Systemic Risk and Cross-Sectional Hedge Fund Returns

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Abstract

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JEL classification: G10, G11, G23, G28, C13.

Keywords: hedge fund, systemic risk, cross-section of expected returns.

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1. Introduction

The hedge fund industry has been one of the most rapidly growing areas of the financial sector over the last decade. Its rapid growth results from its important benefits to financial markets and investors in the form of improved investment opportunity, price discovery, liquidity, risk sharing, and portfolio diversification. For example, hedge funds have provided funds to build infrastructures in emerging countries over the past years. In spite of these benefits, the role of hedge funds in the financial system has been controversial, because they can be a source of systemic risk[1] to the financial system, potentially exacerbating market failures. These concerns have especially deepened since the market collapse triggered by Long-Term Capital Management in 1998 and the recent U.S. subprime crisis.

The relation between hedge fund and systemic risk can be described conceptually as the linkage from hedge funds to real economic activity. To be more exact, hedge funds can pose systemic risk by obstructing the ability of financial intermediaries or the financial market to efficiently provide credit through several different mechanisms, or channels (see, e.g., Chan et al., 2006; McCarthy, 2006; Hildebrand, 2007; Kambhu, Schuermann, and Stiroh, 2007). The first channel is the direct risk exposure of financial institutions to hedge funds. Financial intermediaries are directly connected to hedge funds through their counterparty credit risk exposures, as in prime brokerage activity, short-run financing for leveraged positions, and trading counterparty exposures in over-the-counter and other markets. If a bank has a large exposure to a hedge fund that fails or suffers losses on its investments, the increased risk exposure or eroded bank capital may reduce its ability or willingness to provide credit to worthy borrowers. The second channel is disruptions to the efficient

[1] Although financial stability and systemic risk have become major policy concerns around the world due to the rapid growth in global capital markets and the recent financial crises, systemic risk is not well defined and remains a little vague. Systemic risk usually refers to the risk or probability of collapse of an entire financial system or entire market, as opposed to the risk associated with any individual entity, group, or component of a system (see Kaufman, 2000).

functioning of capital markets that impede credit provision. Such disruptions fundamentally reflect a reduced ability or willingness to bear risk through credit provision due to the loss of investor confidence. The third channel is indirect effects of the feedback of the bank problem in broader financial markets. Because financial intermediaries provide a significant source of liquidity to the hedge fund industry, a shock induced by hedge funds to financial intermediaries can trigger a chain reaction by reducing the liquidity provision of these banks to other hedge funds or to other banks, thus leading to financial market disruption.

Despite the economic and regulatory significance of its implications, very few studies focus on the relation between hedge fund and systemic risk. This paper attempts to expand the literature by examining a cross-sectional relation between hedge fund returns and systemic risk. The primary questions addressed are the following: How is systemic risk related to hedge fund returns? How can we measure the systemic risk of a hedge fund? What is a cross-sectional relation between hedge fund returns and systemic risk? Can the systemic risk contribution of hedge funds explain the cross-sectional variation in hedge fund returns? Do live and defunct funds give rise to different relations between hedge fund returns and systemic risk? Is the relation between hedge fund returns and systemic risk affected by fund characteristics related to fund risk, such as age, asset size, and liquidity, or commonly used hedge-fund factors, such as the Fung-Hsieh (2004) seven factors and the Sadka (2006, 2010) liquidity risk factor?

The most common trouble in hedge fund research is a short history of hedge fund returns, less than 20 years on a monthly basis at the longest. Furthermore, systemic events themselves are rare, making it even more difficult to measure systemic risk in the context of hedge funds. This paper employs the marginal expected shortfall (MES) proposed by Acharya et al. (2010) to measure the systemic risk of individual hedge funds. Although several other

measures of systemic risk exist,[2] we focus on each individual hedge fund's contribution to systemic risk and are further interested in the regulatory implications of ways to limit systemic risk through taxes or regulation. Additionally, this measure is particularly proper to apply to individual hedge fund data.

To examine whether the systemic risk contribution of hedge funds plays a role in explaining the cross-sectional variation in hedge fund returns, we measure the systemic risk of a hedge fund and carry out analyses adopted from an asset pricing framework, not only at the portfolio level (portfolio-based analysis) but also at the individual level (regression-based analysis).

Our paper's major findings can be summarized as follows. First, we find evidence for a positive and statistically significant relation between the systemic risk contribution of hedge funds measured by the MES and hedge fund returns. Funds with a high systemic risk contribution outperform those with a low systemic risk contribution by 1.38% per month (or 16.61% per annum) over the period 1999–2009, while negative performance is observed during crisis periods. Second, the relation between systemic risk and hedge fund returns holds not only for live funds but also for defunct funds. Third, the relation between systemic risk and hedge fund returns holds even after controlling for fund characteristics related to fund risk, such as age, asset size, and liquidity, as well as commonly used hedge-fund factors, such as the Fung-Hsieh (2004) seven factors and the Sadka (2006, 2010) liquidity risk factor. Finally, the systemic risk contribution of hedge funds measured by the MES is one of the most important factors in explaining the cross-sectional variation in hedge fund returns.

[2] Several recent papers focus on measuring systemic risk. Using quantile regressions, Adrian and Brunnermeier (2009) introduce the value at risk (VaR) of the financial sector conditional on a bank being in distress, which the authors denote by CoVaR. Gray and Jobst (2010) propose a measure of systemic risk based on contingent claims analysis, and Kritzman et al. (2010) propose an absorption ratio based on principal component analysis. Brownlees and Engle (2010) propose a multi-step modeling approach based on the DCC-GARCH model and nonparametric tail expectation estimators to estimate the measure of systemic risk, and Acharya et al. (2010) proposes the MES.

This paper basically relates to the recent literature on the risk profile of hedge funds, which has been largely focused on explaining a cross-sectional relation between expected return, specific risk, and other explanatory hedge fund variables. Fung and Hsieh (2002, 2004) and Chan et al. (2006) show that hedge fund returns are nonlinearly related to equity market risk, credit risk, interest rate risk, exchange rate risk, and option-based factors. Bali, Gokcan, and Liang (2007) test the presence and significance of a relation between financial risk measured by the VaR and expected returns on hedge funds. Buraschi, Kosowki, and Trojani (2009) examine the relation between correlation risk and a cross-section of hedge fund returns. Brunnermeier and Pedersen (2009), King and Maier (2009), and Klaus and Rzepkowski (2009) study the role of funding risk related to the interconnectedness of brokers and hedge funds. Sadka (2010) shows that liquidity risk as measured by the covariation of fund returns with unexpected changes in aggregate liquidity explains cross-sectional variations in hedge fund returns. Bali, Brown, and Caglayan (2010) examine the performance of hedge funds' exposures to various financial and macroeconomic risk factors in predicting the cross-sectional variation in hedge fund returns. They find a significantly positive (negative) link between default premium beta (inflation beta) and future hedge fund returns. Unlike these previous works, we focus on the systemic risk of hedge funds as an important determinant in the cross-section of hedge fund returns.

Moreover, this paper relates to the literature on the systemic risk of hedge funds and hedge fund contagion. Chan et al. (2006) develop a number of systemic risk measures for hedge funds based on illiquidity exposure and time-varying hedge fund correlations. Billio et al. (2010) propose several econometric measures of systemic risk to capture the interconnectedness between the finance and insurance sectors, including the hedge fund industry, based on principal components analysis and Granger causality tests. Boyson, Stahel, and Stulz (2010) analyze co-movement among hedge fund style indexes by using quantile

regression and logit models and find strong evidence of contagion across hedge fund styles. Whereas these studies largely use aggregate or index hedge fund data to examine whether the entire hedge fund industry or each hedge fund style is related to systemic risk, we focus on individual hedge fund data to use fund-specific information. Lastly, Joenväärä (2009) measures the systemic risk of an individual hedge fund by using the co-expected shortfall approach proposed by Adrian and Brunnermeier (2009). Whereas Joenväärä (2009) examines the relation between hedge fund characteristics and the systemic risk of a hedge fund, we concentrate on the relation between hedge fund returns and the systemic risk contribution of hedge funds measured by the MES, as proposed by Acharya et al. (2010).

This paper makes several important contributions to the recent literature on measuring the systemic risk of individual hedge funds: It is the first to measure the systemic risk contribution of a hedge fund by using the MES proposed by Acharya et al. (2010), and it provides an example of how the MES can be applied in the context of hedge funds. This paper also contributes to the literature on the risk profiles of hedge funds, none of which has considered the relation between systemic risk and individual hedge fund returns. To the best of our knowledge, this paper is the first to consider the cross-sectional relation between the systemic risk contribution of hedge funds and hedge fund returns in an asset pricing framework.

The rest of the paper is organized as follows. Section 2 describes the data set employed and descriptive statistics. Section 3 introduces the methodology, emphasizing the measure of systemic risk and the cross-sectional approach based on an asset pricing framework. Section 4 presents our empirical results. Section 5 provides additional tests and Section 6 presents our conclusions.

2. Data

The primary hedge fund database employed in this paper is that of the Tremont Advisory Shareholders Services (TASS),[3] the most commonly utilized database by academics and practitioners in the hedge fund industry.[4] In addition, we use returns on the value-weighted portfolio of the financial sector as the market return or, more exactly, the return on the financial system.[5] The TASS database includes 14,317 individual hedge funds over the period February 1977 to December 2009, of which 5,985 are live and 8,332 defunct.[6] These data cover almost half of the estimated total number of existing hedge funds. The majority of funds in the TASS database report returns net of management fees, incentive fees, and other fund expenses on a monthly basis. Moreover, the TASS database provides other fund-specific information, such as investment strategy,[7] assets under management (AUM), fee structure, minimum investment, leverage, subscription, redemption, and lockup information.

