return is defined as:

$$Style\text{-}Adj\ Return_{i,t} = Return_{i,t} - Style\ Return_{i,t}. \tag{1}$$

Raw returns are directly observable to all investors, and style-adjusted returns can be easily calculated from raw returns. Both measures are less noisy than risk-adjusted return measures estimated from factor models.[10] In addition, investors are likely to evaluate and compare hedge funds within the same style because funds in different styles may face very different markets and use significantly different investment strategies. Thus, the style-adjusted return is a reasonable measure of relative performance that provides a good complement to the raw return.

C. *Summary Statistics*

Panel A of Table I presents the summary statistics for our main sample. The means of after-fee returns and style-adjusted returns are 0.61% and 0.10% per month, respectively. The pooled mean fund age is approximately 60 months, or about 5 years. Average fund size is $170 million, while average fund family size is over $700 million with an average of a little over 4 funds per family. Following Sirri and Tufano (1998), we calculate fund flows as in Equation 2 below, and the average flow is 1.35% per month. Funds in our main sample charge a management fee between 1% and 2% and an incentive fee of 20%. Most funds have a high-water mark provision (mean is 0.92) and use leverage (mean is 0.69). In terms of share restrictions, lockup periods are not commonly used, and the mean is about 4 months.

$$Flow_{i,t} = \frac{AUM_{i,t} - AUM_{i,t-1} \times (1 + Return_{i,t})}{AUM_{i,t-1}}. \tag{2}$$

[10] While the literature commonly uses a rolling window approach to estimate risk-adjusted returns, such an approach is inappropriate in our setting because we examine hedge fund performance from a life cycle perspective (e.g., a rolling window approach would exclude data from early years when evaluating risk-adjusted returns in later years).

Panel B of Table I reports the summary statistics for funds in our reference group. The performance of the reference group is slightly lower than the performance of our main sample, with an average raw return of 0.49% and an average style-adjusted return of -0.02% per month. The means of fund size and family size are $263 million and $622 million, respectively. Hedge funds in the reference group charge an average management fee of 1.5% and an average incentive fee of about 20%. Most funds have a high-water mark provision, use leverage, and do not have lockup periods.

[Insert Table I about here]

II. Life Cycle of Hedge Fund Performance

A. Performance of Hedge Funds: Event Time

We begin our analysis by examining the performance life cycle of hedge funds. We follow Aggarwal and Jorion (2010) and group fund-month observations by "event time," where event month 1 is the month of a fund's performance start date, event month 2 is the following month, etc. Next, we form equal-weighted portfolios of funds for each event month. We treat the first 12 event months as the first event year, the next 12 event months as the second event year, etc.

Table II presents the average monthly performance for each event year.[11] The average raw return is decreasing with fund age, from 1.30% per month in the first year to 0.41% per month in year 5. After the fifth year, some funds become liquidated and the pattern is somewhat mixed. However, the performance in later years is never as good as it is during the first few years. Because the raw return results might be driven by funds in certain style categories, we also examine style-adjusted returns in the last two columns of Table II. Style-adjusted returns exhibit a similar pattern of declines, from 0.62% per month in year 1 to -0.01% per month in year 5. After year 5, most style-adjusted returns are negative, which suggests older funds underperform their style average.

[Insert Table II about here]

[11] We only present the first 10 event years in Table II because less than half of the funds in our main sample survive past their 10th year. The complete performance life cycle is reported in Internet Appendix Table IA.IV.

In columns 4 and 6 of Table II, we compare portfolio performance in adjacent years using a *t*-test. The results indicate that there are two significant performance declines over the first 5 event years using both raw returns and style-adjusted returns. The first decline occurs when going from year 1 to year 2. As argued in Aggarwal and Jorion (2010), newly established hedge funds may generate superior performance from implementing innovative strategies. However, performance does not remain at a high level for long, either because other funds learn about and adopt innovative strategies or because those strategies have limited capacities.[12] The second decline in performance occurs when going from year 4 to year 5. This result may reflect our chosen minimum fund life span of 5 years, as funds that liquidate in year 6 are likely to have poor performance in year 5. If so, the decline would support our earlier concern that fund failures impart a bias in favor of finding a negative age-performance relation.

Overall, the results in Table II show that hedge fund performance declines with fund age, consistent with anecdotal evidence and prior studies such as Aggarwal and Jorion (2010). Performance appears to peak in year 1, significantly drops off in year 2, and gradually declines thereafter. The performance life cycle evidence in Table II may also help explain why prior studies have trouble documenting long-term performance persistence. Prior studies commonly find evidence of short-term performance persistence lasting up to six months, but persistence evidence becomes mixed when extending the performance horizon beyond one year. The results in Table II indicate that, on average, hedge fund performance declines over time, which suggests long-term performance persistence might be difficult to achieve. Nevertheless, it may be possible that certain types of hedge funds can provide consistent performance. In Sections II.B and II.C, we examine whether the patterns in Table II relate to a variety of fund or family characteristics, respectively.

B. Fund Performance and Fund Characteristics

As documented in the literature, hedge funds with different characteristics may have different performance. Thus, the return patterns in Table II could be driven by certain fund-level

[12] We examine innovation over the performance life cycle in Section IV, B.5.

characteristics. In this section, we examine four specific fund characteristics. The first one is a lockup period, which is a period of time wherein investors cannot redeem their money. Because fund managers do not need to worry about redemptions during lockup periods, managers may use the time to invest in illiquid assets. Consequently, funds with lockup periods may be able to generate superior performance, especially during the early years of their life cycle. The second characteristic is a high-water mark provision, which requires managers to make up for any past losses before they can collect an incentive fee. Managers of funds with high-water mark provisions may deliver strong performance because they face strong incentives to keep their fund value above the high-water mark. The third characteristic is the incentive fee percentage. Although most hedge funds charge a 20% incentive fee, some funds deviate from the industry standard, and such deviations may create different incentives for performance. The last characteristic is fund leverage, which allows managers to take on additional risk to boost performance. To examine the impact of these fund characteristics, we divide our sample into subgroups and conduct the event-time analysis as in Section II.A. The results are summarized in Table III, and for simplicity, we only present results for the first 5 event years.

[Insert Table III about here]

In Panel A of Table III, we divide our main sample into two groups based on whether or not they have lockup periods. The results indicate that fund performance in both groups decreases with fund age. The last two columns compare the performance of the two groups using a *t*-test. The results show that while funds with lockup periods tend to have better performance over the first 5 years, the performance gap is generally not statistically significant.

Table III, Panel B examines the impact of the high-water mark provision. Using raw returns, we find that fund performance declines over time for funds with and without high-water mark provisions and that performance differences between the groups are not statistically significant. Using style-adjusted returns, it is interesting to see that the performance of funds without high-water marks decreases to around zero after the first year. By contrast, funds with high-water marks maintain reasonable performance over their first four years. However, performance differences are not statistically significant.

In Panel C of Table III, we divide hedge funds into three groups based on their incentive fee percentages. Using both raw and style-adjusted returns, we find that the performance of funds with incentive fee percentages at or below 20% decreases over time. However, we do not observe a clear pattern for funds that charge an incentive fee higher than 20%. For instance, funds with incentive fees greater than 20% underperform funds with incentive fees less than 20% in the first event year, and the difference is statistically significant using raw returns. However, funds with incentive fees greater than 20% significantly outperform their lower fee peers in event years 2 through 4 using style-adjusted returns.

Panel D of Table III compares hedge funds with and without leverage. In both groups, we continue to observe declining performance with age. The results of the *t*-tests in the last two columns indicate that funds with leverage deliver better performance than funds without leverage in most years, although superior performance is only significant in event year 2.

Overall, the results in Table III indicate that hedge funds with varying fund-level characteristics generate superior performance early in their lives, only to see performance decline over time. Although we find that funds with lockup periods, high-water mark provisions, and leverage typically generate higher performance, performance differences are generally not statistically significant.

C. Fund Performance and Fund Family Characteristics

In addition to fund-level characteristics, fund family-level characteristics may also influence hedge fund performance. Fung et al. (2016) argue that fund families have strong incentives to generate good performance for their flagship funds (i.e., their first funds) and use the flagship's performance record to attract capital flows and launch new funds. Therefore, the outperformance of young funds may be stronger among flagship funds. Moreover, Boyson (2008a) shows that fund families that focus on their core competencies have better performance, implying that non-flagships funds that share the flagship's investment style may also outperform.

Table IV reports the results of our tests of these hypotheses. In Panel A, we divide our sample into flagship funds and non-flagship funds. Following the literature, we define a fund as a flagship fund if it is the first fund established by its family. The results show that funds in both groups provide superior performance in their early years. Notably, flagship funds outperform non-flagship funds in all five years. The differences are statistically significant in the first event year, and the differences in raw returns and style-adjusted returns are 0.35% and 0.28% per month, respectively. The performance differences are still economically significant over event years 3 to 5 but not statistically significant at conventional levels. In Panel B, we further divide the non-flagship funds into two groups based on whether they use the same investment strategy as their family's flagship fund or not. Again, we find that performance declines with age for both groups. Interestingly, the *t*-tests in column 3 suggest that the performance of non-flagship funds that use the same investment strategy as their family's flagship fund decreases at a slower pace than other non-flagship funds. In addition, they outperform other non-flagship funds in most years, although performance differences are mostly insignificant.

[Insert Table IV about here]

To summarize, the return patterns in Table II do not appear to be driven by funds with certain family-level characteristics. Younger hedge funds provide superior performance, and fund performance declines with fund age. Meanwhile, we also find that flagship funds outperform non-flagship funds, and that non-flagship funds employing the same investment strategy as their family's flagship fund outperform other non-flagship funds. However, the performance differences are not statistically significant in most cases.

III. Fund Size and Performance Declines with Age

In Section II, we find that hedge fund performance declines as funds age and funds generate superior performance at the early stage of their life cycle. Further analysis reveals that performance declines with age are not limited to funds with certain fund- and family-level characteristics. So what could be driving the decline in performance with fund age? One possible explanation is that fund growth over time erodes performance. As shown in Internet Appendix Table IA.IV, both the mean and median of fund assets increases with fund age. Prior studies, such as Teo (2009), Getmansky (2012), and Yin (2016), show in cross-sectional settings that hedge funds suffer from diseconomies of scale, that is, performance decreases with fund size. In this section, we examine whether fund growth contributes to performance declines with age in the hedge fund industry.

A. Fund Size and Diseconomies of Scale

Prior studies commonly use panel data to examine the impact of fund size on fund performance and thus look at the size-performance relation in the cross-section. In this study, we complement the literature by examining diseconomies of scale in the time-series dimension. The time-series dimension is more appropriate for our study because we are interested in examining whether diseconomies of scale contribute to performance declines over the life cycle of a hedge fund. To this end, we employ two different approaches. For our first approach, we form size portfolios based on assets under management (AUM) at the beginning of each event year, and we divide funds into three groups using two fixed cutoff points: $10 million and $100 million. If we had instead assigned size classifications based on inception year size or cohort size (e.g., Boyson (2008b) and Aggarwal and Jorion (2010)), we might classify as "small" funds that grow to be quite large in their later years, while we might classify as "large" funds with starting sizes that are small relative to older funds in our sample. We chose $10 million and $100 million as our cutoff points based on the size distribution shown in Internet Appendix Table IA.V. For each size group, we form an equal-weighted portfolio, and we hold the portfolio over the event year. Table V reports the average performance of each portfolio over time.

[Insert Table V about here]

The results show that hedge funds in all three size groups generate superior performance in their early years, but that performance decreases with age. However, funds in the small size group suffer milder declines with age relative to the medium and large size groups, and the small group outperforms the large group over multiple event years. For example, we find that the year-to-year decrease in performance for small funds is mostly insignificant based on *t*-tests and that style-adjusted returns for small funds are positive in each event year. By contrast, performance of large funds decreases significantly after the first year, and their style-adjusted returns drop to nearly zero. Moreover, when we compare performance between the small and large groups in the last two columns, we find that small funds outperform large funds in event years 2 through 5, with statistically significant outperformance in years 2 through 4. Overall, the results suggest that the deterioration of fund performance is driven primarily by large hedge funds, while small hedge funds generally maintain good performance.

One drawback to the portfolio approach is that portfolio membership varies across event years as fund size changes over time. To better distinguish size and age effects, our second approach uses a modified version of the Fama-MacBeth regression. Specifically, following Coval and Shumway (2005), we first perform time-series regressions for each fund, and we then take cross-sectional averages of the fund-specific coefficients and use the averages as our estimates of the size and age effects on performance. We use this modified regression for two reasons. The first reason is that we are interested in how size and age influence performance over the life cycle of a hedge fund. Thus, conducting time-series regressions for each fund is more appropriate for answering our research question. The second reason is that we have a large number of funds that exist only for a short period of time.[13] The results of the modified Fama-MacBeth regressions are reported in Table VI.

[Insert Table VI about here]

In Panels A and B, the dependent variables are raw returns and the style-adjusted returns, respectively. In regression (1), we only include fund age as the independent variable. The coefficients are negative and significant in both panels (coefficients are -0.40 and -0.29, respectively, and *t*-statistics are -19.04 and -15.10, respectively). These results are consistent with Table II and suggest that fund performance declines with fund age. In regression (2), we only include fund size as the independent variable. The coefficients are also negative and significant in both panels (coefficients are -1.18 and -0.61, respectively, and *t*-statistics are -13.97 and -12.31, respectively). These results are consistent with Table V and consistent with the diseconomies of scale documented in the literature. In regression (3), we include both fund size and fund age as independent variables. In Panel A, the coefficient on size is -1.12 with a *t*-statistic of -14.81, while

[13] See Skoulakis (2008) for more details regarding the econometrics of the modified Fama-MacBeth regression.

the coefficient on age is -0.07 with a *t*-statistic of -1.76. In other words, after controlling for fund size, the impact of fund age on performance diminishes precipitously in magnitude and becomes only marginally significant. We find similar results using style-adjusted returns in Panel B. In regression (4), we add controls for the number of other funds in the fund family, total assets of other funds in the fund family, and fund capital flows. In both panels, the coefficients on size are negative and highly significant, but the coefficients on age become insignificant. Economically, a 10% increase in fund size in regression (4) is expected to result in a decrease of 13 basis points per month (or 1.53% per year) in raw returns and a decrease of 10 basis points per month (or 1.21% per year) in style-adjusted returns, holding all other variables in the regression constant.

The results in Tables V and VI suggest that hedge funds suffer from diseconomies of scale and that fund growth over time significantly contributes to performance declines as funds age. Our results also speak to the persistence of hedge fund performance. On the one hand, the literature documents that investors chase fund performance. Thus, good performance attracts capital inflows and fund growth erodes fund performance. Eventually, as predicted by Berk and Green (2004), all superior performance will be chased away, leaving no persistence in fund performance. On the other hand, our results imply that hedge funds can maintain good performance if they can restrict fund growth. Given that many hedge funds close themselves off to new investment, restricting fund growth is quite feasible in practice.

B. Implications for Investors' Fund Selection

So far, our results suggest that the decline of hedge fund performance with age is related to fund size and that smaller hedge funds are able to generate and maintain superior performance for multiple years after their inception. Thus, a natural question is whether investors could profitably exploit these results in real time using the universe of hedge funds. To help answer this question, we pool our main sample and our reference sample and assign each fund to one of nine (3x3) portfolios based on size (small, medium, and large) and age (young, mid-age, and old) at the beginning of each calendar year. Along the age dimension, we define "young" funds as those that are no more than 2 years old, "old" funds as those that are at least 5 years old, and mid-age funds as those in between. Along the size dimension, we use $10 million and $100 million as the cutoff points. Thus, portfolios are formed on independent sorts of size and age. Then we form an equal-weighted portfolio for each group and hold the portfolio for one year.

[Insert Table VII about here]

Table VII reports the average performance of each portfolio over our sample period. Panel A shows the average raw return of each portfolio. When we compare portfolio performance along the size dimension, we find that small funds outperform large funds across all three age groups. The differences by size are statistically significant for the young and mid-age groups. By contrast, when we compare portfolio performance along the age dimension, funds in the young group only outperform the old group when fund size is small, and the young-old differences are statistically insignificant, regardless of size. Patterns are similar in Panel B, where performance is measured using style-adjusted returns. Small funds provide superior performance in all age groups, while young funds do not always outperform funds in the old group. The results in Table VII suggest that selecting smaller funds might be a good strategy for investors.

Although we find that small funds, on average, outperform medium and large funds in all age groups in Table VII, these results do not indicate whether small funds provide superior performance consistently over our sample period. To address this question, we rank the performance of the nine size-age portfolios in each calendar year, labeling the top three portfolios as “winners,” the bottom three portfolios as “losers,” and the middle three portfolios as “neutral.” We then calculate the frequency with which each portfolio is classified as a “winner,” “loser,” and “neutral” portfolio over our sample period. The results are summarized in Figure 1.

[Insert Figure 1 about here]

Over our sample period, portfolios with small funds are more likely to be classified as “winners” than portfolios with medium and large funds. For instance, portfolios with “small & young” funds and “small & mid-age” funds are both winners in over 60% of the calendar years in our sample. This frequency far exceeds the frequencies of the other portfolios. Meanwhile, although we find that the “large & young” portfolio is classified as a winner more often than the "small & old" portfolio, the "small & old" portfolio is classified as a loser less often than the "large & young" portfolio (20% for the "small & old" portfolio vs. 50% for the "large & young" portfolio).

Taken together, the results in Table VII and Figure 1 indicate that small funds not only outperform medium and large funds (on average), they also generate superior performance consistently over our sample period. These results are quite useful for hedge fund investors. For example, even when investors (e.g., institutional investors) require a multi-year performance record to invest in a hedge fund, they can achieve stable returns if they invest in small hedge funds.

C. Managers' Incentives

The literature provides several explanations for the negative effect of fund size on fund performance, including managers' limited abilities, the price impact of large block trading, and the hierarchy cost discussed in Stein (2002). More recent studies provide another possible explanation related to how managers' incentives change with fund size. Lan, Wang, and Yang (2013) show in their baseline model that 75% of the total value created by managers comes from the management fee. Lim, Sensoy, and Weisbach (2016) show that hedge fund managers' indirect incentives per dollar change in fund value decrease with fund age. Thus, younger funds may have stronger incentives to improve fund performance. One way to interpret this is that additional capital flows become less important as funds grow larger. Yin (2016) shows that because of diseconomies of scale, the management fee becomes the more important part of a hedge fund managers' total compensation in absolute dollar terms when funds grow large. Consequently, managers of large funds may have weaker incentives to deliver strong performance, as chasing performance may risk eroding fund size.

Based on the above literature, we examine whether the impact of fund size on fund performance corresponds with changes in managers' incentives over time. To be more specific, we calculate the present value of managers' future fees at the end of each event quarter based on the baseline model in Goetzmann, Ingersoll, and Ross (2003; GIR hereafter). Note that unlike most empirical studies in the literature, which calculate realized compensation at the end of each quarter, we focus on managers' "expected" compensation for the future. Because managers' behavior cannot change realized fees but can influence future compensation, our measure is more likely to capture managers' incentives. We use the GIR model because it provides a closed-end solution to, and a lower bound on, the magnitude of managers' future compensation. The calculation requires the market value of each investor's assets in the fund and their individual high-water marks. Because these values are not provided by commercial databases, we estimate them following the approach in Agarwal, Daniel, and Naik (2009).[14] We measure managers' incentives as the contribution of the present value of future management fees to the present value of future total fees as follows:

$$FMFEE\% = \frac{PV\ of\ Future\ Mgmt\ Fees}{PV\ of\ Future\ Total\ Fees} \times 100. \tag{3}$$

Panel A of Table VIII reports *FMFEE%* at the end of each event year. Following the literature, we assume that managers' skills (represented by α) are either 0 or 3% per year and the withdrawal rate (represented by δ+λ) is either 5% or 10% per year. First, we find that the management fee comprises most of the managers' total compensation in present value terms, as *FMFEE%* is higher than 50% over each of the first five event years. Second, *FMFEE%* increases over time. Because fund size also increases over time, our results are consistent with the literature and the intuition that the management fee becomes more important as funds grow large. Thus, fund managers may have lower incentives to improve fund performance because most of their compensation comes from the management fee, which only depends on fund assets. Moreover, as funds grow larger, incentives become even lower, thereby creating a self-reinforcing process.

[Insert Table VIII about here]

In Panels B through E, we divide our sample into three size groups (i.e., small, medium, and large). The results indicate that funds in the small group have lower *FMFEE%* in all event years, and the differences between the small and large groups are all statistically significant. Notice that, for small funds with skills (i.e., α=3%) in Panels D and E, *FMFEE%* is actually below 50%. In other words, managers of small funds collect more of their compensation from the incentive fee. However, as fund assets increase, we still find that *FMFEE%* grows over time. Also note that

[14] The details of our calculation are outlined in the Appendix.

FMFEE% increases more with age for large funds than it does for small funds. For example, looking at Panels B through E, the range of increase of *FMFEE%* over event years 1 to 5 for large funds is 5.13% to 6.19%, while the range of increase for small funds is 0.04% to 0.82%. These findings may help explain why performance declines with age are greater for large funds relative to small funds.

To examine whether the results in Table VIII are driven by hedge funds with high management fee percentages, we divide our sample into three groups: funds with management fee percentages no more than 1%, funds with management fee percentages no less than 2%, and funds in between. We then repeat our analysis as in Table VIII Panel A for each group and the results are summarized in Internet Appendix Table IA.XII. Using different parameter choices, we find that *FMFEE%* for all three groups increases over time with fund size.

IV. Further Analysis and Robustness Tests

A. Downside Risk

Another possible explanation for declining performance with age is managers' risk-taking behavior. Getmansky (2012) argues that younger funds tend to increase their riskiness to obtain high returns. When funds become more mature and bigger in size, they take less risk. Bernhardt and Nosal (2013) argue that hedge fund managers initially take risky gambles to boost returns and attract capital flows. Over time, as investors set lower cutoffs for continued reinvestment, fund managers take less risk and generate lower returns. In other words, the superior performance of young funds is driven by their higher risk-taking. On the other hand, Chevalier and Ellison (1999) argue that young managers have incentives to "herd" to increase their survival probabilities. Thus, fund managers may want to play it safe and avoid taking risks because of their career concerns. Also, Aggarwal and Jorion (2010) suggest that managers of newly established hedge funds may have new and innovative ideas for trades. If this is true, then fund managers can generate good performance without taking additional risk. In this section, we try to shed light on whether declining performance with age relates to higher risk-taking in funds' early years.

Because traditional risk measures may not fully capture hedge funds' risk exposure, we utilize several different measures of downside risk as in Liang and Park (2007).[15] The first measure is Value-at-risk (*VaR*). Because hedge fund returns are skewed, we use nonparametric *VaR* (*VaR_NP*) and Cornish-Fisher *VaR* (*VaR_CF*) in this study. Nonparametric *VaR* does not make any assumptions on the distribution of returns. It uses the left tail of observed returns. Thus, the 5th percentile of all observations in a time window is the 95th percentile of *VaR_NP*. Another way to deal with the non-normal distribution of hedge fund returns is to use Cornish-Fisher expansion. The *VaR_CF* is defined in equation (4). Here, μ is the average return, σ is the standard deviation, S is the skewness, K is the excess kurtosis, and z is the critical value from the standard normal distribution corresponding to the confidence level. In this study, we use a 95% confidence level. As shown in equation (5), *VaR_CF* takes the skewness and the kurtosis of the empirical distribution into consideration.

$$VaR\_CF = \mu + \Omega \times \sigma \tag{4}$$

$$\Omega = z + \frac{1}{6}(z^2 - 1)S + \frac{1}{24}(z^3 - 3z)K - \frac{1}{36}(2z^3 - 5z)S^2 \tag{5}$$

The second measure of downside risk is expected shortfall (*ES*). The expected shortfall provides more information about how big the loss could be once returns fall below *VaR*. Again, we use nonparametric expected shortfall (*ES_NP*) and expected shortfall based on Cornish-Fisher expansion (*ES_CF*) in this study, because of the non-normal distribution of hedge funds returns. To calculate *ES_NP*, we first estimate *VaR_NP* using observed returns. Then, we calculate the average of returns that are equal to or below *VaR_NP*. *ES_CF* is computed in a similar way. The last measure is Tail Risk (*TR*), which is the standard deviation of returns below *VaR*. Similar to the expected shortfall, we calculate tail risk using both *VaR_NP* and *VaR_CF*.

We employ two approaches to examine downside risk over time. For our first approach, we form an equal-weighted portfolio every event month as in Section III and then calculate *VaR* of portfolio performance every event year. Because *VaR* covers the bottom 5th percentile of the

[15] In Internet Appendix Table IA.IV, we report annualized return volatility of equal-weighted portfolios and average fund volatility by event year. The results show that young funds do not take higher risk based on traditional measures.

return distribution, higher values of *VaR* would suggest better performance and lower downside risk. The results in Table IX Panel A indicate that younger funds have higher *VaR_NP* and *VaR_CF*, and both *VaR* measures decrease over time. Thus, hedge funds tend to have lower downside risk early in their life cycle.

[Insert Table IX about here]

One drawback to forming portfolios is that we do not have enough observations in each event year to calculate expected shortfall and tail risk. Thus, for our second approach, we first calculate the expected shortfall and the tail risk using cross-sectional returns of individual funds in our main sample for every event month. Then we compute the time-series average for each event year. Results in Table IX, Panel B show that below-*VaR* fund performance in the early years have higher mean values and lower volatilities. In other words, younger funds have lower downside risk based on both expected shortfall and tail risk.

To summarize, Table IX provides some evidence that young hedge funds do not take on higher downside risk. Given the superior performance of young funds, our results do not support the hypothesis that young fund managers boost their performance by taking extra risk.

B. *Robustness Tests*

B.1. Sub-Periods

Our results could be driven by fund performance in certain time periods, especially financial crisis periods. To examine this possibility, we conduct our analysis in different sub-periods. Following the literature, we choose several period cutoff points: the bankruptcy of LTCM in September 1998, the peak of the tech bubble in March 2000, and the beginning of the subprime crisis in January 2008. To be more specific, we define the first sub-period as January 1994 to August 1998, the second sub-period as April 2000 to December 2007, and the third sub-period as July 2009 to December 2016.[16] Table X, Panel A presents the results of our portfolio approach by

[16] We exclude the period from September 1998 to March 2000 because it is too short to conduct meaningful analysis.

sub-period. While we do not observe a monotonic decline, the overall picture that emerges is that performance declines with age in all three sub-periods.

[Insert Table X about here]

Panels B through D of Table X provide portfolio analysis by sub-period with partitions for the fund- and family-level characteristics examined in Tables III and IV. Panel B presents the sub-period 1 return differentials in each event year for (i) funds with or without lockup periods, (ii) funds with or without high-water mark provisions, (iii) funds with high (> 20%) or low (< 20%) incentive fees, (iv) funds with or without leverage, (v) flagship and non-flagship funds, and (vi) non-flagship funds with the same or different style than the family's flagship fund. Similarly, Panels C and D present return differential results for sub-period 2 and 3, respectively. The results in these panels show that while return differentials are occasionally significant in certain event years, there are no clear and consistent return differential patterns across the six characteristic groups in any of the three sub-periods. Thus, the decline in performance over time is not driven by funds with certain characteristics.

Panel E of Table X presents the results of Fama-MacBeth regressions by sub-period. In all three sub-periods, size has a significantly negative coefficient. Meanwhile, the coefficients on age are all insignificant. Thus, the results from Table VI hold across all three sub-periods.

B.2. Different Main Samples

In Internet Appendix Tables IA.VI and IA.VII, we use different criteria to define our main sample. Specifically, we increase our minimum starting size requirement to $5 million (Table IA.VI), and we reduce the minimum number of observations from 5 to 3 years (Table IA.VII). Panel A of both tables exhibit fund performance in event time. As in Table II, we again find that fund performance declines over time using both performance measures.

Panel B of Tables IA.VI and IA.VII examine performance differences between funds with different characteristics. Consistent with Table III, we do not find a clear pattern and the performance differences are not statistically significant in most cases. In Panel C of both tables, we conduct our modified Fama-MacBeth regressions. Similar to Table VI, we find negative and significant coefficients on fund size and insignificant coefficients on fund age. In other words, our results are robust and the decline in fund performance over the life cycle is mostly driven by fund growth.

B.3. Additional Control Variables

In this section, we examine whether our specification in Table VI is robust. In the first test, we control for style size and style fund numbers. Style size is the total assets of funds in the same investment style but not in the same family as fund *i*. Style fund numbers are similarly defined. Some studies (e.g., L. Pástor and Stambaugh (2012) and Ľ. Pástor, Stambaugh, and Taylor (2015)) argue that the decline of fund performance is the result of diseconomies of scale at the industry level. In other words, competition between funds using similar strategies drives declining fund performance. To control for this possibility, we include both style size and style fund numbers in our modified Fama-MacBeth regressions.[17]

Internet Appendix Table IA.VIII shows the results of our regression analysis with these added control variables. In Panel A, when we use raw returns as the dependent variable, the coefficient on style size is negative and significant. This result is consistent with the literature and suggests that growth of style size erodes fund performance. When we use style-adjusted returns, the coefficient on style size is significantly positive. The result implies that increased style size leads to lower average style performance and thus better style-adjusted returns for fund *i*. Both regressions provide some evidence supporting diseconomies of scale at the industry level. More importantly, after controlling for style size, we still find negative and significant coefficients on fund size.