This paper applies several restrictions to filter the primary hedge fund database. First, we select the sample period from January 1994 to December 2009 to alleviate any survivorship bias, since the TASS database started tracking defunct funds in 1994 and therefore does not contain information on defunct funds prior to 1994. Second, we select

[3] For further information about this database, see http://www.lipperweb.com/products/LipperTASS.aspx.

[4] The TASS database is used by Fung and Hsieh (1997, 2000), Liang (2000), Brown, Goetzmann, and Park (2001), Lo (2001), Brown and Goetzmann (2003), Agarwal and Naik (2004), Getmansky, Lo, and Makarov (2004), Getmansky, Lo, and Mei (2004), Chan et al. (2006), Bali, Gokcan, and Liang (2007), Kosowski, Naik, and Teo (2007), Agarwal, Daniel, and Naik (2009), Kang et al. (2009), Aggarwal and Jorion (2010), and Bali, Brown, and Caglayan (2010), among others.

[5] We thank Kenneth R. French for providing these data on his respective website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[6] The TASS database consists of two parts: "live" funds and "graveyard" (or defunct) funds. The live funds indicate actively reporting hedge funds as of the most recent database update, December 2009 in our case. By contrast, graveyard funds indicate hedge funds that have stopped reporting to the TASS database due to liquidation, merger, and so forth.

[7] The TASS database classifies funds into 14 categories across different investment strategies: convertible arbitrage, dedicated short bias, emerging markets, equity market neutral, event driven, fixed income arbitrage, fund of funds, global macro, long/short equity hedge, managed futures, multi-strategy, options strategy, other hedge funds, and undefined hedge funds.

hedge funds that report their returns in U.S. dollars, net of fee, and on a monthly basis. In other words, we eliminate funds that report returns denominated in currencies other than U.S. dollars or gross of fee, as well as funds that report returns on a weekly, quarterly, or annual basis. Third, we concentrate on the following strategies: convertible arbitrage, dedicated short bias, emerging markets, equity market neutral, event driven, fixed income arbitrage, global macro, long/short equity hedge, multi-strategy, and options strategy. As of December 2009, these strategies covered 54.5% of all hedge funds contained in the TASS database. Similar to Bali, Gokcan, and Liang (2007), we eliminate funds of funds and managed futures because we want to focus on individual hedge funds rather than funds of funds and CTAs. Fourth, we require that each fund have at least a 24-month return history for estimating a reliable measure of systemic risk. Finally, we exclude funds that did not report AUM or that reported only partial AUM. Funds with AUM less than $10 million are also excluded,[8] thus reducing any bias that might be caused by small funds.

[Insert Table 1 about here]

After applying all these restrictions, the remaining sample includes 1,406 funds, of which 645 are live and 761 defunct. Table 1 presents descriptive statistics for the monthly hedge fund returns in our sample, providing for each hedge fund group the number of observations, the average value of the sample mean, standard deviation, skewness, excess kurtosis, and the results of normality tests. The results of the normality tests show the percentage of funds for which the null hypothesis of normally distributed returns is rejected by the Jarque–Bera test. Table 1 reports that the average mean of hedge fund returns is positive and 0.86% per month (10.29% per annum) across all funds. The average standard

[8] Some indexes (e.g., Dow Jones Credit Suisse Hedge Fund Index) also require a minimum AUM of $10 million.

deviation of hedge fund returns is 4.22% per month (14.61% per annum). The average mean and standard deviation of live funds are, respectively, 0.20% per month (2.43% per annum) and 0.57% per month (1.99% per annum) higher than for defunct funds. This result may be caused by the fact that successful funds, as well as failed funds, are also more likely to stop reporting to TASS because they do not have to advertise their performance. Not surprisingly, hedge fund returns have negative average skewness and positive average excess kurtosis, consistent with previous studies (see, e.g., Fung and Hsieh, 1999; Brooks and Kat, 2002; Agarwal and Naik, 2004; Gupta and Liang, 2005; Bali, Gokcan, and Liang, 2007) showing that hedge fund returns are not normally distributed. In addition, the Jarque–Bera test rejects normality for 73% of hedge funds, on average. This suggests that the VaR or expected shortfall (ES) is more suitable to measure hedge fund risk than the standard deviation, because while the standard deviation focuses only on average variations from the mean, the VaR and ES take into account extreme outcomes. This paper uses the concept of ES rather than VaR, since ES is more sensitive to the shape of the loss distribution in the tails.

3. Methodology

3.1. Measure of systemic risk

This section introduces the measure of systemic risk employed in this paper, the MES of Acharya et al. (2010). These authors present a simple model of systemic risk based on externalities that spill over to the rest of the economy due to undercapitalization of the financial system. They propose a systemic expected shortfall (SES), which is a financial institution's propensity to be undercapitalized when the system as a whole is undercapitalized, as a measure of each financial institution's contribution to systemic risk. According to their model, the SES increases with the institution's leverage and its MES, which is an expected loss in the tail of the system's loss distribution. However, leverage is hard to use in the

context of hedge funds to measure systemic risk, because there are almost no time series data related to information on hedge fund leverage. For that reason, we use only the MES to measure a hedge fund's contribution to systemic risk.[9]

Here the MES is defined as the marginal contribution of an individual entity to the system's risk. Let *I* denote the set of individual entities in the system. The return of the entire system can be calculated by the value-weighted average return of all individual entities, which denotes the market return:

$$r_m = \sum_{i \in I} w_i r_i, \tag{1}$$

where r_i and w_i are the return and weight in the entire system of entity *i*, respectively. The risk of the entire system can be measured by the VaR and ES. The VaR is the potential maximum loss for a given confidence level 1 - α:

$$\Pr(r_m < VaR_\alpha) = \alpha. \tag{2}$$

The ES is the expected loss conditional on the loss being greater than the VaR:

$$ES_\alpha = E[r_m \,|\, r_m \le VaR_\alpha] = \sum_{i \in I} w_i E[r_i \,|\, r_m \le VaR_\alpha]. \tag{3}$$

From this equation, we can derive entity *i*'s MES, which is the marginal contribution of entity *i* to the overall risk, as the partial derivative of the system's ES with respect to the weight of entity *i* in the system:

$$MES_i^\alpha \equiv \frac{\partial ES_\alpha}{\partial w_i} = E[r_i \,|\, r_m \le VaR_\alpha]. \tag{4}$$

This paper uses a 95% confidence level, that is, $\alpha \approx 5\%$. Here the MES measures how entity *i*'s risk taking adds to the system's overall risk. In brief, the MES can be measured by estimating entity *i*'s losses when the system as a whole is doing poorly (see, e.g., Acharya et al., 2010; Brownlees and Engle, 2010).

[9] We also investigate the impact of leverage on our main results. The results are provided in Section 5.3.

3.2. Portfolio-based analysis

To investigate the cross-sectional relation between hedge fund returns and systemic risk, we use portfolios of individual hedge funds. The portfolio formation process is adopted from Fama and French (1992), except for the sorting criteria and the frequency of portfolio updates.

We form 10 decile portfolios of hedge funds every month based on their MES rank. Funds are kept in the portfolios for one month, that is, we update the portfolios on a monthly basis. We use equal-weighted portfolios with an equal number of funds in each portfolio and calculate the MES of each fund using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period, that is, the prior 60 months. These 60 months provide sufficient observations to estimate reliable MESs without losing too many observations in the beginning of the sample.[10] For this reason, we have 132 monthly observations (from January 1999 to December 2009) for the 10 equal-weighted portfolios formed based on their MES. We generate these portfolios for both live and defunct funds and then calculate their next month's returns.

Since portfolios 1 and 10 have the lowest and highest average value of the MES, respectively, we examine the presence and significance of a cross-sectional relation between hedge fund returns and systemic risk using the difference of one-month-ahead returns between these two portfolios.

We repeat the above procedure by using fund characteristics related to fund risk, such as age, asset size, and liquidity, instead of the MES as the criteria for portfolio formation. We

[10] The empirical results are robust to the length of the estimation period. For instance, when we use 30 and 90 months instead of 60 months as the length of the estimation period, the main empirical results are similar and qualitatively unchanged. The results are provided in Section 5.1.

construct 10 age (or asset size) portfolios and two liquidity portfolios. The age is measured in months. The asset size is measured by the natural logarithm of AUM. A lockup dummy is used to measure liquidity of a fund. If a hedge fund has a lockup provision, hedge fund investors cannot withdraw their money immediately and fund managers can mitigate liquidity problems stemming from investing in illiquid securities. If a fund has a nonzero lockup period, the dummy variable is set to one, and zero otherwise.[11]

To examine whether the cross-sectional relation between hedge fund returns and systemic risk is still statistically and economically significant after controlling for age, asset size, and liquidity effects, we conduct analyses based on bivariate as well as univariate sorting. To put it concretely, we make groups first based on age (asset size or liquidity) and then form portfolios based on the MES within each group. For example, in the case of separating the age effect from the MES, we first sort hedge funds based on their ages and then categorize them into low, medium, and high age groups, with an equal number of funds in each group. Finally, within each age group, we re-sort the hedge funds based on their MESs and form 10 equal-weighted portfolios with an equal number of funds in each portfolio. This process is repeated every month from January 1999 to December 2009. Similar to the analysis based on univariate sorting, we have 132 monthly observations for the 10 equal-weighted portfolios formed based on their MESs within each age (asset size or liquidity) subgroup.

Since portfolios 1 and 10 formed based on bivariate sorting have the lowest and highest MESs, respectively, we examine the cross-sectional relation between hedge fund returns and systemic risk after controlling for age, asset size, and liquidity effects using the difference of one-month-ahead returns between these two portfolios.

[11] We use a dummy variable instead of a continuous variable because the lockup period does not have enough variation. According to TASS, the lockup period can be up to 7.5 years but mostly clusters around one year.

3.3. Regression-based analysis

Although portfolio-based analysis makes it easy to mimic the risk factor in returns related to the MES, this approach does not take into account fund-specific information. To consider the importance of risk factors in one model and fund-specific information, we utilize Fama and MacBeth's (1973) cross-sectional regression framework and run monthly cross-sectional regressions for the following econometric specifications:

$$R_{i,t+1} = \alpha_t + \beta_{1,t} MES_{i,t} + I_{\{2\in M\}}\beta_{2,t} Age_{i,t} + I_{\{3\in M\}}\beta_{3,t} Asset_{i,t} + I_{\{4\in M\}}\beta_{4,t} LockupD_{i,t} + \varepsilon_{i,t+1}, \quad (5)$$

where $R_{i,t+1}$ is the realized return on fund *i* in month *t + 1*; $MES_{i,t}$ is the MES for fund *i* in month *t*; $Age_{i,t}$ is the age of fund *i* in month *t*; $Asset_{i,t}$ is the natural logarithm of the AUM of fund *i* in month *t*; $LockupD_{i,t}$ [12] is the dummy variable for the existing lockup period of fund *i* in month *t*; $I_{\{x\in X\}}$ is an indicator function whose value equals one if x is an element of X, and zero otherwise; and M is a set of independent variables in each regression model. Since we repeat the above monthly cross-sectional regressions from January 1999 to December 2009, we have 132 time series of regression coefficients. We then calculate the average values of these coefficients and test their statistical significance using standard t-statistics.

4. Empirical results

4.1. Portfolio-based analysis (univariate sorting)

4.1.1. MES and cross-sectional hedge fund returns

[12] If a fund has a nonzero lockup period, we set the dummy variable equal to one; otherwise, the dummy variable equals zero.

[Insert Table 2 about here]

Table 2 reports the cross-sectional relation between the MES and expected returns. To examine whether the cross-sectional relation between the MES and the expected returns of defunct funds is different from that between the MES and the expected returns of live funds, we form portfolios that use all funds, as well as live and defunct funds separately. This table presents the average monthly return for each MES portfolio for all, live, and defunct funds. When we calculate the MES of each hedge fund, we do not perform any sign conversion. Thus a significantly negative MES value suggests that a specific group of funds poses a significant systemic risk or has a high systemic risk. This table also reports the average return differential between deciles 1 (low-MES portfolio) and 10 (high-MES portfolio). *T*-statistics are reported in square brackets.

The expected returns across different MES portfolios in Table 2 indicate that there is a positive relation between systemic risk measured by the MES and hedge fund return. From deciles 1 to 10, the expected returns decrease almost monotonically. The highest portfolio return (1.63% per month) and the lowest (0.25% per month) correspond to the lowest-MES portfolio (-11.84% per month) and the highest (8.89% per month), respectively. Moreover, the last column in Table 2 shows that the average return differential between deciles 1 and 10 is positive and statistically significant. The average return difference between portfolios 1 and 10 is 1.38% per month (or 16.61% per annum) and significant at the 1% level. This result means that if one invests in the lowest-MES portfolio while short-selling the highest-MES portfolio, one will achieve an annual profit of 16.61%.

According to Bali, Gokcan, and Liang (2007), the risk profile of defunct funds may be different from that of live funds because of the nature of voluntary closure. Although

Liang (2000) and Getmansky, Lo, and Mei (2004) indicate that the main reason for a fund to transfer from the live database to the graveyard database is poor performance, funds can be assigned to the graveyard for other reasons, such as mergers and acquisitions, voluntary withdrawals, and name changes.[13] For example, successful funds, as well as failed funds, are also more likely to withdraw from the TASS database, because they no longer need investors and want to keep away from the public. Furthermore, the proportion of defunct funds in hedge funds is relatively larger than in mutual funds. Hence, when all funds are considered simultaneously, the actual underlying relation may seem to be hidden and unclear. For these reasons, we investigate the cross-sectional relation between the MES and hedge fund returns using live and defunct funds separately.

Table 2 shows that, regardless of whether a fund is live or defunct, the cross-sectional relation between systemic risk measured by the MES and the expected returns on hedge funds is positive and statistically significant. In the case of live funds, the average return difference between portfolios 1 and 10 is 1.22% per month (or 14.69% per annum) and significant at the 1% level. The relation for defunct funds is even a little stronger than that for live funds. Defunct funds have a slightly wider MES distribution (from -12.22% to 9.42% per month) across the 10 portfolios than live funds (from -11.04% to 8.65% per month), and the average return difference between the two extreme portfolios of defunct funds is also slightly higher (1.42% per month, or 17.10% per annum) than that of live funds. The difference is significant at the 1% level.

In summary, the results in Table 2 provide evidence for a positive and statistically significant relation between the systemic risk contribution of hedge funds measured by the

[13] The TASS database provides one of eight distinct reasons for a fund being assigned to the graveyard: fund liquidated, fund no longer reporting, unable to contact fund, fund closed to new investment, fund has merged into another entity, program closed, fund dormant, and unknown.

MES and hedge fund returns. Furthermore, this relation holds even after taking into account differences in fund characteristics between live and defunct funds.

4.1.2. Fund characteristics related to fund risk (age, asset size, and liquidity) and cross-sectional hedge fund returns

Previous literature on the risk profile of hedge fund shows that fund characteristics such as age, size, and liquidity are related to the cross-section of hedge fund returns (see, e.g., Liang, 1999; Aragon, 2007; Bali, Gokcan, and Liang, 2007). In other words, not only systemic risk measured by the MES but also these fund characteristics can explain the cross-sectional variation in hedge fund returns.

[Insert Table 3 about here]

Table 3 reports the cross-sectional relation between age and expected returns. For all funds, returns seem to decrease with age, but the relation is not strong. While the average return differential between low-age and high-age portfolios has a positive value (0.13% per month), it is not statistically significant. This weak relation results from the weak relation between age and expected returns for defunct funds.

In the live fund group, portfolio returns generally decrease with age. In other words, younger funds outperform older funds, on average. The average return difference between the two extreme portfolios is 0.30% per month (or 3.61% per annum), significant at the 5% level. This result is consistent with previous studies, where younger funds can be attractive because they are more eager to achieve good performance to attract new investors, whereas older funds that have survived already have track records for attracting and keeping investments

(see Aggarwal and Jorion, 2010).[14] However, the age effect is much weaker for defunct funds: The average return difference between the two extreme portfolios is only 0.03% per month, which is not statistically significant. This result comes from our restriction on the primary hedge fund database, where each fund must have at least a 24-month return history. While the average age of defunct funds in the primary database is much lower than that of live funds, Table 3 reports that this difference lessens considerably after applying the above requirement. Hence, defunct funds can weaken their relation between age and expected returns through the data filtering process.[15]

[Insert Table 4 about here]

Table 4 reports the cross-sectional relation between asset size and expected returns. Portfolio returns generally decease with portfolio rank across the 10 portfolios, from low to high asset size, in an almost monotonic relation. Specifically, while the smallest fund portfolio makes a profit of 1.25% per month, the largest one makes a profit of 0.67% per month. The average return difference between these two portfolios is 0.57% per month (or 6.85% per annum), significant at the 1% level. The size effect is much stronger for live funds than for defunct funds. In the live fund group, the smallest fund portfolio (with a return of 1.43%) outperforms the largest one (with a return of 0.79%) by 0.64% per month (or 7.64% per annum), which is significant at the 1% level. On the contrary, in the defunct fund group, the average return difference between the two extreme portfolios is 0.36% per month (or 4.26% per annum) and significant at the 15% level. This result is consistent with previous literature,

[14] The following are possible reasons why younger funds are attractive in the hedge fund industry: incentive effects (Agarwal, Daniel, and Naik, 2009), size effects (Goetzmann, Ingersoll, and Ross, 2003; Getmansky, 2004), newer ideas for trades, and the career concerns of portfolio managers (Boyson, 2008).

[15] In fact, without a restriction on the number of nonmissing return observations, we find that there is a statistically significant relation between age and expected returns for defunct funds.

where hedge funds may provide decreasing returns to scale due to limited market opportunities and the high market impact of trades (see, e.g., Goetzmann, Ingersoll, and Ross, 2003; Agarwal, Daniel, and Naik, 2005; Berk and Green, 2004; Getmansky, 2004). This literature reports that large hedge funds are closed to new investors because fund managers do not want their funds to become too large to manage. Since market opportunities are limited and the market impact of trades is high in the hedge fund industry, the asset size of a fund should be small enough for fund managers to fully invest fund assets into their favorable securities and move quickly between different market sectors when needed. Furthermore, these studies indicate that there is an optimal fund size, because fund managers with large assets may choose to close the funds to new investors before facing a decrease in returns and an increase in liquidation probabilities.

[Insert Table 5 about here]

Lastly, Table 5 reports the cross-sectional relation between liquidity and expected returns. Consistent with Liang (1999) and Aragon (2007), fund liquidity measured by the lockup dummy variable has a very important role in explaining the cross-sectional variation in hedge fund returns. Funds with a lockup provision outperform those without one by 0.21% per month (or 2.46% per annum), significant at the 1% level. Moreover, the relation between a lockup provision and expected returns is positive and statistically significant for both live and defunct funds. As mentioned in Section 3.2, this result comes from the fact that fund managers with lockup provisions have the flexibility to invest in illiquid securities.

4.2. Portfolio-based analysis (bivariate sorting)

The results in Section 4.1.2 show that hedge fund returns are related to fund characteristics such as age, asset size, and liquidity. Hence, to examine the actual underlying relation between systemic risk and hedge fund returns, we must control for age, asset size, and liquidity. In other words, the relation between systemic risk and hedge fund returns can be affected by these fund characteristics. To separate the age (asset size or liquidity) effect from the MES, we form portfolios using bivariate sorting: We first form fund groups based on individual fund age (asset size or liquidity) and then form 10 portfolios based on funds' MESs within each age (asset size or liquidity) group. After constructing portfolios through the above process, we confirm whether the relation between systemic risk contribution and expected returns still holds within each age (asset size or liquidity) group.