As a second alternative specification, we include *FMFEE%* as an additional explanatory variable in our modified Fama-MacBeth regressions, and the results are summarized in Internet Appendix Table IA. VIII Panels B and C. In Panel B, the coefficients on *FMFEE%* are all negative and significant. The results indicate that when the management fee becomes more important, fund

---

[17] The last two columns in Panel A of Table X compare fund performance between sub-periods 1 and 3. The results show that funds in sub-period 1 outperform those in sub-period 3, although the differences are significant only when we use raw returns. Data from Barclay Hedge shows that the total assets under management of regular hedge funds increase from $118.23 billion to $3,537.60 billion over our sample period. Thus, observing lower performance in later years is consistent with the argument that there are diseconomies of scale at the industry level.

performance deteriorates. This is consistent with Table VIII and our prediction that managers have less incentive to improve performance when they collect most of their compensation from the asset-based management fee. After controlling for *FMFEE%*, we still find that the coefficients on fund size are significantly negative. Thus, while we saw in Table VIII that managers' incentives are decreasing with fund size, fund size can affect fund performance outside of the incentive effect, (e.g., diseconomies of scale attributable to managers' limited abilities). Interestingly, we find that the coefficients on fund age are positive and significant. Thus, after controlling for fund size and managers' incentives, older funds have better performance. Our interpretation is that, holding constant fund size and managers' incentives, older funds appear to have skills, on average. As a result, older funds are more likely to generate better performance.

The results in Panel C, based on style-adjusted returns, are similar. All coefficients on *FMFEE%* are negative, but become insignificant when we use style-adjusted returns as the performance measure. The negative and significant coefficients on fund size suggest that funds still suffer from diseconomies of scale after controlling for managers' incentives. Again, the impact of fund age on fund performance becomes positive when we include both fund size and managers' incentives in the regression.

B.4. Analyses by Style

In this section, we examine whether our results are driven by funds using certain strategies. As mentioned earlier, we divide hedge funds in our sample into four general styles following the algorithm in Agarwal, Daniel, and Naik (2009). To assess style effects, we repeat our earlier analyses separately for each style, and the results are reported in Internet Appendix Section B.5.

Table IA.XIII reports fund performance over time for each style. Across all styles, we find that funds generate superior performance early in their life cycles with steady performance declines thereafter. The results are consistent with our findings in Table II. In Table IA.XIV, we repeat our modified Fama-MacBeth regressions for each style. The results are similar to those reported in Table VI in that we find significantly negative coefficients on fund size, while the coefficients on fund age are insignificant. Thus, the decrease in fund performance over time is mostly the result of growth in fund assets, and our findings are not driven by funds in certain styles.

B.5. Strategy Distinctiveness

Table II shows that there is a significant decrease in fund performance from event year 1 to event year 2, while Table V indicates that fund size cannot fully explain this drop in performance. One possible explanation is that newly established funds have new ideas for trades that generate superior performance early in a fund's life, but over time, such strategies become less profitable as other funds begin imitating them and as newer strategies are introduced by newer funds. To examine whether innovation can explain the superior performance of newly established funds, we follow Sun, Wang, and Zheng (2012) and calculate the Strategy Distinctiveness Index (*SDI*) for each fund. To be more specific, we first divide funds (both in the main sample and the reference sample) into four clusters based on their past 12 months of returns. We then calculate the *SDI* of a fund as 1 minus the sample correlation between the fund's returns with the average returns of all funds in the same cluster. Internet Appendix Table IA.XV shows the *SDI* for our main sample at the end of each event year. The results indicate that, on average, *SDI* decreases over time and that there is a significant decrease from event year 1 to event year 2. This decline provides a possible explanation for the significant drop in performance from events years 1 to 2 in Table II.

V. Conclusion

In this study, we use an event time approach to examine the performance life cycle of hedge funds with the aim of furthering our understanding of the factors that contribute to declining performance with age in the hedge fund industry. We find that diseconomies of scale significantly drive performance declines over a hedge fund's life cycle and that smaller funds provide superior performance at different stages of the life cycle, particularly after the first year. We also find that performance incentives decrease with fund size throughout a hedge fund's life cycle. We rule out a number of fund- and family-level characteristics as potential drivers of performance declines (e.g., lockup periods, high-water mark provisions, flagship funds, etc.), and we also rule out managers of young funds taking on higher downside risk as a contributing factor to the age effect.

Overall, our study contributes to the hedge fund literature by being the first to provide evidence on factors that drive performance declines with age in the hedge fund industry. While prior studies have linked diseconomies of scale to lower performance using cross-sectional data, we show in a time series context that fund growth over time drives down performance and that the weight of the management fee, which increases with fund size, may provide a disincentive to chase performance when funds grow large. A key implication of our findings for investors is that performance persistence is more achievable when funds maintain a small size. Thus, investing in small funds, regardless of age, may provide for superior and sustainable returns.

Reference

Ackermann, Carl, Richard McEnally, and David Ravenscraft. 1999. "The Performance of Hedge Funds: Risk, Return, and Incentives." *The Journal of Finance* 54 (3): 833–74. https://doi.org/10.1111/0022-1082.00129.

Agarwal, Vikas, Naveen D. Daniel, and Narayan Y. Naik. 2009. "Role of Managerial Incentives and Discretion in Hedge Fund Performance." *The Journal of Finance* 64 (5): 2221–2256.

Aggarwal, Rajesh K., and Philippe Jorion. 2010. "The Performance of Emerging Hedge Funds and Managers." *Journal of Financial Economics* 96 (2): 238–56. https://doi.org/10.1016/j.jfineco.2009.12.010.

Aiken, Adam L., Christopher P. Clifford, and Jesse A. Ellis. 2015. "Hedge Funds and Discretionary Liquidity Restrictions." *Journal of Financial Economics* 116 (1): 197–218. https://doi.org/10.1016/j.jfineco.2015.01.002.

Ammann, Manuel, Otto Huber, and Markus Schmid. 2013. "Hedge Fund Characteristics and Performance Persistence." *European Financial Management* 19 (2): 209–50. https://doi.org/10.1111/j.1468-036X.2012.00574.x.

Aragon, George O. 2007. "Share Restrictions and Asset Pricing: Evidence from the Hedge Fund Industry." *Journal of Financial Economics* 83 (1): 33–58. https://doi.org/10.1016/j.jfineco.2005.11.001.

Berk, Jonathan B., and Richard C. Green. 2004. "Mutual Fund Flows and Performance in Rational Markets." *Journal of Political Economy* 112 (6): 1269–95. https://doi.org/10.1086/424739.

Bernhardt, Dan, and Ed Nosal. 2013. "Gambling for Dollars: Strategic Hedge Fund Manager Investment." SSRN Scholarly Paper ID 2367475. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=2367475.

Boyson, Nicole M. 2008a. "The Impact of Hedge Fund Family Membership on Performance and Market Share." *Journal of Financial Transformation* 25 (September): 123–29.

———. 2008b. "Hedge Fund Performance Persistence: A New Approach." *Financial Analysts Journal* 64 (6): 27–44. https://doi.org/10.2469/faj.v64.n6.6.

Brown, Stephen J., William N. Goetzmann, and James Park. 2001. "Careers and Survival: Competition and Risk in the Hedge Fund and CTA Industry." *The Journal of Finance* 56 (5): 1869–86. https://doi.org/10.1111/0022-1082.00392.

Chevalier, Judith, and Glenn Ellison. 1999. "Career Concerns of Mutual Fund Managers." *The Quarterly Journal of Economics* 114 (2): 389–432. https://doi.org/10.1162/003355399556034.

Coval, Joshua D., and Tyler Shumway. 2005. "Do Behavioral Biases Affect Prices?" *The Journal of Finance* 60 (1): 1–34. https://doi.org/10.1111/j.1540-6261.2005.00723.x.

Eling, Martin. 2009. "Does Hedge Fund Performance Persist? Overview and New Empirical Evidence." *European Financial Management* 15 (2): 362–401. https://doi.org/10.1111/j.1468-036X.2008.00471.x.

Fung, William, David A. Hsieh, Narayan Y. Naik, and Melvyn Teo. 2016. "Growing the Asset Management Franchise: Evidence from Hedge Fund Firms." SSRN Scholarly Paper ID

2542476. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=2542476.

Getmansky, Mila. 2012. "The Life Cycle of Hedge Funds: Fund Flows, Size, Competition, and Performance." *Quarterly Journal of Finance* 02 (01): 1250003. https://doi.org/10.1142/S2010139212500036.

Goetzmann, William N., Jonathan E. Ingersoll, and Stephen A. Ross. 2003. "High-Water Marks and Hedge Fund Management Contracts." *The Journal of Finance* 58 (4): 1685–1718. https://doi.org/10.1111/1540-6261.00581.

Jagannathan, Ravi, Alexey Malakhov, and Dmitry Novikov. 2010. "Do Hot Hands Exist among Hedge Fund Managers? An Empirical Evaluation." *The Journal of Finance* 65 (1): 217–55. https://doi.org/10.1111/j.1540-6261.2009.01528.x.

Jones, Meredith. 2007. "Examination of Fund Age and Size and Its Impact on Hedge Fund Performance." *Derivatives Use, Trading & Regulation* 12 (4): 342–50. https://doi.org/10.1057/palgrave.dutr.1850052.

Jorion, Philippe, and Christopher Schwarz. 2017. "The Fix Is In: Properly Backing Out Backfill Bias." SSRN Scholarly Paper ID 3010469. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=3010469.

Kosowski, Robert, Narayan Y. Naik, and Melvyn Teo. 2007. "Do Hedge Funds Deliver Alpha? A Bayesian and Bootstrap Analysis." *Journal of Financial Economics* 84 (1): 229–64. https://doi.org/10.1016/j.jfineco.2005.12.009.

Lan, Yingcong, Neng Wang, and Jinqiang Yang. 2013. "The Economics of Hedge Funds." *Journal of Financial Economics* 110 (2): 300–323. https://doi.org/10.1016/j.jfineco.2013.05.004.

Liang, Bing. 1999. "On the Performance of Hedge Funds." *Financial Analysts Journal* 55 (4): 72–85.

Liang, Bing, and Hyuna Park. 2007. "Risk Measures for Hedge Funds: A Cross-Sectional Approach." *European Financial Management* 13 (2): 333–70. https://doi.org/10.1111/j.1468-036X.2006.00357.x.

Lim, Jongha, Berk A. Sensoy, and Michael S. Weisbach. 2016. "Indirect Incentives of Hedge Fund Managers." *The Journal of Finance* 71 (2): 871–918. https://doi.org/10.1111/jofi.12384.

Naik, Narayan Y., Tarun Ramadorai, and Maria Stromqvist. 2007. "Capacity Constraints and Hedge Fund Strategy Returns." *European Financial Management* 13 (2): 239–56. https://doi.org/10.1111/j.1468-036X.2006.00353.x.

Pástor, Luboš, and Robert F. Stambaugh. 2012. "On the Size of the Active Management Industry." *Journal of Political Economy* 120 (4): 740–81. https://doi.org/10.1086/667987.

Pástor, Ľuboš, Robert F. Stambaugh, and Lucian A. Taylor. 2015. "Scale and Skill in Active Management." *Journal of Financial Economics* 116 (1): 23–45. https://doi.org/10.1016/j.jfineco.2014.11.008.

Schaub, Nic, and Markus Schmid. 2013. "Hedge Fund Liquidity and Performance: Evidence from the Financial Crisis." *Journal of Banking & Finance* 37 (3): 671–92. https://doi.org/10.1016/j.jbankfin.2012.09.019.

Sirri, Erik R., and Peter Tufano. 1998. "Costly Search and Mutual Fund Flows." *The Journal of Finance* 53 (5): 1589–1622. https://doi.org/10.1111/0022-1082.00066.
Skoulakis, Georgios. 2008. "Panel Data Inference in Finance: Least-Squares vs Fama-Macbeth." SSRN Scholarly Paper ID 1108865. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=1108865.
Stein, Jeremy C. 2002. "Information Production and Capital Allocation: Decentralized versus Hierarchical Firms." *The Journal of Finance* 57 (5): 1891–1921. https://doi.org/10.1111/0022-1082.00483.
Sun, Zheng, Ashley Wang, and Lu Zheng. 2012. "The Road Less Traveled: Strategy Distinctiveness and Hedge Fund Performance." *Review of Financial Studies* 25 (1): 96–143. https://doi.org/10.1093/rfs/hhr092.
Teo, Melvyn. 2009. "Does Size Matter in the Hedge Fund Industry?" SSRN Scholarly Paper ID 1331754. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=1331754.
———. 2013. "Hedge Fund Managers Who Eschew Asset Gathering." *Hedge Fund Insights*, October, 2–8.
Yin, Chengdong. 2016. "The Optimal Size of Hedge Funds: Conflict between Investors and Fund Managers." *The Journal of Finance* 71 (4): 1857–94. https://doi.org/10.1111/jofi.12413.

Appendix

This appendix outlines the algorithm we use to estimate the contribution of future management fees to managers' total compensation. In this study, we use the closed-end solution provided by Goetzmann, Ingersoll, and Ross (2003) to calculate the present value of future total fees per dollar in the fund as follows:

$$f(\omega) = \frac{1}{c+\delta+\lambda-\alpha}\left[c + \frac{(\delta+\lambda-\alpha)k+[\eta(1+k)-1]cb^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}\omega^{\gamma-1} - \frac{b^{\gamma-\eta}(\delta+\lambda-\alpha)k+[\gamma(1+k)-1]cb^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}\omega^{\eta-1}\right], \text{(A1)}$$

where γ and η are the larger and smaller roots of the following equation:

$$\begin{pmatrix}\gamma\\ \eta\end{pmatrix} \equiv \frac{\frac{1}{2}\sigma^2+c-r-\alpha-c'+g\pm\sqrt{(\frac{1}{2}\sigma^2+c-r-\alpha-c'+g)^2+2\sigma^2(r+c'-g+\delta+\lambda)}}{\sigma^2}. \qquad \text{(A2)}$$

The present value of future incentive fees per dollar in the fund is calculated as:

$$i(\omega) = \frac{1}{c+\delta+\lambda-\alpha}\left[\delta+\lambda - \frac{(\delta+\lambda)k+[\eta(1+k)-1](c-\alpha)b^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}\omega^{\gamma-1} + \frac{b^{\gamma-\eta}(\delta+\lambda)k+[\gamma(1+k)-1](c-\alpha)b^{1-\eta}}{\gamma(1+k)-1-b^{\gamma-\eta}[\eta(1+k)-1]}\omega^{\eta-1}\right]. \text{(A3)}$$

Then the present value of future management fee per dollar in the fund is m(ω)=f(ω)-i(ω).

We estimate the parameters from observable fund-level data whenever possible. c and k are the contractual management fee and incentive fee rate, respectively, from the databases. σ is the volatility of fund returns. c' is the accounting choice of costs and fees allocated to reducing HWM and is set to zero. g is the contractual growth rate in the HWM level (i.e., hurdle rate), and we assume it is zero for simplicity. b is the lowest acceptable fraction of the HWM below which the investor loses confidence in the fund and liquidates all of his position and is set to 0.8 following Goetzmann, Ingersoll, and Ross (2003). r is the risk-free interest rate, and we use 3-month LIBOR rate as the risk-free rate. α is the risk-adjusted return, reflecting manager skill. δ + λ is the total withdrawal rate, which is the sum of the regular payout rate to investors (δ) and the exogenous liquidation probability of the fund (λ). Following the literature, we assume that α = 0% and 3%; δ + λ = 5% and 10%.

ω is defined as S/X, where S and X are the market value of investors' assets and their high-water marks, respectively. To estimate S and X, we use the approach in Agarwal, Daniel, and Naik (2009) and Lim, Sensoy, and Weisbach (2016) and make the following assumptions.

1. The first investor enters the fund at the inception (beginning of quarter 1). There is no capital investment by the manager at inception. Therefore, the entire assets at inception come from a single investor.
2. All cash flows including fee payments, investors' capital allocation, and the manager's reinvestment take place once a quarter at the end of each quarter.
3. The high-water mark (X) for each investor is reset at the end of each quarter and applies to the following quarter.
4. All new capital inflows come from a single new investor.

5. When capital outflows occur, we adopt the first-in-first-out (FIFO) rule to decide which investor's money leaves the fund. In particular, the asset value of the first investor is reduced by the magnitude of outflow. If the absolute magnitude of outflow exceeds the first investor's net asset value, then the first investor is considered as liquidating her stake in the fund, and the balance of outflow is deducted from the second investor's assets, and so on.

6. Managers reinvest all of their incentive fees, after paying 35% personal tax, into the fund.

Then we calculate S and X using the following algorithm.

1. First, we solve the following recursive problem iteratively to back out gross returns (gross), using observable information on net-of-fee returns (net), assets under management (AUM):

$$net_t = \frac{\sum_i [S_{i,t-1}(1+gross_t) - ifee_{i,t} - mfee_{i,t}] + MS_{t-1}(1+gross_t)}{AUM_{t-1}} - 1, \tag{A4}$$

where the incentive fee (ifee) and the management fee (mfee) of investor *i* at time *t* are calculated as:

$$ifee_{i,t} = Max\big[\big(S_{i,t-1}(1+gross_t) - X_{i,t-1}\big), 0\big] \times k, \tag{A5}$$

$$mfee_{i,t} = S_{i,t-1} \times c. \tag{A6}$$

The initial values are set as: $S_{1,0} = X_{1,0} = AUM_0;\ MS_0 = 0$.

2. We update the market value of the manager's stake (MS) as follows:

$$MS_t = MS_{t-1}(1+gross_t) + \textstyle\sum_i ifee_{i,t} \times (1-35\%). \tag{A7}$$

3. Then we update S and X of investor *i* as follows:

$$S_{i,t} = S_{i,t-1}(1+gross_t) - ifee_{i,t} - mfee_{i,t}, \tag{A8}$$

$$X_{i,t} = \begin{cases} Max\big[S_{i,t}, X_{i,t-1}\big], if\ with\ HWM \\ S_{i,t}, if\ without\ HWM \end{cases}. \tag{A9}$$

4. The net flow into the fund is defined as the difference between the reported value of quarter-end AUM and the current market value of all existing investors' assets and the manager's assets:

$$Flow_t = AUM_t - \left(\textstyle\sum_i S_{i,t} + MS_t\right). \tag{A10}$$

If $Flow_t$ is positive, then we assume that a new investor enters the fund, and her assets and high-water mark are equal to $Flow_t$. If $Flow_t$ is negative, then we apply the FIFO rule above.

After we estimate S and X, then we can calculate the contribution of future management fees to managers' total compensation as:

$$FMFEE\% = \frac{m(\omega)}{f(\omega)} \times 100. \tag{A11}$$

Table I
Summary Statistics

This table reports the summary statistics of our sample. We collect hedge fund data from Lipper TASS and HFR databases, and our sample period is from January 1994 to December 2016. Panel A reports the summary statistics of our main sample. Funds in the main sample were established after 1994, do not have backfilled data, have at least 5 years of observations, and have a starting size of at least $1 million. The reference sample in Panel B consists of funds excluded from the main sample with at least $5 million in AUM. We exclude pre-add date data, and when add dates are missing, we remove the first 18 months of data. *Returns* is after-fee raw returns reported by hedge funds. *Style-adjusted returns* is the difference between funds' reported returns and the average return of all funds in the same style. Following Agarwal, Daniel, and Naik (2009), we group hedge funds into four general styles. *Fund age* is the number of months since the fund inception date. *Family assets* is total assets of all other funds in the same family. *Family Fund Number* is the number of other funds in the same family. *Capital Flows* is defined in equation 1. *Management Fee* is the percentage of fund assets that investors pay to fund managers. *Incentive Fee* is the percentage of fund profits that investors pay to the fund managers. *High-water Mark* equals 1 if a fund uses a high-water mark provision, and 0 otherwise. *Leverage* equals 1 if a fund uses leverage, and 0 otherwise. *Lockup Period* is the period over which investors of a hedge fund are not allowed to redeem shares.

Panel A. Main Sample

Variable	N	Mean	Median	Std Dev	Q1	Q3
Returns (%)	74753	0.61	0.61	4.30	-0.89	2.17
Style-adjusted Returns (%)	74753	0.10	0.01	3.83	-1.46	1.60
Fund Age (months)	74753	60.48	52	44.24	26	84
Fund Assets ($millions)	74753	170.44	46.03	512.35	13.61	141.05
Family Assets ($millions)	74753	716.74	65	2740.60	0	402.75
Family Fund Number	74753	4.22	2	7.25	1	4
Capital Flows (%)	74018	1.35	0.04	12.66	-1.32	2.03
Management Fee (%)	720	1.52	1.5	0.53	1	2
Incentive Fee (%)	720	19.27	20	4.06	20	20
High-water Mark	720	0.92	1	0.27	1	1
Leverage	720	0.69	1	0.46	0	1
Lockup Period (months)	710	3.89	0	7.49	0	6

Panel B. Reference Sample

Variable	N	Mean	Median	Std Dev	Q1	Q3
Returns (%)	462012	0.49	0.53	4.28	-1.07	2.11
Style-adjusted Returns (%)	462012	-0.02	-0.05	3.81	-1.57	1.51
Fund Age (months)	462012	87.80	73	62.81	40	121
Fund Assets ($millions)	462012	262.60	57.69	1287.85	21.55	175.53
Family Assets ($millions)	458432	621.54	47	1771.16	0	400.69
Family Fund Number	458432	4.42	2	9.63	1	4
Capital Flows (%)	461579	0.62	0.01	11	-1.42	1.58
Management Fee (%)	8417	1.50	1.5	0.58	1	2
Incentive Fee (%)	8372	18.35	20	5.53	20	20
High-water Mark	8485	0.83	1	0.38	1	1
Leverage	8451	0.64	1	0.48	0	1
Lockup Period (months)	8265	3.54	0	6.56	0	6

Table II
Fund Performance in Event Time

This table shows fund performance in event time. The event here is the start of fund performance. We group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. Column 2 reports the number of funds at the beginning of each event year. Columns 3 and 5 report the average monthly raw return and the average monthly style-adjusted return for each event year. We compare fund performance between years *t* ant *t*+1 using a *t*-test, and results are reported in columns 4 and 6. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Event year	Number of Funds	Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return
1	720	1.2972	5.16***	0.6231	5.53***
2	720	0.8537	0.48	0.2023	-0.53
3	720	0.8105	1.50	0.2407	1.64
4	720	0.6738	3.55***	0.1294	2.38**
5	720	0.4148	1.36	-0.0125	2.27**
6	696	0.3145	-0.69	-0.1444	-1.15
7	521	0.3647	-0.84	-0.0689	-0.38
8	405	0.4521	1.96*	-0.0324	1.82*
9	326	0.2087	-2.40**	-0.2175	-3.15***
10	262	0.5054	0.93	0.1148	1.29

Table III
Fund Performance in Event Time: by Fund Characteristics

This table shows performance in event time of funds with different characteristics. Panels A through D present results when we divide our sample based on lockup periods, high-water mark provisions, incentive fees, and leverage. The event here is the start of fund performance. Within each subsample, we group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. We compare performance of funds with different characteristics using a *t*-test in the last two columns. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Lockup Periods

	with Lockup		without Lockup			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.44	3.42***	1.24	4.86***	0.20	1.64
2	0.97	1.15	0.81	-0.04	0.16	1.49
3	0.80	0.71	0.81	1.43	-0.01	-0.11
4	0.69	0.96	0.66	3.56***	0.03	0.25
5	0.58		0.35		0.23	2.35**

	with Lockup		without Lockup			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.72	3.68***	0.59	5.08***	0.13	1.14
2	0.22	0.10	0.20	-0.73	0.02	0.18
3	0.20	0.90	0.25	1.33	-0.05	-0.50
4	0.11	0.37	0.14	2.29**	-0.03	-0.28
5	0.06		-0.04		0.10	1.08

Panel B. High-Water Mark						
	with HWM		without HWM			
Event year	Raw Returns	*t*-stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.27	4.17***	1.62	3.04***	-0.35	-1.47
2	0.87	0.72	0.61	-0.59	0.27	1.06
3	0.81	1.51	0.80	0.80	0.02	0.07
4	0.68	3.78***	0.54	0.80	0.14	0.58
5	0.42		0.34		0.09	0.73

	with HWM		without HWM			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.61	4.73***	0.72	2.62**	-0.10	-0.60
2	0.22	-0.57	0.03	-0.10	0.18	0.86
3	0.26	1.52	0.06	1.10	0.20	1.56
4	0.16	2.83***	-0.19	-1.04	0.35	1.77*
5	-0.02		0.07		-0.09	-0.53

Panel C. Incentive fee								
	<20%		=20%		>20%			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff: H-L	*t*
1	1.36	3.17***	1.32	4.64***	0.69	-2.66**	-0.67	-2.30**
2	0.46	-0.42	0.85	0.22	1.84	1.55	1.38	3.24***
3	0.56	1.25	0.83	1.40	1.02	0.29	0.46	1.16
4	0.32	-0.34	0.71	3.94***	0.86	1.59	0.53	1.20
5	0.41		0.44		0.04		-0.36	-1.03

	<20%		=20%		>20%			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff: H-L	*t*
1	0.56	3.20***	0.65	5.29***	0.24	-1.76*	-0.33	-1.28
2	-0.14	-1.06	0.20	-0.63	0.96	1.26	1.09	2.82***
3	0.07	2.32**	0.25	1.30	0.38	-0.38	0.31	0.98
4	-0.34	-1.48	0.16	2.50**	0.57	2.02*	0.90	2.20**
5	-0.05		0.01		-0.43		-0.38	-1.13

Panel D. Use of Leverage						
	With Leverage		Without Leverage			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.33	4.28***	1.22	4.31***	0.11	0.88
2	0.94	1.15	0.67	-1.96*	0.27	2.64**
3	0.78	0.62	0.88	2.36**	-0.10	-0.73
4	0.69	2.40**	0.63	2.78**	0.06	0.61
5	0.49		0.24		0.25	1.92*

	With Leverage		Without Leverage			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.63	4.67***	0.61	4.69***	0.02	0.21
2	0.28	0.48	0.02	-2.30**	0.26	2.83***
3	0.23	0.77	0.26	1.80*	-0.03	-0.27
4	0.15	1.81*	0.08	1.70	0.07	0.86
5	0.04		-0.13		0.17	1.59

Table IV
Fund Performance in Event Time: by Family Characteristics

This table shows performance in event time of funds with different family characteristics. In Panel A, we divide our sample into two groups based on whether a fund is the flagship fund of a fund family. We define the flagship fund as the first fund established by the family. In Panel B, we focus on non-flagship funds and divide the sample based on whether those fund have the same style as the flagship fund in the same family. The event here is the start of fund performance. Within each subsample, we group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. We compare performance of funds with different family characteristics using a *t*-test in the last two columns. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Flagship fund

	Flagship		Non-flagship			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.47	3.88***	1.12	2.35**	0.35	2.71**
2	0.95	-0.16	0.80	0.99	0.14	1.02
3	0.97	1.15	0.67	0.76	0.31	1.81*
4	0.78	2.35**	0.57	2.34**	0.21	1.77*
5	0.51		0.35		0.17	1.78*

	Flagship		Non-flagship			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.78	5.47***	0.50	2.28**	0.28	2.45**
2	0.23	-1.10	0.21	0.64	0.02	0.18
3	0.36	1.35	0.14	0.54	0.22	1.87*
4	0.21	1.75*	0.09	1.71	0.12	1.27
5	0.07		-0.08		0.15	1.82*

Panel B. Style of the non-flagship fund						
	Same Style		Different Style			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.05	0.95	1.33	4.36**	-0.28	-1.46
2	0.91	1.40	0.48	-0.92	0.42	2.62**
3	0.67	0.30	0.67	1.05	0.00	-0.02
4	0.62	2.18**	0.43	0.68	0.19	1.04
5	0.37		0.28		0.08	0.49

	Same Style		Different Style			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.44	1.10	0.66	3.63***	-0.22	-1.37
2	0.29	0.99	-0.02	-0.73	0.31	1.80*
3	0.15	-0.06	0.13	1.18	0.02	0.11
4	0.16	2.09**	-0.13	-0.01	0.28	1.60
5	-0.07		-0.12		0.05	0.35

Table V
Diseconomies of Scale: Portfolio Approach

This table shows the results of our portfolio approach. The event here is the start of fund performance. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. At the beginning of each event year, we divide funds into three groups based on their assets under management, and we use $10 and $100 million as cutoff points. We form an equal-weighted portfolio for each group in every event month. The table shows average performance for each event year. We compare performance between year *t* ant *t*+1 and between the small and large groups using *t*-tests. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

	Small		Medium		Large			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.44	1.58	1.10	2.15**	1.45	4.79***	-0.02	-0.10
2	1.19	0.32	0.85	0.12	0.41	-1.12	0.78	3.98***
3	1.12	-0.40	0.83	1.48	0.60	1.69	0.52	2.60**
4	1.23	2.47**	0.66	2.46**	0.44	0.42	0.80	3.42***
5	0.45		0.42		0.40		0.05	0.23

	Small		Medium		Large			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.66	1.43	0.54	4.29***	0.88	4.39***	-0.22	-1.11
2	0.46	0.20	0.17	-0.77	-0.06	-1.46	0.52	3.07***
3	0.41	-0.14	0.24	1.61	0.14	1.39	0.28	1.50
4	0.45	1.42	0.11	1.69	0.01	0.66	0.44	1.99*
5	0.03		-0.01		-0.04		0.08	0.36

Table VI
Diseconomies of Scale: Modified Fama-MacBeth Regressions

This table reports the results of our modified Fama-MacBeth regressions. We first conduct time-series regressions for each fund and regress fund performance on fund age and fund size. We control for the number of funds in the same family, total assets of other funds in the same family, and fund capital flows. The table shows the cross-sectional average of the coefficients. Panels A and B use raw returns and style-adjusted returns as the dependent variable, respectively. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Raw returns

	(1)		(2)		(3)		(4)	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
Log Lagged Fund Age	-0.40***	-19.04			-0.07*	-1.76	0.02	0.27
Log Lagged Fund Size			-1.18***	-13.97	-1.12***	-14.81	-1.34***	-12.95
Log Lagged Family Fund Number							-0.25	-0.13
Log Lagged Family Size							-0.61***	-4.96
Lagged Capital Flows							0.12	0.57
Intercept	2.01***	26.10	21.58***	15.06	20.24***	16.67	35.65***	17.53
Number of Obs	720		720		720		720	
Adj R-Squared	0.0291		0.0311		0.0518		0.0697	