[Insert Table 6 about here]

Table 6 reports the cross-sectional relation between the MES and expected returns, controlling for the age effect. We first construct three age groups with equal amounts of funds in each group; we then form 10 portfolios within each age group based on their MESs. The results for all funds in Panel A of Table 6 indicate that the relation between systemic risk measured by the MES and expected return is positive and statistically significant across all three age groups. In particular, the relation is the strongest in the low-age group, where the average return difference between the two extreme portfolios is 1.89% per month (or 22.63% per annum) and significant at the 1% level. The relation in the medium- and high-age groups is a little weaker, but still statistically significant. Furthermore, the relation for all funds is similar to that for both live and defunct funds. For live and defunct funds, the positive

relation between systemic risk measured by the MES and expected return holds across all three age groups and is statistically significant except for the high-age group.

[Insert Table 7 about here]

Table 7 reports the cross-sectional relation between the MES and expected returns, controlling for asset size. We first construct three asset size groups with equal amounts of funds in each group; we then form 10 portfolios within each asset size group based on their MESs. Similar to the results in Table 6, the results for all funds in Panel A of Table 7 indicate that the relation between systemic risk measured by the MES and expected return is positive and statistically significant across all three asset size groups. In particular, this relation is strongest in the low-asset group, where the low-MES portfolio (with a return of 1.83%) outperforms the high-MES portfolio (with a return of 0.15%) by 1.67% per month (or 20.08% per annum), which is significant at the 1% level. The relation in the medium- and high-asset groups is a little weaker, but still statistically significant at the 1% level. Furthermore, the relation for all funds is similar to that for both live and defunct funds. For live and defunct funds, the positive relation between systemic risk measured by the MES and expected return holds across all three asset groups and is the strongest in the low-asset group.

[Insert Table 8 about here]

Table 8 reports the cross-sectional relation between the MES and expected returns, controlling for liquidity. We first construct two liquidity groups based on the lockup dummy; we then form 10 portfolios within each liquidity group based on their MESs. The results for all funds in Panel A of Table 8 indicate that the relation between systemic risk measured by

the MES and expected return is positive and statistically significant across both liquidity groups. The average return difference between the two extreme portfolios for funds with and without a lockup provision is 1.20% per month (or 14.34% per annum) and 1.25% per month (or 14.96% per annum), respectively, both statistically significant at the 1% level. Moreover, regardless of whether a fund is live or defunct, the relation between systemic risk measured by the MES and expected return is positive and statistically significant across both liquidity groups.

In summary, these results show that, regardless of whether a fund is live or defunct, the relation between the systemic risk contribution of a hedge fund measured by the MES and hedge fund returns is positive and statistically significant, even after controlling for age, asset size, and liquidity effects. However, the strength of the relation is complicated by fund characteristics related to fund risk. In particular, the relation is the strongest for young and small funds.

4.3. Regression-based analysis

Since Section 4.1 and 4.2 investigate the relation between the systemic risk contribution of a hedge fund measured by the MES and hedge fund returns at the portfolio level, we lose fund-specific information. To consider different risk factors in one model and include fund-specific information, we run the cross-sectional one-month-ahead predictive regressions to examine the predictive power of the MES at the individual fund level.

[Insert Table 9 about here]

Table 9 reports the results from the cross-sectional regressions of the one-month-ahead returns on the MES, age, asset size, and lockup dummy for all, live, and defunct funds.

The regression models can be represented as Eq. (5) in Section 3.3, where the MES is that when the market return is below its fifth percentile, and Age, Asset, and LockupD are the age, the natural logarithm of AUM, and the dummy variable for the lockup provision of an individual hedge fund, respectively. Table 9 presents the time series averages of the monthly slope coefficients over the 132 monthly observations (from January 1999 to December 2009). *T*-statistics, which is the average slope divided by its time series standard error, are reported in square brackets.

Consistent with the results from portfolio-based analysis based on univariate sorting in Section 4.1, the result from the univariate regressions (Model (1)–(4)) shows that hedge fund returns have a statistically significant negative relation to the MES, age, and asset size, whereas the relation between hedge fund returns and the lockup dummy is positive and statistically significant. Although the regression coefficients for the live funds are more significant than for the defunct funds, the signs of the regression coefficients for both live and defunct funds are in the same direction. In addition, the average adjusted R^2 values are much higher for MES regression (about 6%) than for age, asset size, or liquidity regressions (below 1%). This result indicates that the MES plays a more important role than the other factors in explaining the cross-sectional variation in hedge fund returns.

Consistent with the results from portfolio-based analysis based on bivariate sorting in Section 4.2, the results from the multivariate regressions (Model (5)–(8)) report that the MES is statistically significant across all models. While the age variable is statistically significant at the 10% significance level, at least, for all regression specifications, the asset size variable and lockup dummy lose their significance in some of the models; they are subdued by the other factors, such as the MES and age variable. For example, the lockup dummy loses its significance for live funds and both the asset size variable and lockup dummy lose their significance for defunct funds. Therefore, the MES and fund age are more important variables

than asset size and liquidity in explaining the cross-sectional variation in hedge fund returns based on multivariate regression analysis. Lastly, the sign of each variable in multivariate regression is the same as that in univariate regression.

In summary, the results from regression-based analysis are consistent with those from portfolio-based analysis. The cross-sectional relation between the systemic risk contribution of a hedge fund measured by the MES and hedge fund returns are statistically and economically significant after controlling for age, asset size, and liquidity effects. Moreover, the systemic risk contribution of a hedge fund measured by the MES is one of the most important factors in explaining the cross-sectional variation in hedge fund returns. In addition, significant factors in explaining the cross-sectional variation in hedge fund returns are slightly different between live and defunct funds. Whereas the MES, age, and asset size are important factors for live funds, only the MES and age are important for defunct funds. Lastly, the result indicates that young and small funds with a high systemic risk contribution and a nonzero lockup period outperform old, large funds with a low systemic risk contribution and zero lockup period, on average.

5. Additional tests

The previous sections present the main result of the paper about the relation between the systemic risk contribution of hedge funds and a cross-section of hedge fund returns. This section provides additional analysis, including robustness tests, to highlight the significance of the results.

5.1. Number of observations in the estimation of the MES

In the previous section, we use a 95% MES using nonmissing return observations over the past 60 months (length of the MES estimation period) to form a systemic risk

portfolio. In addition, in any given month, we use only funds with at least 24 months (restriction on the number of nonmissing return observations) of return observations over the estimation period. Although these MESs are all 95% MESs, they are obtained from different numbers of return observations across each individual fund. To check the effect of different numbers of observations in the estimation of the MES on our main results, we repeat the analysis in Section 4 across different MES estimation periods and restrictions on the number of nonmissing return observations.

[Insert Table 10 about here]

Table 10 reports the cross-sectional relation between the MES and expected hedge fund returns across different MES estimation periods (30, 60, and 90 months) and restrictions on the number of nonmissing return observations (24, 36, and all observations). Although some cases, as in case 4, may induce more survivorship bias than the benchmark case (case 3) due to a stricter minimum number of nonmissing return observations, our main results remain significant within most cases of different MES estimation periods and restrictions on the number of nonmissing return observations. More exactly, the positive relation between systemic risk and hedge fund return does not significantly vary with the length of the MES estimation period and the restriction on the number of nonmissing return observations. From deciles 1 to 10, the expected returns decrease almost monotonically within most cases. Moreover, the average return differentials between deciles 1 and 10 are positive and statistically significant at the conventional level, with the exception of case 7, which has the biggest survivorship bias among the cases.

5.2. Risk-adjusted returns of hedge fund portfolios sorted by MES

This section examines whether the cross-sectional relation between hedge fund returns and systemic risk is affected by commonly used hedge-fund factors. To investigate this effect, we repeat the analysis in Section 4 using risk-adjusted portfolio returns instead of raw portfolio returns. To compute risk-adjusted portfolio returns, we use the Fung-Hsieh (2004) seven-factor model which is the most widely used factor model. Fung and Hsieh (2004) propose an asset-based style factor model using seven risk factors to explain the risk of well diversified portfolios of hedge funds. The Fung-Hsieh seven factors include two equity-oriented risk factors (the equity market factor and the size spread factor), two bond-oriented risk factors (the bond market factor and the credit spread factor), and three trend-following risk factors of Fung and Hsieh (2001) on bonds (PTFSBD), currencies (PTFSFX), and commodities (PTFSCOM).[16] We simply regress the monthly portfolio returns sorted by MES on the seven hedge-fund factors, and then use the intercept of this regression, which is called the Fung-Hsieh alpha, as the risk-adjusted portfolio returns.

[Insert Table 11 about here]

Table 11 reports the cross-sectional relation between hedge fund returns and systemic risk, controlling for the commonly used hedge-fund factors. The results in Table 11 indicate that, regardless of whether a fund is live or defunct, the cross-sectional relation between

[16] The equity market factor is measured by Standard & Poor′s 500 index monthly total return. The size spread factor is measured by Russell 2000 index monthly total return less Standard & Poor′s 500 monthly total return. The bond market factor is measured by the monthly change in the 10-year treasury constant maturity yield. The credit spread factor is measured by the monthly change in the Moody's Baa yield less 10-year treasury constant maturity yield. The trend-following factors, the so-called ″primitive trend following strategies″ (PTFS), which are based on Fung and Hsieh (2001), are calculated by the monthly returns of the portfolios of look-back options (on long-term bonds, currencies and commodities). We thank David A. Hsieh for providing his risk factors on his respective website: http://faculty.fuqua.duke.edu/~dah7/DataLibrary/TF-FAC.xls.

hedge fund returns and systemic risk is still statistically and economically significant, even after controlling for commonly used hedge-fund factors. From deciles 1 to 10, the risk-adjusted portfolio returns decrease almost monotonically. For all funds, the highest risk-adjusted portfolio return (1.35% per month) and the lowest (0.19% per month) correspond to the lowest-MES portfolio and the highest, respectively. Moreover, the average return differential between deciles 1 and 10 is positive and statistically significant. The average return differences between portfolios 1 and 10 for all, live, and defunct funds are 1.16% per month (or 13.88% per annum), 1.13% per month (or 13.51% per annum), and 1.15% per month (13.79% per annum), respectively, which are all significant at the 1% level.