Panel B. Style-adjusted returns

	(1)		(2)		(3)		(4)	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
Log Lagged Fund Age	-0.29***	-15.10			-0.07*	-1.93	0.00	-0.02
Log Lagged Fund Size			-0.61***	-12.31	-0.81***	-12.90	-1.06***	-11.46
Log Lagged Family Fund Number							-0.56	-0.61
Log Lagged Family Size							-0.07	-0.76
Lagged Capital Flows							-0.08	-0.38
Intercept	1.11***	15.73	10.53***	12.86	14.21***	14.19	19.81***	11.90
Number of Obs	720		720		720		720	
Adj R-Squared	0.0191		0.0217		0.0370		0.0518	

Table VII
Size-Age Portfolio Horse Race

This table reports the average performance of funds with different size-age combinations. At the beginning of each calendar year, we sort all available funds (i.e., available funds from our main sample and our reference sample) into 9 (3-by-3) groups based on their age and size at the sorting date. Funds with age no older than 2 years are defined as young funds, funds with age between 2 and 5 years are defined as mid-age funds, and funds with age at or above 5 years are defined as old funds. In terms of size, we use $10 million and $100 million as cutoff points. We then form equal-weighted portfolios for each group and hold the portfolios for a year. The table presents the average performance over our sample period. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Raw Returns (%)

	Small		Medium		Large			
	Return	*t*	Return	*t*	Return	*t*	Small - Large	*t*
Young	0.8783***	6.56	0.5797***	5.49	0.4275***	3.77	0.4508**	2.57
Mid	0.7895***	5.91	0.5807***	5.45	0.4879***	4.86	0.3016*	1.82
Old	0.7514***	5.34	0.5937***	5.18	0.5695***	4.64	0.1819	0.97
Young-Old	0.1269	0.65	-0.0140	-0.09	-0.1420	-0.85		

Panel B. Style-adjusted Returns (%)

	Small		Medium		Large			
	Style-adjusted	*t*	Style-adjusted	*t*	Style-adjusted	*t*	Small - Large	*t*
Young	0.2494***	4.88	-0.0434	-1.11	-0.1618**	-2.28	0.4112***	4.70
Mid	0.1975***	3.64	-0.0837***	-3.51	-0.1291***	-3.28	0.3266***	4.91
Old	0.1140*	1.79	-0.0744***	-2.79	-0.0358	-0.80	0.1498*	1.92
Young-Old	0.1355*	1.66	0.0310	0.66	-0.1260	-1.50		

Table VIII
Managers' Incentives

Panel A reports average fund size at the beginning of each event year and managers' incentives at the end of each event year. We calculate the present value of managers' future management fees and the present value of managers' total compensation following Goetzmann, Ingersoll, and Ross (2003), Agarwal, Daniel, and Naik (2009), and Lim, Sensoy, and Weisbach (2016). To make our calculations, we need to impose assumptions about managers' abilities (represented by α) and the withdrawal rate (represented by $\delta+\lambda$). Following the literature, we assume that α is either 0 or 3% and $\delta+\lambda$ is either 5% or 10%. We then calculate *FMFEE%* as future management fees divided by future total fees (i.e., *FMFEE%* measures the contribution of the management fee to total compensation). In Panels B through E, we divide funds into three groups based their assets at the beginning of each event year (using $10 million and $100 million as size cutoff points) and we examine how managers' incentives change over event time. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. *FMFEE%*

Event Year	Fund Size ($million)	α=0, $\delta+\lambda$=5%	α=0, $\delta+\lambda$=10%	α=3%, $\delta+\lambda$=5%	α=3%, $\delta+\lambda$=10%
1	23.05	61.02	60.48	53.20	52.85
2	70.83	61.27	60.79	53.46	53.16
3	115.36	62.94	62.53	54.81	54.56
4	150.34	65.17	64.80	56.91	56.71
5	161.45	66.95	66.58	58.58	58.40

Panel B. *FMFEE%* (α=0, $\delta+\lambda$=5%)

Event Year	Small	Medium	Large	Diff: S-L	*t*
1	54.1758	62.3449	66.9496	-12.7738***	-4.66
2	52.8222	60.4833	67.4605	-14.6383***	-5.50
3	52.9114	61.5804	69.8633	-16.9519***	-6.16
4	53.1781	63.6993	72.0846	-18.9065***	-7.13
5	54.2183	67.3770	73.0655	-18.8472***	-7.19

Panel C. *FMFEE%* (α=0, $\delta+\lambda$=10%)

Event Year	Small	Medium	Large	Diff: S-L	*t*
1	53.7269	61.7773	66.3605	-12.6336***	-4.66
2	52.4689	59.9954	66.9227	-14.4538***	-5.48
3	52.5949	61.2128	69.3320	-16.7371***	-6.13
4	52.9439	63.3728	71.5906	-18.6467***	-7.07
5	54.0251	67.0544	72.5566	-18.5315***	-7.10

Panel D. *FMFEE%* (α=3%, δ+λ=5%)					
Event Year	Small	Medium	Large	Diff: S-L	*t*
1	47.6221	54.1043	58.6179	-10.9958***	-4.76
2	46.6423	52.5450	58.9600	-12.3177***	-5.43
3	46.6347	53.4742	60.8005	-14.1658***	-5.99
4	46.7697	55.6405	62.7962	-16.0264***	-6.91
5	48.1583	58.8003	63.7512	-15.5930***	-6.84

Panel E. *FMFEE%* (α=3%, δ+λ=10%)					
Event Year	Small	Medium	Large	Diff: S-L	*t*
1	47.3168	53.7314	58.2274	-10.9106***	-4.76
2	46.4527	52.2345	58.6009	-12.1482***	-5.38
3	46.4494	53.2700	60.4585	-14.0091***	-5.96
4	46.6819	55.4732	62.4942	-15.8124***	-6.84
5	48.1394	58.6751	63.4148	-15.2754***	-6.72

Table IX
Downside Risk

This table shows the downside risk of hedge funds in event time. In Panel A, we use Value-at-risk (*VaR*) as the downside risk measure. *VaR_NP* is the nonparametric *VaR* and it uses the left tail of observed returns (5^{th} percentile in our study) as *VaR*. *VaR_CF* is based on the Cornish-Fisher expansion and is defined in equations (4) and (5). We form an equal-weighted portfolio in each event month, and Panel A presents the *VaR* of portfolio performance in each event year. In Panel B, we use expected shortfall (*ES*) and Tail Risk (*TR*) as the downside risk measures, which are the mean and the standard deviation of returns that are at or below *VaR*, respectively. We use both *VaR_NP* and *VaR_CF* above to calculate *ES* and *TR*. We first calculate the *ES* and *TR* measures using cross-sectional returns every event month, and Panel B shows the average of *ES* and *TR* for every event year.

Panel A. Value-at-risk (*VaR*)

Raw Returns

Event year	VaR_NP	VaR_CF
1	0.9661	0.8989
2	0.5515	0.5596
3	0.3550	0.3402
4	0.3571	0.4184
5	0.1800	0.1563

Style-Adj Returns

Event year	VaR_NP	VaR_CF
1	0.2634	0.2797
2	-0.0453	-0.0909
3	-0.1056	-0.0736
4	-0.1017	-0.0709
5	-0.2092	-0.2489

Panel B. Expected Shortfall (*ES*) and Tail Risk (*TR*)

Raw Returns

Event year	ES_NP	ES_CF	TR_NP	TR_CF
1	-8.6597	-8.6383	10.6078	10.5841
2	-11.2271	-11.6126	12.7606	13.0945
3	-10.6940	-11.0939	12.1828	12.5277
4	-9.9774	-10.0695	11.3164	11.3901
5	-10.5549	-10.8836	11.5746	11.8524

Style-Adj Returns

Event year	ES_NP	ES_CF	TR_NP	TR_CF
1	-7.7711	-7.6941	8.9304	8.8498
2	-9.7089	-10.0713	10.5054	10.8159
3	-9.4657	-10.0423	10.4188	10.9279
4	-8.9007	-8.8191	9.6523	9.5666
5	-9.2646	-9.5793	9.8684	10.1484

Table X
Robustness Tests: Sub-periods

This table reports the results when we conduct our analysis in three different sub-periods. Sub-period 1 is from January 1994 to September 1998, sub-period 2 is from April 2000 to December 2007, and sub-period 3 is from July 2009 to December 2016. Panel A shows fund performance in event time as in Table II. Panels B through D present performance differences between funds with different characteristics. In Panel E, we conduct the modified Fama-MacBeth regressions for each sub-period. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Performance over Event Time: by Sub-periods

	Sub-period 1		Sub-period 2		Sub-period 3			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Sub-period 1-3	*t*
1	1.7980	1.82*	1.1262	3.90***	0.9103	3.36***	0.8877	5.00***
2	1.3450	-0.08	0.6834	-0.96	0.4612	-3.35***	0.8839	4.02***
3	1.3704	1.41	0.7908	0.62	0.8404	3.57***	0.5300	2.14**
4	0.9905	2.96***	0.7210	3.38***	0.4135	1.51	0.5770	3.58***
5	0.4036		0.3465		0.2464		0.1572	0.98

	Sub-period 1		Sub-period 2		Sub-period 3			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Sub-period 1-3	*t*
1	0.6918	2.40**	0.5011	3.73***	0.4771	3.15***	0.2147	1.56
2	0.2502	-0.39	0.1361	-1.35	0.1176	-1.83*	0.1326	0.80
3	0.3384	0.64	0.2596	1.00	0.2847	2.92***	0.0537	0.31
4	0.2044	0.49	0.1699	2.49**	-0.0119	-0.39	0.2163	1.44
5	0.1238		-0.0690		0.0280		0.0958	0.77

Panel B. Performance Difference by Characteristics: Sub-period 1

Raw Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.4242	1.43	0.2128	1.03	0.0950	0.16	0.1924	0.78	0.8389	2.72***	1.5571	1.96**
2	0.0388	0.08	0.0906	0.26	2.1069	3.47***	0.3585	0.92	-0.2042	-0.49	-0.2224	-0.27
3	0.1325	0.32	-0.2429	-0.64	-0.3301	-0.50	0.6582	1.44	0.1391	0.32	-0.7119	-0.83
4	-0.0668	-0.23	0.0718	0.20	-0.3945	-0.52	-0.7450	-2.26**	0.6652	1.45	0.0070	0.01
5	0.0915	0.35	-0.1147	-0.45	-0.0179	-0.02	-0.2184	-0.68	0.0315	0.10	-1.6392	-1.93*

Style-adj Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.1012	0.46	0.3711	1.99**	0.5535	0.97	0.4846	1.99**	0.6065	2.20**	1.3960	2.41**
2	-0.0549	-0.14	-0.2350	-0.80	1.8104	3.21***	0.2978	1.10	-0.0326	-0.09	-0.3522	-0.47
3	-0.1375	-0.48	-0.1859	-0.65	-0.0462	-0.08	0.4526	1.28	-0.1849	-0.48	-0.6641	-0.75
4	0.0374	0.14	0.6674	2.26**	1.0248	1.59	-0.2219	-0.76	0.4564	1.03	0.4593	0.56
5	0.2582	1.39	-0.1665	-0.54	-0.3006	-0.37	-0.1349	-0.61	0.2068	0.71	-1.5680	-2.11**

Panel C. Performance Difference by Characteristics: Sub-period 2												
Raw Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.1367	0.97	0.0997	0.31	-0.5981	-0.89	-0.0869	-0.49	0.2818	1.75*	-0.1854	-0.83
2	0.2196	2.17**	0.3010	0.73	1.7796	2.24**	0.4903	3.48***	0.1110	0.58	0.5417	2.07**
3	-0.1667	-1.03	-0.2975	-0.94	0.7410	1.03	-0.3102	-1.56	0.3105	1.33	-0.3331	-1.29
4	-0.1139	-0.94	-0.2859	-0.96	0.3838	0.43	0.2384	1.59	0.1805	1.16	0.0153	0.07
5	0.2726	1.90*	0.5261	1.36	-1.0640	-1.85*	0.5120	2.55**	0.1914	1.32	0.3957	1.76*

Style-adj Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.1755	1.27	-0.0461	-0.15	-0.4379	-0.75	-0.2290	-1.51	0.2994	2.04**	-0.1548	-0.83
2	0.0212	0.21	0.1094	0.31	1.3021	1.99**	0.4433	3.86***	-0.0283	-0.21	0.3152	2.07**
3	-0.1253	-1.09	-0.0043	-0.02	0.5455	0.85	-0.1126	-0.63	0.2630	1.75*	-0.1862	-1.29
4	-0.2032	-1.80	-0.2716	-1.30	0.5986	0.73	0.1527	1.34	0.1322	1.10	0.2258	0.07
5	0.0441	0.32	0.0215	0.07	-1.2678	-2.26**	0.3411	2.12**	0.1718	1.39	0.1581	1.76*

Panel D. Performance Difference by Characteristics: Sub-period 3

Raw Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.0238	0.10	0.8293	1.69*	-0.9038	-1.44	0.0199	0.06	0.4696	1.77*	-0.0570	-0.12
2	-0.0641	-0.33	0.3994	1.14	0.0984	0.25	-0.0728	-0.35	0.2164	1.27	0.6256	2.00**
3	0.0113	0.05	0.3575	1.06	0.0482	0.12	0.0248	0.14	-0.1179	-0.75	-0.1813	-0.43
4	0.2576	1.72*	0.6356	1.99**	0.8371	2.12**	0.5766	3.77***	-0.1838	-0.96	0.2952	0.82
5	0.2743	1.56	0.5128	1.24	0.3964	1.06	0.3085	1.30	0.1543	0.89	0.6281	2.07**

Style-adj Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.0288	0.13	0.7732	2.20**	-0.7004	-0.96	0.0518	0.19	0.3627	1.67*	-0.0595	-0.15
2	-0.0300	-0.15	0.4708	1.53	0.0015	0.00	-0.0616	-0.29	0.1153	0.82	0.3517	1.17
3	-0.1233	-0.53	0.2435	0.92	0.0756	0.19	0.0165	0.10	0.0396	0.26	-0.2142	-0.55
4	0.1943	1.60	0.4876	1.60	0.9705	2.57**	0.6335	4.29***	-0.2632	-1.45	0.3759	1.05
5	0.3580	2.02**	0.4430	1.22	0.3194	0.98	0.3127	1.57	-0.0209	-0.12	0.7001	2.65***

Panel E. Fama-MacBeth Regressions												
	Sub-period 1				Sub-period 2				Sub-period 3			
	Raw Return		Style-adj		Raw Return		Style-adj		Raw Return		Style-adj	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.19	1.18	0.22	1.62	-0.02	-0.26	-0.03	-0.41	0.23	1.19	0.13	0.75
Log Lagged Fund Size	-1.36***	-5.46	-1.05***	-4.85	-1.28***	-9.02	-1.00***	-7.86	-1.78***	-5.52	-1.47***	-5.22
Log Lagged Family Fund Number	1.78	0.75	1.46	0.46	-0.19	-0.16	-1.56	-1.32	-8.26	-0.68	-1.49	-0.58
Log Lagged Family Size	-0.41**	-2.02	-0.05	-0.29	-0.80***	-5.19	-0.13	-0.97	0.21	0.39	0.42	1.47
Lagged Capital Flows	-0.16	-0.39	-0.21	-0.35	-0.10	-0.33	-0.34	-1.13	0.66	1.23	0.65	1.41
Intercept	29.53***	7.03	16.99***	4.89	38.91***	13.02	20.96***	8.95	31.99***	5.91	17.58***	3.59
Number of Obs	112		112		390		390		104		104	
Adj R-Squared	0.0647		0.0411		0.0685		0.0487		0.0534		0.0456	

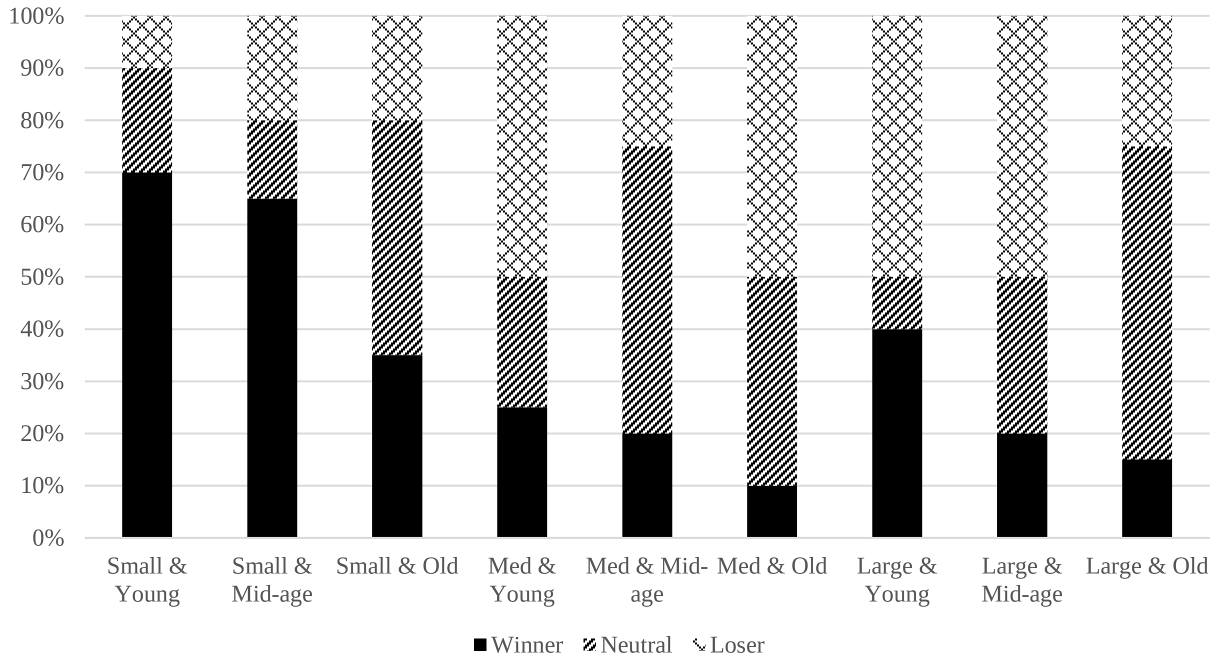

Figure 1 Size-age portfolio performance. At the beginning of each calendar year, we sort all available funds (i.e., available funds from our main sample and our reference sample) into 9 (3-by-3) groups based on their age and size at the sorting date. Funds with age no older than 2 years are defined as young funds, funds with age between 2 and 5 years are defined as mid-age funds, and funds with age at or above 5 years are defined as old funds. In terms of size, we use $10 million and $100 million as cutoff points. We form equal-weighted portfolios for each group and hold the portfolios for a year. For each calendar year, we rank the nine portfolios based on their performance and we refer to the top three portfolios as winners, the bottom three portfolios as losers, and the middle three portfolios as neutral. This figure shows how often (% of years) each portfolio belongs to the winner, loser, and neutral group over our sample period.

Internet Appendix for

"Size, Age, and the Performance Life Cycle of Hedge Funds"

Chao Gao, Tim Haight, and Chengdong Yin

This document provides supplementary results for the paper "Size, Age, and the Performance Life Cycle of Hedge Funds." The first section presents additional summary statistics for our sample. The second section reports the results of our robustness tests in Section IV.

A. Summary Statistics

This section presents additional summary statistics for our sample to support the criteria we use to form our main sample. Table IA.I provides statistics on the life spans of defunct funds in our sample. The mean is around 6 years (71.83 months) and the median is about 5 years (58 months). As a result, we require hedge funds in our main sample to have at least 5 years of data. This allows us to have a better picture of hedge funds' life cycle. Table IA.II reports minimum investment requirements for newly established funds in each calendar year. The most common requirement over our sample period is \$1 million. The median of minimum investment requirements is also quite stable over time and is about \$500,000. Table IA.III shows funds' starting sizes, as first reported to databases, by calendar year. Over time, both the mean and the median size are growing. However, the 25th percentile is quite stable and is between \$1 million and \$3 million. Thus, we require funds in our main sample to have a starting size of at least \$1 million. This is not only consistent with the most common minimum investment requirement, but it also excludes extremely small funds.

Table IA.IV reports fund performance, fund size, and return volatility in event time. In columns 3 and 5, we group fund-month observations by event time and form an equal-weighted portfolio for each event month. Then we report portfolio raw returns and style-adjusted returns, and we compare portfolio performance between years *t* and *t*+1 using a *t*-test. Columns 7 and 8 present the mean and median of fund assets at the beginning of each event year. Over time, funds are growing larger on average. Columns 9 and 10 examine return volatility. In column 9, we calculate the annualized return volatility of portfolios we form in columns 3 and 5. In column 10, we report the cross-sectional average of raw return volatility in each calendar year. The results indicate that younger hedge funds do not have higher risk even when we use traditional risk measures.

Table IA.V provides fund asset distribution statistics by calendar year and the results indicate that fund sizes are increasing over time. Based on the 25^{th} and 75^{th} percentiles, we choose \$10 million and \$100 million as the cutoff points to form our small and large fund groups.

B. Robustness Tests

B.1. Different Main Samples

In Tables IA.VI and IA.VII, we use different criteria to define our main sample. Specifically, we increase our minimum starting size requirement to \$5 million in Table IA.VI, and we reduce the minimum number of observations from 5 to 3 years in Table IA.VII. Panel A of both tables exhibit fund performance in event time. As in Table II, we again find that fund performance declines over time using both performance measures.

Panel B of Tables IA.VI and IA.VII examine performance differences between funds with different characteristics. Consistent with Table III, we do not find a clear pattern and the performance differences are not statistically significant in most cases. In Panel C of both tables, we conduct our modified Fama-MacBeth regressions. Similar to Table VI, we find negative and significant coefficients on fund size and insignificant coefficients on fund age. In other words, our results are robust and the decline in fund performance over the life cycle is mostly driven by fund growth.

B.2. Additional Control Variables

Because some previous studies show that there are diseconomies of scale at the industry level, we control for style size in Panel A of Table IA.VIII. To be more specific, we include style size and style fund number in our modified Fama-MacBeth regressions. Style size is the total assets of funds in the same investment style but not in the same family as fund *i*. Style fund number is similarly defined. When we use raw returns as the dependent variable, the coefficient on style size is negative and significant. This result is consistent with the literature and suggests that growth of style size erodes fund performance. When we use style-adjusted returns, the coefficient on style size is significantly positive. The result implies that increased style size leads to lower average style performance and thus better style-adjusted returns. Both regressions provide some evidence supporting diseconomies of scale at the industry level. More importantly, after controlling for style size, we still find negative and significant coefficients on fund size.

Panels B and C of Table IA.VIII reports the results of Fama-MacBeth regressions that include *FMFEE%* as an additional explanatory variable. In Panel B, we use raw returns as the performance measure, and the coefficients on *FMFEE%* are all negative and significant. The results indicate that when the management fee becomes more important, fund performance deteriorates. This is consistent with Table VIII and our prediction that managers have less incentive to improve performance when they collect most of their compensation from the asset-based management fee. After controlling for *FMFEE%*, we still find that the coefficients on fund size are significantly negative. Thus, while we saw in Table VIII that managers' incentives are decreasing with fund size, fund size can affect fund performance outside of the incentive effect, such as diseconomies of scale due to limited abilities. Interestingly, we find that the coefficients on fund age are positive and significant. Thus, after controlling for fund size and managers' incentives, older funds have better performance. Our interpretation is that, holding constant fund size and managers' incentives, older funds appear to have skills, on average. As a result, older funds are more likely to generate better performance.

The results in Panel C, based on style-adjusted returns, are similar. All coefficients on *FMFEE%* are negative, but become insignificant when we use style-adjusted returns as the performance measure. The negative and significant coefficients on fund size suggest that funds still suffer from diseconomies of scale after controlling for managers' incentives. Again, the impact of fund age on fund performance becomes positive when we include both fund size and managers' incentives in the regression.

B.3. Expanded Main Sample

We collect our data from both the TASS and the HFR databases. One potential issue presented by the TASS database is that add-date information stopped being updated around 2011. Thus, TASS funds established after 2011 are excluded from our main sample even if they meet our other criteria. To address this issue, we follow the procedure in Jorion and Schwarz (2017) and estimate add dates for these funds. As a result, we expand our main sample to 721 funds when we require 5 years of performance data and to 1,318 funds when we require 3 years of performance data. With these expanded samples, we repeat our analyses and report the results in Tables IA.IX through IA.XI.

The results in Table IA.IX are similar to those reported in Table II. We find that fund performance declines as they age and that funds provide superior performance at the early stage of their life cycle. The results in Table IA.X are consistent with Table V in that they indicate that small funds outperform large funds and are more likely to maintain good performance over time. In Table IA.XI, we conduct the modified Fama-MacBeth regressions from Table VI using the expanded sample. As in Table VI, the coefficients on fund size are negative and significant while the coefficients on fund age are statistically insignificant. Thus, declining performance with age is mainly driven by the increase in fund size and diseconomies of scale.

B.4. Managers' Incentives: Different Management Fee Percentages

We divide our sample into three groups: funds with management fee percentages no more than 1%, funds with management fee percentage no less than 2%, and funds in between. Then we repeat our analysis as in Table VIII Panel A for each group and the results are summarized in Internet Appendix Table IA.XII. Using different parameter choices, we find that *FMFEE%* for all three groups increases over time with fund size. The results are similar to those reported in Table VIII and are not driven by funds with high management fee percentages.

B.5. Analyses by Style

In this section, we examine whether our results are driven by funds using certain strategies. We divide hedge funds in our sample into four general styles following the algorithm in Agarwal, Daniel, and Naik (2009), and then we repeat our analyses separately for each style.

Table IA.XIII reports fund performance over time for each style. Across all styles, we find that funds generate superior performance early in their life cycles with steady performance declines thereafter. The results are consistent with our findings in Table II. In Table IA.XIV, we repeat our modified Fama-MacBeth regressions for each style. The results are similar to those reported in Table VI in that we find significantly negative coefficients on fund size, while the coefficients on fund age are insignificant. Thus, the decrease in fund performance over time is mostly the result of growth in fund assets, and our findings are not driven by funds in certain styles.

B.6. Strategy Distinctiveness

Table II shows that there is a significant decrease in fund performance from event year 1 to event year 2, while Table V indicates that fund size cannot fully explain this drop in performance. One possible explanation is that newly established funds have new ideas for trades that generate superior performance early in a fund's life, but over time, such strategies become less profitable as other funds begin imitating them and as newer strategies are introduced by newer funds. To examine whether innovation can explain the superior performance of newly established funds, we follow Sun, Wang, and Zheng (2012) and calculate the Strategy Distinctiveness Index (*SDI*) for each fund. To be more specific, we first divide funds (both in the main sample and the reference sample) into four clusters based on their past 12 months of returns. We then calculate the *SDI* of a fund as 1 minus the sample correlation between the fund's returns with the average returns of all funds in the same cluster. Table IA.XV shows the *SDI* for our main sample at the end of each event year. The results indicate that, on average, *SDI* decreases over time and that there is a significant decrease from event year 1 to event year 2. This decline provides a possible explanation for the significant drop in performance from events years 1 to 2 in Table II.

Table IA.I
Life Span of Defunct Funds

This table shows summary statistics of the life span of defunct funds in our sample. Life span is measured as the number of months between fund inception and liquidation.

Mean	Median	Std Dev	Q1	Q3
71.83	58	52.61	33	96

Table IA.II
Minimum Investment Requirement

This table reports the summary statistics of minimum investment requirements (in $thousands) of funds established in each calendar year.

Calendar Year	N	Mean	Median	Std Dev	Mode	Q1	Q3
1994	298	1045	500	3245.75	1000	250	1000
1995	274	881	500	2030.09	1000	100	1000
1996	373	939	500	3457.24	1000	250	1000
1997	381	1117	500	3402.40	1000	250	1000
1998	420	824	500	1135.56	1000	250	1000
1999	448	836	500	1018.59	1000	250	1000
2000	511	847	500	1167.70	1000	250	1000
2001	528	850	500	1329.72	1000	250	1000
2002	615	1232	500	4766.45	1000	250	1000
2003	675	939	500	1641.62	1000	250	1000
2004	771	996	500	1818.90	1000	250	1000
2005	868	1223	500	4194.86	1000	250	1000
2006	729	1206	500	4475.06	1000	100	1000
2007	673	1444	500	4883.97	1000	150	1000
2008	598	1292	500	2590.68	1000	150	1000
2009	508	1243	500	3124.96	1000	100	1000
2010	430	1220	500	4136.47	1000	100	1000
2011	441	1223	500	3803.22	1000	100	1000
2012	350	1041	500	3432.72	1000	100	1000
2013	345	1323	500	3173.73	1000	100	1000
2014	222	1475	500	4165.92	1000	100	1000
2015	136	2673	500	17311.50	1000	100	1000
2016	21	950	1000	1123.62	1000	250	1000

Table IA.III
Starting Size over Time

This table reports summary statistics of starting size (in $millions) of funds established in each calendar year. Starting size is the first reported assets under management of each fund.