This result is consistent with Sadka (2010), where the risk associated with violent crises can be priced in the cross-section of hedge fund returns, despite the rarity of such crises, whereas the Fung-Hsieh factors do not seem to generate a spread in expected hedge fund returns. In this context it is important to note that the Fung-Hsieh factors are originally designed to explain time-series variation of hedge fund returns, not the cross-sectional variation of expected hedge fund returns. Moreover, systemic risk is related to infrequent yet violent crises. This implies that the systemic risk contribution of hedge funds is priced in the cross-section of hedge fund returns, while it would not explain much of the time-series variation of hedge fund returns.

5.3. Leverage effect

Although Acharya et al. (2010) propose that the SES increases with the institution's leverage and its MES, we use only the MES to measure a hedge fund's contribution to systemic risk in Section 4 due to the lack of time series data related to information on hedge fund leverage. This section briefly examines whether the cross-sectional relation between hedge fund returns and systemic risk is affected by hedge fund leverage. To separate the

leverage effect from the MES, we form portfolios using bivariate sorting: We first form two leverage groups based on the leverage dummy[17] and then form 10 portfolios based on funds' MESs within each leverage group.

[Insert Table 12 about here]

Table 12 reports the cross-sectional relation between hedge fund returns and systemic risk, controlling for leverage. The results in Table 12 indicate that the relation between systemic risk measured by the MES and expected return is positive and statistically significant across both leverage groups. From deciles 1 to 10, the risk-adjusted portfolio returns decrease almost monotonically. The average return difference between the two extreme portfolios for funds with and without leverage is 1.48% per month (or 17.79% per annum) and 1.30% per month (or 15.66% per annum), respectively, both statistically significant at the 1% level. Moreover, regardless of whether a fund is live or defunct, the relation between systemic risk and hedge fund returns holds even after controlling for leverage effect.

5.4. Liquidity risk

Sadka (2010) shows that liquidity risk as measured by the covariation of fund returns with unexpected changes in aggregate liquidity is an important determinant in the cross-section of hedge fund returns. In other words, high-liquidity-loading funds significantly outperform low-liquidity-loading funds in the future, consistent with the interpretation of an expected return premium to holding liquidity risk. He focuses on the concept of market-wide liquidity as an undiversifiable risk factor (the liquidity risk) rather than on the asset-specific

[17] The TASS database provides information on whether each individual fund uses leverage or not.

liquidity characteristic (the liquidity level). This literature emphasizes an apparent imbalance between the liquidity risk and the liquidity level in explaining the cross-section of hedge fund returns. It shows that the impact of liquidity risk on the cross-section of hedge fund returns is independent of share restrictions, such as lockup and redemption notice periods, which are used to proxy for fund illiquidity. For this reason, this section examines the impact of liquidity risk on the cross-sectional relation between hedge fund returns and systemic risk.

To separate the effect of exposure to liquidity risk from the MES, we form portfolios using bivariate sorting: We first form fund groups based on two-year rolling liquidity factor loadings and then form 10 portfolios based on funds' MESs within each liquidity-loading group. The liquidity loading of each fund is calculated using a simple regression of the fund's monthly return on the market return and the liquidity factor. We use the permanent-variable component[18], one of the price-impact factors constructed in Sadka (2006), as the liquidity factor. In any given month, we include only funds with at least 18 months of return observations over the prior 24 months.[19]

[Insert Table 13 about here]

Table 13 reports the cross-sectional relation between hedge fund returns and systemic risk, controlling for liquidity risk. The results in Table 13 are consistent with Sadka (2010) showing that high-liquidity-loading funds outperform low-liquidity-loading funds, on average. Nevertheless, our main results are still statistically and economically significant. For all funds, the average return differences between the two extreme portfolios vary in the range 0.59–1.28% per month (t-statistics above 1.61). In particular, regardless of whether a fund is live or

[18] These data are obtained from Wharton Research Data Service (WRDS). Since the data are available up to December 2008, we perform the analysis in Section 5.4 over the period 1999-2008.

[19] For further details on the evaluation of a fund′s exposure to liquidity risk, see Sadka (2006, 2010).

defunct, the relation between systemic risk measured by the MES and expected return is the strongest in the high-liquidity-loading group. Overall, these results imply that, although liquidity events can cause systemic shocks, the impact of systemic risk measured by the MES on the cross-section of hedge fund returns is different from that of liquidity risk exposure on the cross-section of hedge fund returns.

5.5. Long-term predictability

Because hedge fund investors are often confronted with share restrictions, such as a lockup provision, or a redemption notice period, they cannot immediately withdraw or rebalance their shares. It is of interest therefore to examine how early MES predict the cross-section of hedge fund returns. To check the long-term predictive power of the MES, we calculate portfolio returns using not only one-month-ahead returns but also one-quarter-ahead, two-quarter-ahead, three-quarter-ahead, and one-year-ahead returns. For example, in case of the MES measured over the period from January 1994 to December 1998, we assign one-month-ahead (i.e., January 1999), one-quarter-ahead (i.e., April 1999), two-quarter-ahead (i.e., July 1999), three-quarter-ahead (i.e., October 1999), and one-year-ahead (i.e., January 2000) returns to the estimated MES.

[Insert Table 14 about here]

Table 14 reports the cross-sectional relation between the MES and expected hedge fund returns across different assigned returns. Although the results in Table 14 show that the predictive power of the MES declines as we use lagged data for calculating the measure, the positive relation between systemic risk and hedge fund return still holds. From deciles 1 to 10, the expected returns decrease almost monotonically, except for the one-year-ahead return

case. Moreover, the average return differentials between deciles 1 and 10 are positive and statistically significant at the conventional level, with the exception of the one-year-ahead return case, which exhibits insignificant but still positive average return differentials. These results suggest that MES is a useful tool for evaluating the systemic risk contribution of hedge funds in practice, even after taking into account share restrictions.

5.6. Long-run performance

Hedge fund researchers have been aware of the reliability of hedge fund databases resulting from the voluntary nature of the data collection process. Although the hedge fund literature has documented various biases in hedge fund databases, such as survivorship bias, liquidation bias, backfill bias, and selection bias, this section focuses on the serial correlation of hedge fund returns. Asness, Krail, and Liew (2001) find that hedge fund indexes have serial correlation and that their returns are correlated to past returns of market factors such as the Standard & Poor's 500. This correlation can be the result of the infrequent trading of illiquid securities in their portfolios or of managerial manipulation to smooth returns.[20] The serial correlation of hedge fund returns suggests that measuring a fund's performance over a long period can be more indicative of its performance.

To investigate this effect, we use multiple-month cumulative returns computed for non-overlapping intervals. For example, to calculate a three-month holding period return, portfolios are updated only at the beginning of January, April, July, and October of each year.

[Insert Table 15 about here]

[20] Getmansky, Lo, and Makarov (2004) provide a formal statistical model applied to individual hedge funds. Unfortunately, neither Asness, Krail, and Liew (2001) nor Getmansky, Lo, and Makarov (2004) are able to distinguish between the two causes of serial correlation in hedge funds; illiquid securities and return smoothing.

Table 15 reports the cross-sectional relation between the MES and expected hedge fund returns across different holding periods (one, three, six, and 12 months). The returns in Table 15 are annualized to facilitate easy comparisons across different holding periods. The results in Table 15 indicate that the positive relation between systemic risk and hedge fund return does not significantly vary with the holding period or rebalancing frequency. From deciles 1 to 10, the expected returns decrease almost monotonically. Moreover, the average return differential between deciles 1 and 10 varies over 14.96–20.38% per annum (t-statistics above 1.97). From a practical point of view, the long-run performance of the low-minus-high portfolio also relaxes some concerns about the monthly portfolio rebalancing, which would require redemptions subject to notice periods and lockups.

[Insert Fig. 1 about here]

Since the profitability of the strategy over longer holding periods can vary with a particular starting month, we calculate the long-run performance of the low-minus-high portfolio re-formed at the beginning of each month. Each panel in Fig. 1 presents the time series of the returns of the low-minus-high portfolio formed at the beginning of each month, but returns are cumulated over the following few months without rebalancing. For example, Panel C of Fig. 1 plots the six-month cumulative return for the low-minus-high portfolio while keeping the funds fixed for six months, and the portfolio is re-formed in each month. Panels B and C in Fig. 1 suggest that no matter when the portfolio is formed during the sample period, as long as it is not rebalanced for three or six months, it is likely to earn positive profits most of the time, which supports the results in Table 15.

5.7. Crisis versus noncrisis periods

This section compares the performance of the low-minus-high portfolio during crisis and noncrisis periods. If the higher systemic risk contribution of hedge fund the higher expected hedge fund return, the low-minus-high portfolio should earn negative returns during crisis periods and positive returns during noncrisis periods.

[Insert Table 16 about here]

Table 16 reports the cross-sectional relation between the MES and expected hedge fund returns over the crisis and noncrisis periods. The sample period includes two significant crises: August–October of 2007 (the "quant" crisis), and September–November of 2008 (the U.S. subprime crisis). Panel A of Table 16 reports the average monthly returns of portfolios that are rebalanced monthly and Panel B reports the three-month cumulative returns of portfolios that are rebalanced quarterly. For the crisis periods, the portfolios are rebalanced at the beginning of each crisis and are held for the three-month crisis period. For the noncrisis periods, portfolios are rebalanced at the beginning of each calendar quarter and only quarters that do not overlap with any of the crisis periods are used. For the entire sample period, all calendar quarters are used. The results in Table 16 show that the low-minus-high portfolios earn negative returns during crisis periods, while positive returns are observed during noncrisis periods. Moreover, the average negative returns during crisis periods are higher (in absolute value) than those during noncrisis periods. These results suggest that the systemic risk contribution of hedge funds explains the cross-sectional variation in hedge fund returns during crisis and noncrisis periods.