Calendar Year	N	Mean	Median	Std Dev	Q1	Q3
1994	304	17.21	6.04	39.42	2.00	16.20
1995	283	9.96	3.25	19.87	1.00	10.03
1996	387	12.32	3.14	34.15	1.10	9.76
1997	395	14.57	4.52	40.04	1.45	12.16
1998	425	18.81	3.80	91.12	1.26	11.79
1999	452	12.62	3.65	25.93	1.26	10.55
2000	513	14.47	3.30	49.07	1.10	10.19
2001	532	15.74	4.83	45.82	1.17	14.88
2002	615	17.05	4.95	79.34	1.50	14.00
2003	675	18.95	5.20	46.81	1.50	17.78
2004	771	24.33	7.00	56.35	1.99	22.48
2005	868	23.88	8.00	58.46	2.12	22.25
2006	730	37.60	10.00	138.74	2.52	26.20
2007	673	32.94	10.27	73.48	2.50	31.67
2008	598	34.32	9.00	88.52	2.04	28.94
2009	509	33.63	7.59	102.93	1.90	25.00
2010	431	21.62	7.50	42.51	1.95	24.78
2011	441	37.61	8.60	167.02	2.10	25.37
2012	350	36.10	6.00	239.28	1.40	18.50
2013	345	36.09	7.00	143.82	1.93	23.94
2014	222	33.05	7.24	125.04	1.79	22.70
2015	136	29.83	7.70	73.19	1.23	20.00
2016	21	11.24	3.42	17.42	2.60	6.30

Table IA.IV
Fund Performance, Fund Size, and Return Volatility in Event Time

This table reports fund performance, fund size, and return volatility of our main sample in event time. We group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. Column 2 reports the number of funds at the beginning of each event year. Columns 3 and 5 report the average return and average style-adjusted return for each event year. We compare fund performance between years *t* and *t*+1 using a *t*-test, and results are reported in columns 4 and 6. Columns 7 and 8 report the mean and median of fund assets at the beginning of each event year. Column 9 shows the annualized standard deviation of portfolio returns. In column 10, we first calculate the annualized volatility for each fund in each event year. Then we report the cross-sectional average of fund volatility.

Event Year	Number of funds	Returns (%)	*t*-Statistic of Equal Return	Style-adj Returns (%)	*t*-Statistic of Equal Return	Size ($million)		Annualized Vol (%)	Average of Fund Vol (%)
						Mean	Median		
1	720	1.30	5.16***	0.62	5.53***	23.05	8.70	0.83	11.24
2	720	0.85	0.48	0.20	-0.53	70.83	27.12	0.61	11.89
3	720	0.81	1.50	0.24	1.64	115.36	44.51	0.90	11.68
4	720	0.67	3.55***	0.13	2.38**	150.34	52.00	0.63	11.15
5	720	0.41	1.36	-0.01	2.27**	161.45	56.00	0.61	11.10
6	696	0.31	-0.69	-0.14	-1.15	173.81	54.10	0.66	11.12
7	521	0.36	-0.84	-0.07	-0.38	214.37	60.00	0.62	11.51
8	405	0.45	1.96**	-0.03	1.82*	240.99	57.21	1.16	11.18
9	326	0.21	-2.40**	-0.22	-3.15***	241.99	59.92	1.21	10.92
10	262	0.51	0.93	0.11	1.29	267.03	63.62	1.22	11.02
11	205	0.37	1.37	-0.06	0.23	261.88	69.00	1.23	11.65
12	152	0.16	0.81	-0.10	0.25	218.95	53.40	1.57	12.37
13	104	-0.01	-2.72**	-0.14	-0.99	232.62	54.57	1.80	12.79
14	81	0.63	1.76*	0.03	1.12	267.66	58.96	2.08	11.45
15	58	0.22	0.36	-0.16	-0.31	334.95	54.15	1.92	11.46
16	44	0.12	-1.76*	-0.07	-0.45	390.69	47.05	3.23	12.42
17	33	0.60	1.58	0.05	1.16	406.38	39.70	2.30	8.55
18	24	0.32	0.27	-0.17	-1.34	550.25	39.80	1.32	7.23
19	19	0.25	0.62	0.12	0.77	262.54	34.30	2.39	8.06
20	13	0.04	-0.53	-0.10	0.51	170.65	42.10	3.71	8.49
21	5	0.33		-0.30		129.64	74.90	6.53	7.54

Table IA.V
Fund Size in Calendar Time

This table reports the summary statistics of fund assets (in $million) at the end of each calendar year for the entire sample (main sample and reference sample).

Calendar Year	N	Mean	Median	Std Dev	Q1	Q3
1994	965	69.81	14.30	254.13	3.95	45.00
1995	1316	62.84	13.35	255.04	3.49	42.55
1996	1736	67.79	15.41	255.28	4.10	52.04
1997	2091	88.76	21.49	362.33	5.55	67.49
1998	2371	81.16	19.60	304.93	5.65	59.00
1999	2647	89.98	22.40	288.95	6.23	70.00
2000	2939	93.58	23.12	281.76	6.07	73.80
2001	3220	103.35	24.92	311.92	6.76	81.34
2002	3592	101.40	26.11	298.03	7.56	80.61
2003	3989	131.64	33.55	369.37	9.70	107.00
2004	4522	160.76	39.58	438.93	11.10	131.63
2005	4998	168.73	39.12	527.76	11.08	130.80
2006	5182	209.49	44.51	760.21	12.70	154.73
2007	5315	256.18	52.79	936.15	14.70	180.00
2008	4939	190.24	34.89	865.92	10.00	124.04
2009	4768	193.49	37.36	922.46	10.75	126.00
2010	4618	217.22	42.24	1120.10	11.89	134.85
2011	4484	221.78	39.00	1157.34	10.72	133.37
2012	4169	238.66	39.48	1303.41	10.39	141.10
2013	3924	274.84	47.19	1454.56	12.36	159.75
2014	3660	313.15	51.00	1637.55	12.96	180.01
2015	3189	351.16	54.90	1891.71	13.00	200.00
2016	2135	411.15	63.29	2262.55	16.72	233.72

Table IA.VI
Robustness Tests: $5 million Starting Size

This table presents the results when we require funds in our main sample to have a starting size of at least $5 million. Panel A shows fund performance in event time as in Table II. Panel B reports performance differences between funds with different characteristics. In Panel C, we conduct the Fama-MacBeth regressions using the new main sample. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Performance in Event Time

Event Year	N	Raw Returns	*t*-Statistic of Equal Return	Style-adj Returns	*t*-Statistic of Equal Return
1	467	1.2423	4.96***	0.5976	5.26***
2	467	0.7875	-0.42	0.1742	-1.39
3	467	0.8204	2.50**	0.2726	2.45**
4	467	0.6508	3.01***	0.1259	2.15**
5	467	0.4141	1.60	-0.0128	1.68*
6	449	0.2780	0.45	-0.1281	0.39
7	346	0.2431	-2.53**	-0.1573	-2.04**
8	269	0.4898	1.69*	0.0474	1.90*
9	216	0.2914	-2.11**	-0.1500	-2.54**
10	175	0.5615	0.12	0.1570	0.44

Panel B. Performance Differences by Characteristics

Raw Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.0886	0.66	-0.4554	-1.27	-0.4200	-1.06	0.1193	0.82	0.2422	1.59	-0.3771	-2.03**
2	-0.0375	-0.34	0.1473	0.51	0.9529	1.79*	0.2232	1.71	0.1006	0.59	0.4126	1.79*
3	0.1527	1.17	0.1466	0.48	0.1683	0.52	-0.1139	-0.84	0.3952	2.41**	0.0805	0.42
4	0.2839	2.15**	0.1258	0.46	0.5691	1.61	-0.0091	-0.09	0.1878	2.08**	0.2354	1.40
5	-0.0433	-0.34	-0.0719	-0.31	-0.1600	-0.35	0.4894	2.56**	0.0760	0.57	0.1040	0.66

Style-adj Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.0729	0.59	-0.2581	-0.91	-0.1093	-0.27	0.0453	0.38	0.0971	0.73	-0.2443	-1.53
2	-0.2213	-1.88*	0.2147	0.80	0.7385	1.44	0.1794	1.59	0.0411	0.32	0.2390	1.01
3	0.0491	0.46	0.3190	1.19	0.1368	0.46	-0.0297	-0.26	0.3061	2.26**	0.1459	0.80
4	0.2375	2.08**	0.1274	0.63	0.7000	2.18**	-0.0229	-0.24	0.1449	1.81*	0.2711	1.57
5	-0.0689	-0.63	-0.1741	-0.86	-0.0648	-0.15	0.2972	1.96**	0.0415	0.37	0.1875	1.25

Panel C. Fama-MacBeth Regressions				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	-0.01	-0.11	-0.03	-0.35
Log Lagged Fund Size	-1.43***	-10.92	-1.07***	-9.00
Log Lagged Family Fund Number	-1.80	-0.62	-1.70	-1.26
Log Lagged Family Size	-0.52***	-3.02	0.07	0.55
Lagged Capital Flows	0.19	0.73	-0.04	-0.15
Intercept	38.17***	14.52	19.06***	9.35
Number of Obs	467		467	
Adj R-Squared	0.0662		0.0500	

Table IA.VII
Robustness Tests: 3 Years of Performance Data

This table reports the results when we require funds in our main sample to have at least 3 years of performance data. Panel A reports fund performance in event time as in Table II. Panel B reports performance differences between funds with different characteristics. In Panel C, we conduct the Fama-MacBeth regressions using the new main sample. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Performance in Event Time

Event Year	N	Raw Returns	*t*-Statistic of Equal Return	Style-adj Returns	*t*-Statistic of Equal Return
1	1303	1.1757	5.54***	0.5187	5.98***
2	1303	0.7400	3.06***	0.1122	1.91*
3	1303	0.5163	1.04	-0.0058	0.50
4	1253	0.4395	1.90*	-0.0386	1.28
5	925	0.3164	0.06	-0.1087	0.78
6	708	0.3124	-1.00	-0.1486	-1.42
7	527	0.3843	-0.66	-0.0585	-0.26
8	412	0.4526	1.87*	-0.0334	1.74*
9	330	0.2103	-2.02**	-0.2135	-2.84***
10	266	0.4845	0.72	0.1025	1.18

Panel B. Performance Differences by Characteristics												
Raw Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.2657	2.42**	-0.0678	-0.44	-0.2389	-1.36	0.0470	0.50	0.3076	2.96***	0.1461	0.91
2	0.2387	2.57**	0.1710	0.81	0.7663	2.30**	0.1625	1.97**	0.0860	0.77	-0.2012	-1.37
3	0.0545	0.52	-0.0143	-0.11	0.4133	1.23	-0.0439	-0.39	0.2596	2.35**	0.0357	0.21
4	0.0671	0.68	0.0795	0.42	0.3212	0.70	0.0402	0.43	0.2275	2.54**	-0.2246	-1.21
5	0.2323	2.37**	0.0151	0.14	-0.3030	-0.84	0.2066	1.84*	0.1266	1.34	-0.2727	-1.81*

Style-adj Returns	With - Without Lockup		With - Without HWM		High - Low Incentive		With - Without Leverage		Flagship - Nonflagship		Same - Different Style	
Event year	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return	Diff	*t*-stat of Equal Return
1	0.1896	1.81*	0.0621	0.53	-0.0469	-0.25	-0.0148	-0.16	0.2460	2.60***	-0.1070	-0.89
2	0.1279	1.57	0.2172	1.35	0.6256	1.92*	0.1826	2.63**	0.0464	0.51	0.1451	1.04
3	0.0528	0.69	0.0340	0.35	0.2435	0.84	-0.0256	-0.28	0.1704	2.07**	-0.0039	-0.03
4	0.0187	0.21	0.2132	1.26	0.6240	1.52	0.0797	0.91	0.1308	1.56	0.2440	1.57
5	0.1165	1.21	-0.0459	-0.31	-0.3524	-1.03	0.1155	1.19	0.1600	2.07**	0.1453	1.06

Panel C. Fama-MacBeth Regressions				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.12	1.60	0.02	0.34
Log Lagged Fund Size	-1.79***	-5.00	-2.06***	-4.49
Log Lagged Family Fund Number	4.04*	1.92	1.08	0.62
Log Lagged Family Size	-1.11***	-7.77	-0.28**	-2.10
Lagged Capital Flows	0.50***	2.58	0.25	1.31
Intercept	47.67***	6.86	39.58***	4.53
Number of Obs	1303		1303	
Adj R-Squared	0.0769		0.0590	

Table IA.VIII
Modified Fama-MacBeth Regressions: Additional Control Variables

This table reports our modified Fama-MacBeth regressions when we include as regressors style size and *FMFEE%*, respectively. We first conduct time-series regressions for each fund and regress fund performance on fund age and fund size. The table shows the cross-sectional average of the coefficients. In Panel A, we include style fund number and style size in the regressions. Style fund number is the total number of funds other than those in the same family as fund *i*. Style size is similarly defined. In Panels B and C, we include FMFEE% which is defined in equation (3). Common control variables include the number of funds in the same family, total assets of other funds in the same family, and fund capital flows. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. with Style Size				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.45***	4.13	0.26***	2.78
Log Lagged Fund Size	-1.67***	-12.26	-1.58***	-12.75
Log Lagged Family Fund Number	-1.04	-0.63	-2.66	-1.12
Log Lagged Family Size	-0.38***	-2.79	-0.22	-1.63
Log Lagged Style Fund Number	7.53***	7.21	1.95**	2.11
Log Lagged Style Size	-6.19***	-14.89	1.05***	2.67
Lagged Capital Flows	0.39*	1.83	0.20	0.94
Number of Obs	720		720	
Adj R-Squared	0.1083		0.0877	

Panel B. with FMFEE%: Raw Returns								
	α=0, δ+λ=5% (1)		α=0, δ+λ=10% (2)		α=3%, δ+λ=5% (3)		α=3%, δ+λ=10% (4)	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
FMFEE%	-0.02***	-2.61	-0.02***	-2.16	-0.04***	-3.89	-0.03***	-3.10
Log Lagged Fund Age	0.74***	2.71	0.73***	2.70	0.79***	2.91	0.78***	2.89
Log Lagged Fund Size	-5.34***	-7.34	-5.35***	-7.34	-5.43***	-7.27	-5.44***	-7.26
Log Lagged Family Fund Number	4.27	0.60	4.29	0.61	3.85	0.52	3.84	0.53
Log Lagged Family Size	-1.18	-1.45	-1.18	-1.45	-1.15	-1.38	-1.14	-1.37
Lagged Capital Flows	0.50	0.12	0.53	0.13	0.05	0.01	0.05	0.01
Number of Obs	693		693		693		693	
Adj R-Squared	0.1581		0.1580		0.1595		0.1586	

Panel C. with FMFEE%: Style-adjusted Returns								
	α=0, δ+λ=5%		α=0, δ+λ=10%		α=3%, δ+λ=5%		α=3%, δ+λ=10%	
	(1)		(2)		(3)		(4)	
	Coef	*t*	Coef	*t*	Coef	*t*	Coef	*t*
FMFEE%	-0.01	-1.38	-0.01	-1.13	-0.01	-0.92	-0.01	-0.90
Log Lagged Fund Age	0.73***	3.14	0.73***	3.11	0.83***	3.56	0.82***	3.51
Log Lagged Fund Size	-4.15***	-6.49	-4.16***	-6.46	-4.23***	-6.53	-4.26***	-6.51
Log Lagged Family Fund Number	3.47	0.45	3.43	0.44	3.86	0.48	3.82	0.48
Log Lagged Family Size	0.33	0.43	0.33	0.43	0.32	0.41	0.32	0.41
Lagged Capital Flows	-4.94	-1.62	-4.83	-1.64	-4.62	-1.66	-4.56	-1.69
Number of Obs	693		693		693		693	
Adj R-Squared	0.1158		0.1155		0.1181		0.1169	

Table IA.IX
Fund Performance in Event Time: Expanded Sample

This table shows fund performance in event time with an expanded sample. We estimate missing add dates following the procedure in Jorion and Schwarz (2017). The event here is the start of fund performance. We group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. Column 2 reports the number of funds at the beginning of each event year. Columns 3 and 5 report the average monthly raw return and the average monthly style-adjusted return for each event year. We compare fund performance between years *t* ant *t*+1 using a *t*-test, and results are reported in columns 4 and 6. Panels A and B require funds to have 5 and 3 years of records, respectively. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. 5 Years of Performance Data

Event year	Number of Funds	Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return
1	721	1.2975	5.18***	0.6265	5.53***
2	721	0.8506	0.44	0.2043	-0.57
3	721	0.8106	1.49	0.2456	1.64
4	721	0.6739	3.54***	0.1339	2.38**
5	721	0.4164	1.42	-0.0070	2.36**
6	697	0.3127	-0.71	-0.1419	-1.18
7	522	0.3650	-0.84	-0.0645	-0.37
8	405	0.4521	1.96*	-0.0287	1.81*
9	326	0.2087	-2.40**	-0.2133	-3.15***
10	262	0.5054	0.93	0.1191	1.29

Panel B. 3 Years of Performance Data

Event year	Number of Funds	Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return
1	1318	1.1687	5.51***	0.5176	5.91***
2	1318	0.7367	2.96***	0.1150	1.76*
3	1318	0.5234	1.23	0.0075	0.70
4	1267	0.4332	1.82*	-0.0381	1.24
5	929	0.3149	0.07	-0.1060	0.81
6	710	0.3101	-1.04	-0.1467	-1.46
7	528	0.3845	-0.65	-0.0542	-0.26
8	412	0.4523	1.87*	-0.0297	1.74*
9	330	0.2101	-2.02**	-0.2093	-2.84***
10	266	0.4842	0.72	0.1066	1.19

Table IA.X
Diseconomies of Scale: Portfolio Approach with Expanded Sample

This table reports the results of our portfolio approach with an expanded sample. We estimate missing add dates following the procedure in Jorion and Schwarz (2017). At the beginning of each event year, we divide funds into three groups based on their assets under management, and we use $10 and $100 million as cutoff points. We form an equal-weighted portfolio for each group in every event month. The table shows average performance for each event year. We compare performance between year *t* ant *t*+1 and between the small and large groups using *t*-tests. Panels A and B require funds to have 5 and 3 years of performance data, respectively. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. 5 Years of Performance Data

	Small		Medium		Large			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.44	1.64	1.10	2.15**	1.45	4.79***	-0.01	-0.09
2	1.18	0.26	0.85	0.12	0.41	-1.12	0.77	3.92***
3	1.12	-0.39	0.83	1.48	0.60	1.69	0.52	2.57**
4	1.23	2.47**	0.66	2.46**	0.44	0.42	0.80	3.41***
5	0.45		0.42		0.40		0.05	0.23

	Small		Medium		Large			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.67	1.45	0.54	4.28***	0.88	4.39***	-0.21	-1.09
2	0.45	0.13	0.18	-0.77	-0.06	-1.47	0.51	3.00***
3	0.42	-0.12	0.25	1.61	0.14	1.39	0.28	1.54
4	0.46	1.43	0.11	1.67	0.01	0.66	0.45	2.01*
5	0.04		0.00		-0.04		0.08	0.36

Panel B. 3 Years of Performance Data

	Small		Medium		Large			
Event year	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Raw Returns	*t*-Stat of Equal Return	Diff	*t*
1	1.29	3.31***	1.02	2.39**	1.17	4.51***	0.12	0.90
2	0.87	0.87	0.77	3.03***	0.46	0.34	0.41	2.86***
3	0.72	-0.41	0.51	1.04	0.42	1.75*	0.30	2.10**
4	0.80	1.85*	0.42	1.35	0.25	-0.85	0.55	3.27***
5	0.29		0.30		0.35		-0.06	-0.21

	Small		Medium		Large			
Event year	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Style-adj Returns	*t*-Stat of Equal Return	Diff	*t*
1	0.57	3.18***	0.44	3.83***	0.65	4.66***	-0.08	-0.61
2	0.22	0.43	0.12	2.10**	-0.03	-0.02	0.25	2.07**
3	0.15	0.21	-0.02	0.38	-0.03	0.85	0.18	1.45
4	0.11	0.95	-0.05	1.21	-0.11	-0.33	0.22	1.37
5	-0.11		-0.12		-0.08		-0.03	-0.16

Table IA XI
Diseconomies of Scale: Fama-MacBeth Regression with Expanded Sample

This table reports the results of our modified Fama-MacBeth regressions with an expanded sample. We estimate missing add dates following the procedure in Jorion and Schwarz (2017). We first conduct time-series regressions for each fund and regress fund performance on fund age and fund size. We control for the number of funds in the same family, total assets of other funds in the same family, and fund capital flows. The table shows the cross-sectional average of the coefficients. Panels A and B require funds to have 5 and 3 years of records, respectively. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. 5 Years of Performance Data				
	Raw Return		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.02	0.23	0.00	-0.04
Log Lagged Fund Size	-1.33***	-12.93	-1.06***	-11.45
Log Lagged Family Fund Number	-0.24	-0.13	-0.56	-0.60
Log Lagged Family Size	-0.61***	-4.94	-0.07	-0.75
Lagged Capital Flows	0.13	0.58	-0.08	-0.36
Intercept	35.57***	17.50	19.77***	11.88
Number of Obs	721		721	
Adj R-Squared	0.0697		0.0516	

Panel B. 3 Years of Performance Data				
	Raw Return		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.14*	1.89	0.04	0.61
Log Lagged Fund Size	-1.85***	-5.19	-2.09***	-4.64
Log Lagged Family Fund Number	4.06*	1.95	1.37	0.78
Log Lagged Family Size	-1.12***	-7.87	-0.30**	-2.28
Lagged Capital Flows	0.51***	2.64	0.25	1.32
Intercept	48.76***	7.06	40.33***	4.69
Number of Obs	1317		1317	
Adj R-Squared	0.0763		0.0584	

Table IA.XII
Managers' Incentives by Management Fee Percentage

This table reports managers' incentives at the end of each event year when we divide our sample into three groups based on funds' management fee percentages. Following Goetzmann, Ingersoll, and Ross (2003), Agarwal, Daniel, and Naik (2009), and Lim, Sensoy, and Weisbach (2016), we calculate the present value of managers' future management fees and the present value of managers' total compensation. To do so, we need to make assumptions about managers' abilities (represented by α) and the withdrawal rate (represented by δ+λ). Following the literature, we assume that α is either 0 or 3% and δ+λ is either 5% or 10%. We then calculate *FMFEE%* as future management fees divided by future total fees, and thus it measures the contribution of the management fee to total compensation. Panels A through D show the results for different parameter combinations. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. FMFEE% (α=0, δ+λ=5%)					
Event Year	Mgmt Fee<=1%	1%<Mgmt Fee<2%	Mgmt Fee>=2%	Diff: High-Low	*t*
1	49.6516	66.8760	64.0331	14.3815***	-6.12
2	51.2815	65.7734	64.5407	13.2592***	-5.32
3	52.9685	67.5700	66.0693	13.1008***	-5.05
4	54.2901	69.6383	69.2951	15.0050***	-6.12
5	56.0981	71.0069	71.4220	15.3239***	-6.11

Panel B. FMFEE% (α=0, δ+λ=10%)					
Event Year	Mgmt Fee <=1%	1%< Mgmt Fee <2%	Mgmt Fee >=2%	Diff: High-Low	*t*
1	49.0748	66.2788	63.5844	14.5096***	-6.25
2	50.7156	65.2837	64.1427	13.4271***	-5.45
3	52.5096	67.1394	65.7120	13.2024***	-5.13
4	53.8637	69.2538	68.9769	15.1131***	-6.21
5	55.6720	70.6618	71.0849	15.4129***	-6.19

Panel C. FMFEE% (α=3, δ+λ=5%)					
Event Year	Mgmt Fee <=1%	1%< Mgmt Fee <2%	Mgmt Fee >=2%	Diff: High-Low	*t*
1	40.8670	58.2030	57.9464	17.0794***	-8.95
2	41.8123	57.3887	58.7547	16.9424***	-8.35
3	42.6846	59.0014	60.2088	17.5242***	-8.28
4	43.7552	60.9931	63.3292	19.5741***	-9.87
5	45.2354	62.4477	65.3147	20.0793***	-9.84

Panel D. FMFEE% (α=3, δ+λ=10%)					
Event Year	Mgmt Fee <=1%	1%< Mgmt Fee <2%	Mgmt Fee >=2%	Diff: High-Low	*t*
1	40.5668	57.8004	57.5883	17.0215***	-9.00
2	41.5436	57.0882	58.4157	16.8721***	-8.38
3	42.5317	58.7471	59.8922	17.3605***	-8.25
4	43.6578	60.7645	63.0631	19.4053***	-9.81
5	45.1611	62.2923	65.0176	19.8565***	-9.76

Table IA.XIII
Fund Performance in Event Time by Style

This table reports fund performance in event time by style. We divide hedge funds in our sample into four general styles following the algorithm in Agarwal, Daniel, and Naik (2009). The event here is the start of fund performance. We group fund-month observations by event month and form an equal-weighted portfolio for each event month. We define the first 12 event months as event year 1, the next 12 event months as event year 2, and so on. We compare fund performance between years *t* ant *t*+1 using a *t*-test, and results are reported in columns 4 and 6. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Raw Returns

	Multi-process		Relative Value		Security Selection		Directional Traders	
Event year	Raw Return	*t*	Raw Return	*t*	Raw Return	*t*	Raw Return	*t*
1	1.4542	3.45***	1.3503	5.25***	1.331	3.62***	1.012	0.60
2	1.0095	2.87***	0.7597	-0.03	0.8265	-0.31	0.9075	0.04
3	0.5981	-0.42	0.763	-0.69	0.8663	1.86*	0.901	2.71**
4	0.661	0.9	0.8492	5.30***	0.6518	2.27**	0.5294	0.19
5	0.5123	-0.08	0.3739	0.56	0.3692	0.66	0.5017	1.38
6	0.5247	2.75***	0.3084	0.37	0.2971	-3.04***	0.197	-0.50
7	0.1089	-1.41	0.2439	-0.53	0.5318	-0.47	0.3206	0.32
8	0.4143	1.31	0.3318	1.71	0.6056	1.61	0.2484	-0.42
9	0.107	-0.04	0.014	-3.78***	0.2617	-1.12	0.3459	-1.27
10	0.1169	0.71	0.715	1.58	0.4924	-0.11	0.6467	0.86

Panel B. Style-adj Returns

	Multi-process		Relative Value		Security Selection		Directional Traders	
Event year	Style-adj Returns	*t*	Style-adj Returns	*t*	Style-adj Returns	*t*	Style-adj Returns	*t*
1	0.6898	2.96***	0.743	5.16***	0.6518	4.97***	0.3463	0.36
2	0.315	1.87*	0.1898	-0.12	0.1358	-1.07	0.2965	-0.78
3	0.1019	0.29	0.2032	-0.83	0.2429	1.89*	0.3974	2.52**
4	0.0684	0.58	0.3001	4.79***	0.0912	0.77	0.0738	0.19
5	-0.0038	0.31	-0.1286	0.28	0.0162	1.61	0.046	1.24
6	-0.0417	1.73*	-0.1576	-0.09	-0.1529	-2.10**	-0.1872	-0.61
7	-0.2843	-0.80	-0.1443	-0.2	0.0374	0.22	-0.0527	-0.44
8	-0.1342	1.09	-0.1137	2.29**	0.0066	0.85	0.0451	0.27
9	-0.3606	-1.00	-0.5014	-4.29***	-0.1376	-1.29	-0.015	-1.46
10	-0.1604	1.32	0.234	1.93*	0.0788	0.32	0.3083	0.59

Table IA. XIV
Modified Fama-MacBeth Regression by Style

This table reports the results of our modified Fama-MacBeth regressions by style. We divide hedge funds in our sample into four general styles following the algorithm in Agarwal, Daniel, and Naik (2009). We first conduct time-series regressions for each fund and regress fund performance on fund age and fund size. We control for the number of funds in the same family, total assets of other funds in the same family, and fund capital flows. The table shows the cross-sectional average of the coefficients. Panels A and D show results for the four general styles, respectively. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Panel A. Multi-process				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.05	0.44	0.06	0.65
Log Lagged Fund Size	-0.95***	-4.88	-0.67***	-4.32
Log Lagged Family Fund Number	-9.48	-0.83	-0.84	-0.50
Log Lagged Family Size	-0.06	-0.12	0.03	0.23
Lagged Capital Flows	-0.32	-0.83	-0.54	-1.62
Intercept	25.7***	5.75	11.88***	3.69
Number of Obs	107		107	
Adj R-Squared	0.0948		0.0596	

Panel B. Relative Value				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.07	0.56	-0.05	-0.49
Log Lagged Fund Size	-0.93***	-5.49	-0.86***	-4.46
Log Lagged Family Fund Number	4.18*	1.81	1.22	0.94
Log Lagged Family Size	-0.92	-4.27	-0.28	-1.32
Lagged Capital Flows	0.01	0.04	0.17	0.62
Intercept	32.73***	8.08	20.85***	6.63
Number of Obs	154		154	
Adj R-Squared	0.1205		0.0964	

Panel C. Security Selection				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	0.02	0.13	-0.01	-0.08
Log Lagged Fund Size	-1.59***	-9.38	-1.23***	-8.68
Log Lagged Family Fund Number	0.87	0.61	-0.82	-0.52
Log Lagged Family Size	-0.85***	-4.98	-0.07	-0.52
Lagged Capital Flows	0.11	0.30	-0.36	-0.88
Intercept	42.92***	12.56	22.06***	7.80
Number of Obs	332		332	
Adj R-Squared	0.0507		0.0377	

Panel D. Directional Traders				
	Raw Returns		Style-adj Returns	
	Coef	*t*	Coef	*t*
Log Lagged Fund Age	-0.05	-0.26	0.02	0.1
Log Lagged Fund Size	-1.50***	-5.48	-1.18***	-4.67
Log Lagged Family Fund Number	-0.75	-0.33	-1.83	-0.72
Log Lagged Family Size	-0.1	-0.4	0.11	0.44
Lagged Capital Flows	0.66	1.25	0.72	1.54
Intercept	28.59***	7.92	19.33***	5.52
Number of Obs	127		127	
Adj R-Squared	0.0367		0.0279	

Table IA. XV
Strategy Distinctiveness Index

This table reports the strategy distinctiveness index (*SDI*) of our main sample at the end of each event year. We follow Sun, Wang, and Zheng (2012) and divide hedge funds in our sample into four style clusters based on their past 12 months of returns. Then we calculate the *SDI* of a fund as 1 minus the sample correlation between a fund's returns with the average returns of all funds in the same cluster. ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.

Event Year	Mean	*t*-stat of Equal *SDI*
1	0.2304	3.72***
2	0.1924	-0.6
3	0.1982	1.53
4	0.1839	-0.67
5	0.1896	