6. Conclusion

This paper examines the cross-sectional relation between systemic risk and hedge fund returns. The systemic risk of individual hedge funds is measured using the MES proposed by Acharya et al. (2010). This paper's main research question is whether the systemic risk contribution of hedge funds explains the cross-sectional variation in hedge fund returns. To answer this question, we conduct analyses adopted from an asset pricing framework, not only at the portfolio level (portfolio-based analysis) but also at the individual level (regression-based analysis).

Our paper's major findings can be summarized as follows. First, we find evidence of a positive and statistically significant relation between the systemic risk contribution of hedge funds measured by the MES and hedge fund returns. Moving from a low- to a high-MES portfolio, expected portfolio returns decrease almost monotonically. The low-MES portfolio outperforms the high-MES portfolio by 1.38% per month (or 16.61% per annum), on average, over the period 1999–2009, while negative performance is observed during crisis periods.

Second, the relation between systemic risk and hedge fund returns holds, regardless of whether a fund is live or defunct. Although the strength of the relation for live funds is slightly different from that for defunct funds, these two relations are economically the same. The low-MES portfolio outperforms the high-MES portfolio by 1.22% per month (or 14.69% per annum) and 1.42% per month (or 17.10% per annum) for the live and defunct funds, respectively.

Third, the relation between systemic risk and hedge fund returns holds even after controlling for fund characteristics related to fund risk, such as fund age, asset size, and liquidity, as well as commonly used hedge-fund factors, such as the Fung-Hsieh (2004) seven factors and the Sadka (2006, 2010) liquidity risk factor.

Finally, the systemic risk contribution of hedge funds measured by the MES is one of the most important factors in explaining the cross-sectional variation in hedge fund returns, even after taking into account fund characteristics such as age, asset size, and liquidity. Moreover, the important risk factors are different for live and defunct funds. Whereas the MES, age, and asset size are significant factors for live funds, only the MES and age are significant factors for defunct funds. Overall, young, small funds with a high systemic risk contribution and a nonzero lockup period outperform old, large funds with a low systemic risk contribution and zero lockup period.

Our findings provide some insights into the financial regulation and risk management of hedge funds and imply that hedge fund managers have an incentive to take systemic risks unless the external costs thereof are internalized by each hedge fund. Whereas current financial regulations and risk management are designed to limit each entity's risk seen in isolation, this paper supports the attitude that they should be focused on limiting systemic risk, which is the risk of a financial crisis and its spillover to the economy at large.

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Table 1
Descriptive statistics for hedge fund returns.

This table shows the descriptive statistics of monthly hedge fund returns for each hedge fund category (all, live, and defunct funds), including the number of funds, the average value of the sample mean, the standard deviation, skewness, and the excess kurtosis of individual hedge fund returns for each hedge fund category. This table also reports the percentage of funds for which the null hypothesis of normally distributed returns is rejected by the Jarque–Bera test at the 10% confidence level. The data are from the TASS database and the sample period is from January 1994 to December 2009. To be included in the analysis, a fund should report its returns in U.S. dollars, net of fee, on a monthly basis and have at least a 24-month return history. Funds of funds and managed futures are excluded. Funds with AUM of less than $10 million are also excluded. Under the null of normality, the Jarque–Bera test statistics follow a chi-squared distribution with two degrees of freedom.

	Number of funds	Mean (%)	Standard deviation (%)	Skewness	Excess kurtosis	Test of normality
						% of funds with Jarque–Bera $p < 0.1$
All funds	1406	0.86	4.22	-0.33	4.52	73.33
Live funds	645	0.97	4.53	-0.34	4.57	78.45
Defunct funds	761	0.76	3.95	-0.33	4.48	68.99

Table 2
Average returns of hedge fund portfolios sorted by MES (January 1999 to December 2009).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. The last column presents the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
MES (%)	-11.84	-5.80	-3.23	-1.75	-0.73	0.02	0.63	1.39	2.83	8.89	
Return (%)	1.63	1.16	1.20	0.78	0.76	0.66	0.55	0.51	0.63	0.25	1.38***
	[3.59]	[4.01]	[4.90]	[4.14]	[4.68]	[5.09]	[4.29]	[4.40]	[4.42]	[1.21]	[3.23]
Panel B: Live funds											
MES (%)	-11.04	-5.36	-3.09	-1.85	-0.86	-0.02	0.76	1.62	3.02	8.65	
Return (%)	2.08	1.37	1.22	0.91	0.82	0.96	0.78	0.59	0.78	0.85	1.22***
	[4.32]	[4.38]	[4.87]	[4.44]	[4.49]	[7.08]	[5.94]	[4.15]	[4.67]	[3.86]	[2.93]
Panel C: Defunct funds											
MES (%)	-12.22	-5.69	-2.88	-1.45	-0.51	0.12	0.61	1.34	2.76	9.42	
Return (%)	1.34	0.74	0.84	0.55	0.48	0.35	0.28	0.18	0.47	-0.08	1.42***
	[3.04]	[2.79]	[3.88]	[2.67]	[2.91]	[2.45]	[1.78]	[1.24]	[3.35]	[-0.34]	[3.07]

Table 3
Average returns of hedge fund portfolios sorted by age (January 1999 to December 2009).

This table presents the average value of the age and the one-month-ahead returns for each age portfolio for all, live, and defunct funds. The age portfolios are formed based on age, where age is measured in months. The last column presents the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Age deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Age (in months)	25.44	31.25	37.63	44.85	53.13	62.95	74.83	88.74	107.86	154.74	
Return (%)	0.83	0.97	0.84	0.90	0.79	0.83	0.82	0.78	0.78	0.69	0.13
	[4.20]	[4.81]	[4.43]	[5.29]	[4.24]	[4.91]	[4.05]	[4.11]	[3.83]	[3.34]	[1.33]
Panel B: Live funds											
Age (in months)	25.74	31.95	38.80	46.31	54.93	64.95	76.54	90.43	109.10	150.91	
Return (%)	1.27	1.30	1.09	1.04	0.93	1.14	0.80	1.16	0.90	0.97	0.30**
	[5.85]	[5.41]	[4.83]	[5.88]	[4.57]	[5.94]	[3.64]	[4.82]	[4.47]	[4.08]	[2.10]
Panel C: Defunct funds											
Age (in months)	25.35	30.66	36.56	43.65	51.96	62.28	75.51	89.29	108.18	159.80	
Return (%)	0.33	0.59	0.55	0.77	0.77	0.53	0.61	0.42	0.40	0.30	0.03
	[1.55]	[3.06]	[2.82]	[3.70]	[3.85]	[3.18]	[3.28]	[2.56]	[1.67]	[1.40]	[0.20]

Table 4

Average returns of hedge fund portfolios sorted by asset size (January 1999 to December 2009).

This table presents the average value of the asset size and the one-month-ahead returns for each asset size portfolio for all, live, and defunct funds. The asset size portfolios are formed based on asset size, with the asset size measured by the natural logarithm of AUM. The last column presents the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Asset deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Ln(Asset)	15.59	16.56	17.02	17.37	17.72	18.07	18.46	18.91	19.48	20.49	
Return (%)	1.25	0.88	0.88	0.80	0.82	0.72	0.78	0.70	0.72	0.67	0.57***
	[5.25]	[3.75]	[3.92]	[4.04]	[4.36]	[3.95]	[4.53]	[4.41]	[3.90]	[4.32]	[3.63]
Panel B: Live funds											
Ln(Asset)	15.78	16.67	17.16	17.51	17.84	18.20	18.61	19.07	19.62	20.54	
Return (%)	1.43	1.35	1.32	0.98	0.77	1.03	1.22	0.91	0.78	0.79	0.64***
	[5.96]	[4.51]	[4.85]	[4.80]	[3.99]	[4.98]	[5.57]	[4.04]	[4.29]	[4.37]	[3.85]
Panel C: Defunct funds											
Ln(Asset)	15.38	16.43	16.88	17.22	17.56	17.93	18.31	18.76	19.36	20.54	
Return (%)	0.92	0.65	0.43	0.45	0.64	0.53	0.23	0.39	0.38	0.57	0.36
	[3.63]	[2.89]	[1.93]	[2.06]	[2.96]	[2.99]	[1.34]	[2.92]	[2.44]	[3.21]	[1.61]

Table 5

Average returns of hedge fund portfolios sorted by lockup period (January 1999 to December 2009).

This table presents the average value of the lockup dummy and the one-month-ahead returns for each liquidity portfolio for all, live, and defunct funds. The liquidity portfolios are formed based on the lockup dummy. If a fund has a nonzero lockup period, we set the dummy variable equal to one; otherwise, the dummy variable equals zero. The last column presents the average return differential between two liquidity portfolios. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Liquidity deciles		
	Lockup	Non-lockup	Lockup - non-lockup
Panel A: All funds			
LockupD	1	0	
Return (%)	0.95	0.75	0.21***
	[4.88]	[4.31]	[2.90]
Panel B: Live funds			
LockupD	1	0	
Return (%)	1.16	1.00	0.17**
	[5.63]	[5.12]	[2.22]
Panel C: Defunct funds			
LockupD	1	0	
Return (%)	0.65	0.47	0.18*
	[3.55]	[3.02]	[1.91]

Table 6

Average returns of hedge fund portfolios for bivariate sorts, first by age and then by MES (January 1999 to December 2009).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed first, sorted by three age groups (low, medium, and high) and then by MES. The MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Panels A, B, and C use all, live, and defunct funds, respectively. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Low-age group											
MES (%)	-10.47	-4.61	-2.53	-1.22	-0.21	0.59	1.36	2.45	4.25	12.20	
Return (%)	1.75	1.42	1.19	0.74	0.71	0.73	0.52	0.86	0.78	-0.14	1.89***
	[3.67]	[4.52]	[4.84]	[4.01]	[5.15]	[4.89]	[3.93]	[4.18]	[4.61]	[-0.46]	[3.75]
Medium-age group											
MES (%)	-11.24	-5.57	-3.25	-1.67	-0.62	0.09	0.64	1.30	2.64	7.20	
Return (%)	1.66	1.31	1.20	0.77	0.86	0.56	0.54	0.39	0.70	0.29	1.36***
	[3.92]	[4.26]	[4.22]	[3.65]	[5.50]	[4.48]	[3.24]	[3.13]	[5.48]	[1.40]	[3.23]
High-age group											
MES (%)	-12.48	-6.79	-3.81	-2.17	-1.19	-0.51	0.20	0.86	1.98	5.76	
Return (%)	1.36	1.14	0.99	0.86	0.55	0.89	0.60	0.38	0.21	0.39	0.97**
	[2.81]	[3.37]	[3.84]	[3.98]	[3.00]	[4.72]	[4.82]	[2.38]	[1.17]	[1.80]	[2.04]
Panel B: Live funds											
Low-age group											
MES (%)	-9.64	-4.55	-2.43	-1.13	-0.08	0.69	1.52	2.70	4.21	11.31	
Return (%)	2.61	1.45	1.42	0.83	0.97	0.86	0.74	0.99	0.91	0.64	1.97***
	[4.29]	[4.07]	[5.52]	[4.76]	[5.55]	[4.07]	[5.35]	[4.78]	[3.83]	[2.36]	[3.43]
Medium-age group											
MES (%)	-10.68	-5.19	-2.99	-1.53	-0.53	0.14	0.79	1.71	2.93	7.23	
Return (%)	1.81	1.12	1.13	0.75	0.92	0.86	1.00	0.70	0.82	0.62	1.19***
	[3.96]	[3.57]	[4.10]	[3.77]	[6.12]	[4.71]	[5.87]	[3.81]	[4.40]	[2.43]	[2.67]
High-age group											
MES (%)	-10.98	-5.93	-3.25	-2.20	-1.40	-0.68	0.08	1.01	2.43	6.05	
Return (%)	1.11	1.91	1.20	0.99	0.57	1.03	0.63	0.32	0.75	0.90	0.21
	[2.34]	[5.00]	[3.63]	[4.15]	[2.60]	[5.84]	[4.16]	[1.54]	[2.33]	[3.02]	[0.37]
Panel C: Defunct funds											
Low-age group											
MES (%)	-10.90	-4.33	-2.16	-0.98	-0.15	0.64	1.37	2.47	4.34	12.83	
Return (%)	0.92	0.83	0.75	0.65	0.32	0.32	0.53	0.32	0.30	-0.19	1.10*
	[1.86]	[2.82]	[2.48]	[3.28]	[2.21]	[1.54]	[2.19]	[1.38]	[1.58]	[-0.47]	[1.87]
Medium-age group											
MES (%)	-11.16	-5.24	-2.98	-1.47	-0.48	0.15	0.74	1.46	2.73	8.36	
Return (%)	1.72	1.71	0.92	0.58	0.40	0.22	0.19	0.35	0.41	-0.10	1.82***
	[3.89]	[4.30]	[2.69]	[2.93]	[2.39]	[1.09]	[0.88]	[2.53]	[2.82]	[-0.30]	[3.29]
High-age group											
MES (%)	-12.35	-6.69	-3.73	-1.70	-0.78	-0.09	0.44	0.92	1.97	5.74	
Return (%)	0.88	0.67	0.32	0.55	0.21	0.67	0.41	0.01	0.10	0.02	0.86
	[1.56]	[2.27]	[1.09]	[2.47]	[0.77]	[4.07]	[1.85]	[0.04]	[0.55]	[0.07]	[1.40]

Table 7
Average returns of hedge fund portfolios for bivariate sorts, first by asset size and then by MES (January 1999 to December 2009).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed first, sorted by three asset size groups (low, medium, and high) and then by MES. The MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Panels A, B, and C use all, live, and defunct funds, respectively. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Low-asset group											
MES (%)	-14.10	-7.78	-4.76	-2.90	-1.53	-0.42	0.41	1.33	3.00	10.82	
Return (%)	1.83	1.64	1.40	1.16	0.83	0.60	0.60	0.73	0.63	0.15	1.67***
	[2.97]	[4.18]	[4.79]	[4.89]	[4.24]	[3.52]	[3.87]	[4.09]	[3.31]	[0.64]	[2.86]
Medium-asset group											
MES (%)	-11.46	-6.12	-3.36	-1.88	-0.92	-0.07	0.61	1.39	2.83	8.31	
Return (%)	1.57	1.09	1.22	0.62	0.60	0.68	0.48	0.42	0.59	0.56	1.01***
	[3.88]	[3.75]	[4.24]	[2.65]	[3.09]	[4.90]	[3.84]	[3.33]	[4.09]	[2.88]	[2.71]
High-asset group											
MES (%)	-7.66	-3.24	-1.68	-0.75	-0.13	0.36	0.89	1.65	2.86	7.60	
Return (%)	0.99	1.10	0.82	0.92	0.74	0.67	0.46	0.58	0.61	-0.06	1.04***
	[2.92]	[4.18]	[3.85]	[5.06]	[6.15]	[4.82]	[3.96]	[4.88]	[3.36]	[-0.18]	[2.57]
Panel B: Live funds											
Low-asset group											
MES (%)	-13.16	-8.16	-4.77	-2.94	-1.57	-0.49	0.44	1.48	3.09	10.29	
Return (%)	2.64	1.84	1.70	1.47	1.00	0.77	0.89	0.83	0.74	0.73	1.91***
	[3.69]	[4.20]	[4.83]	[5.64]	[4.97]	[4.08]	[5.71]	[5.18]	[3.14]	[2.58]	[2.97]
Medium-asset group											
MES (%)	-9.68	-5.16	-3.16	-1.94	-0.83	0.12	0.95	1.92	3.46	8.48	
Return (%)	1.90	0.84	1.10	0.48	0.75	0.89	0.73	0.60	0.82	1.27	0.64
	[4.85]	[2.54]	[4.05]	[2.04]	[3.74]	[5.63]	[4.20]	[3.46]	[3.99]	[4.52]	[1.38]
High-asset group											
MES (%)	-5.86	-2.95	-1.85	-0.99	-0.31	0.30	1.11	1.84	2.73	7.55	
Return (%)	1.29	1.04	0.99	1.05	0.94	0.69	0.54	0.70	0.62	0.64	0.66*
	[3.20]	[3.21]	[4.23]	[6.21]	[5.64]	[4.95]	[3.91]	[4.20]	[2.06]	[2.20]	[1.75]
Panel C: Defunct funds											
Low-asset group											
MES (%)	-14.12	-7.50	-4.50	-2.43	-1.17	-0.19	0.61	1.55	3.36	11.17	
Return (%)	1.33	1.41	0.53	0.84	0.46	0.22	0.33	0.28	0.64	-0.17	1.50**
	[2.13]	[3.15]	[1.76]	[2.97]	[1.81]	[1.16]	[1.21]	[1.48]	[3.07]	[-0.54]	[2.32]
Medium-asset group											
MES (%)	-11.73	-5.96	-2.95	-1.56	-0.67	0.06	0.67	1.46	2.91	10.23	
Return (%)	1.23	0.93	0.77	0.47	0.54	0.48	0.13	0.15	0.10	0.34	0.89*
	[2.97]	[2.90]	[2.96]	[1.46]	[3.23]	[3.31]	[0.78]	[0.82]	[0.49]	[1.02]	[1.82]
High-asset group											
MES (%)	-8.14	-2.81	-1.26	-0.43	0.01	0.39	0.83	1.42	2.73	7.11	
Return (%)	0.72	0.58	0.46	0.66	0.75	0.05	0.07	0.41	0.64	-0.42	1.13**
	[2.39]	[2.70]	[2.54]	[2.96]	[6.36]	[0.21]	[0.24]	[4.21]	[3.19]	[-1.09]	[2.26]

Table 8

Average returns of hedge fund portfolios for bivariate sorts, first by lockup period and then by MES (January 1999 to December 2009).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed first, sorted by two liquidity groups (lockup and non-lockup) and then by MES. The MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Panels A, B, and C use all, live, and defunct funds, respectively. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Lockup group											
MES (%)	-12.78	-7.11	-4.54	-2.56	-1.33	-0.43	0.36	1.23	2.70	8.72	
Return (%)	1.75	1.31	1.29	0.90	0.92	0.53	0.64	0.71	0.85	0.55	1.20***
	[3.74]	[3.98]	[4.52]	[4.26]	[4.59]	[3.17]	[3.50]	[4.85]	[4.76]	[2.65]	[2.59]
Non-lockup group											
MES (%)	-10.88	-4.80	-2.56	-1.30	-0.37	0.24	0.78	1.57	3.00	9.03	
Return (%)	1.33	1.20	1.12	0.75	0.72	0.65	0.46	0.45	0.52	0.08	1.25***
	[2.74]	[4.45]	[4.50]	[4.28]	[4.60]	[5.89]	[3.48]	[3.90]	[3.53]	[0.36]	[2.66]
Panel B: Live funds											
Lockup group											
MES (%)	-11.71	-6.94	-4.34	-2.59	-1.52	-0.57	0.42	1.36	2.83	9.87	
Return (%)	2.08	1.42	1.50	1.13	0.89	0.74	0.87	0.97	0.90	0.86	1.22**
	[4.32]	[3.77]	[4.70]	[4.44]	[4.25]	[4.60]	[6.62]	[5.91]	[4.54]	[3.32]	[2.50]
Non-lockup group											
MES (%)	-9.57	-4.00	-2.27	-1.31	-0.42	0.32	1.03	1.90	3.28	8.02	
Return (%)	2.01	1.21	1.08	0.95	0.86	0.84	0.50	0.64	0.65	0.85	1.15***
	[4.07]	[4.20]	[4.42]	[4.59]	[5.63]	[5.89]	[3.87]	[4.15]	[3.46]	[3.18]	[2.70]
Panel C: Defunct funds											
Lockup group											
MES (%)	-12.77	-6.70	-4.17	-2.14	-0.88	-0.07	0.60	1.41	2.96	9.04	
Return (%)	1.59	0.80	0.93	0.46	0.48	0.41	0.29	0.31	0.64	0.49	1.11**
	[3.33]	[2.13]	[3.18]	[1.91]	[2.07]	[1.79]	[1.43]	[1.81]	[2.18]	[1.64]	[2.06]
Non-lockup group											
MES (%)	-11.41	-4.74	-2.26	-1.08	-0.23	0.31	0.76	1.43	2.84	9.56	
Return (%)	0.81	1.00	0.90	0.51	0.48	0.31	0.27	0.13	0.31	-0.28	1.09*
	[1.65]	[4.00]	[3.87]	[2.45]	[3.02]	[2.42]	[1.63]	[0.76]	[2.10]	[-0.98]	[1.95]

Table 9

Cross-sectional regression of hedge fund returns on MES, age, asset size, and lockup period with a constant (January 1999 to December 2009).

This table presents the time series average of the monthly regression coefficients obtained from the cross-sectional regression framework of Fama and MacBeth (1973). The MES is that when the market return is below its fifth percentile. Age, Asset, and LockupD are the age, the natural logarithm of AUM, and the dummy variable for the lockup provision of an individual hedge fund, respectively. This table also reports the standard *t*-statistic, which is the average slope divided by its time series standard error, in square bracket. Panels A, B, and C use all, live, and defunct funds, respectively. The average adjusted R^2 values are reported in the last row of each panel. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: All funds								
Model	1	2	3	4	5	6	7	8
Constant	0.702***	0.899***	2.342***	0.733***	0.845***	1.512***	0.647***	1.393**
	[4.45]	[5.26]	[3.41]	[4.24]	[5.32]	[2.80]	[4.21]	[2.57]
MES	-0.05**				-0.049**	-0.046**	-0.046**	-0.046**
	[-2.17]				[-2.23]	[-2.13]	[-2.10]	[-2.12]
Age		-0.001**			-0.002***			-0.002**
		[-2.12]			[-3.66]			[-2.49]
Asset			-0.087***			-0.046*		-0.036
			[-2.70]			[-1.77]		[-1.31]
LockupD				0.217***			0.142**	0.143**
				[3.04]			[2.08]	[2.09]
Average adj. R^2	5.80%	0.11%	0.70%	0.41%	5.90%	6.32%	6.11%	6.80%
Panel B: Live funds								
Model	1	2	3	4	5	6	7	8
Constant	0.920***	1.205***	3.328***	0.977***	1.114***	2.383***	0.878***	2.165***
	[5.27]	[6.42]	[4.71]	[5.03]	[6.34]	[4.68]	[4.95]	[4.15]
MES	-0.049**				-0.051**	-0.047**	-0.048**	-0.048**
	[-2.06]				[-2.13]	[-1.98]	[-2.00]	[-2.00]
Age		-0.002***			-0.003***			-0.002**
		[-3.04]			[-3.74]			[-2.48]
Asset			-0.128***			-0.082***		-0.063**
			[-3.70]			[-3.01]		[-2.14]
LockupD				0.171**			0.101	0.087
				[2.26]			[1.34]	[1.18]
Average adj. R^2	6.14%	-0.07%	0.86%	0.22%	6.10%	6.61%	6.34%	6.76%
Panel C: Defunct funds								
Model	1	2	3	4	5	6	7	8
Constant	0.457***	0.579***	1.425*	0.454***	0.578***	0.847	0.418***	0.699
	[3.25]	[3.66]	[1.68]	[2.95]	[3.96]	[1.12]	[3.08]	[0.92]
MES	-0.039*				-0.041*	-0.039*	-0.037*	-0.039*
	[-1.78]				[-1.84]	[-1.81]	[-1.68]	[-1.80]
Age		-0.001			-0.002**			-0.002*
		[-1.08]			[-2.37]			[-1.69]
Asset			-0.052			-0.023		-0.011
			[-1.25]			[-0.61]		[-0.28]
LockupD				0.182*			0.101	0.119
				[1.86]			[1.08]	[1.24]
Average adj. R^2	7.26%	0.06%	0.79%	0.62%	7.30%	7.96%	7.81%	8.68%

Table 10

Average returns of hedge fund portfolios sorted by MES across different MES estimation periods and restrictions on the number of nonmissing return observations (January 1999 to December 2009).

This table presents the average value of the one-month-ahead returns (in percent) for each MES portfolio across different MES estimation periods (30, 60, and 90 months) and restrictions on the number of nonmissing return observations (24, 36, and all observations). The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the assigned past return histories. In any given month, we include only funds with an assigned minimum number of nonmissing return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also presents the average return differential between deciles 1 and 10. T-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Case	Length of measuring period	Restriction on length of nonmissing observations	MES deciles										
			1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
1	30	24	1.48	0.89	0.78	0.77	0.88	0.79	0.70	0.74	0.62	0.74	0.74*
			[3.50]	[2.93]	[3.12]	[3.56]	[5.60]	[6.56]	[4.93]	[5.18]	[4.92]	[4.13]	[1.73]
2	30	30	1.51	0.80	0.90	0.76	0.86	0.71	0.74	0.74	0.60	0.73	0.78*
			[3.49]	[2.80]	[3.54]	[3.59]	[5.24]	[5.76]	[5.30]	[4.88]	[4.60]	[4.08]	[1.75]
3	60	24	1.63	1.16	1.20	0.78	0.76	0.66	0.55	0.51	0.63	0.25	1.38***
			[3.59]	[4.01]	[4.90]	[4.14]	[4.68]	[5.09]	[4.29]	[4.40]	[4.42]	[1.21]	[3.23]
4	60	60	1.43	1.20	0.92	0.87	0.59	0.83	0.68	0.45	0.37	0.37	1.06**
			[3.03]	[3.81]	[3.57]	[4.03]	[3.34]	[5.03]	[5.34]	[3.51]	[2.20]	[1.73]	[2.31]
5	90	24	1.30	0.94	0.74	0.46	0.58	0.41	0.33	0.55	0.51	0.46	0.84**
			[2.73]	[2.99]	[3.05]	[2.26]	[3.48]	[3.23]	[2.68]	[3.82]	[3.34]	[2.32]	[2.02]
6	90	36	1.37	0.92	0.77	0.45	0.49	0.41	0.44	0.42	0.54	0.54	0.83**
			[2.94]	[2.87]	[2.96]	[2.09]	[2.88]	[3.09]	[3.70]	[2.97]	[3.48]	[3.00]	[1.99]
7	90	90	1.20	0.77	0.92	0.67	0.39	0.50	0.20	0.31	0.43	0.69	0.51
			[2.04]	[2.50]	[3.16]	[2.66]	[2.00]	[2.90]	[1.37]	[1.96]	[2.44]	[3.60]	[0.91]

Table 11
Risk-adjusted returns of hedge fund portfolios sorted by MES (January 1999 to December 2009).

This table presents the monthly risk-adjusted returns (in percent) for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. The risk-adjusted portfolio returns are calculated using a regression of monthly portfolio returns on the Fung-Hsieh factors. We use the intercept of this regression, which is called the Fung-Hsieh alpha, as the risk-adjusted portfolio returns. The Fung-Hsieh seven factors include two equity-oriented risk factors (the equity market factor and the size spread factor), two bond-oriented risk factors (the bond market factor and the credit spread factor), and three trend-following risk factors of Fung and Hsieh (2001) on bonds (PTFSBD), currencies (PTFSFX), and commodities (PTFSCOM). This table also presents the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
Category	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
All funds	1.35	0.93	1.02	0.62	0.63	0.58	0.44	0.44	0.56	0.19	1.16***
	[5.13]	[5.06]	[6.58]	[4.78]	[5.85]	[6.11]	[4.42]	[5.07]	[4.97]	[1.01]	[3.61]
Live funds	1.84	1.14	1.05	0.73	0.67	0.87	0.72	0.51	0.73	0.72	1.13***
	[5.93]	[5.34]	[7.22]	[5.36]	[5.19]	[7.37]	[6.75]	[4.60]	[5.56]	[3.58]	[3.75]
Defunct funds	1.02	0.54	0.71	0.45	0.39	0.29	0.13	0.12	0.43	-0.13	1.15***
	[3.39]	[2.87]	[3.82]	[2.41]	[3.00]	[2.43]	[1.03]	[0.90]	[3.18]	[-0.53]	[2.92]

Table 12
Average returns of hedge fund portfolios for bivariate sorts, first by leverage dummy and then by MES (January 1999 to December 2009).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed first, sorted by two leverage groups (leveraged and non-leveraged) and then by MES. The MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Panels A, B, and C use all, live, and defunct funds, respectively. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
Leveraged group											
MES (%)	-11.19	-4.97	-2.62	-1.36	-0.42	0.23	0.79	1.62	3.02	9.85	
Return (%)	1.63	1.26	1.08	0.71	0.85	0.63	0.57	0.53	0.69	0.15	1.48***
	[3.56]	[4.32]	[4.56]	[3.67]	[4.67]	[5.22]	[4.49]	[4.18]	[3.96]	[0.66]	[3.08]
Non-leveraged group											
MES (%)	-12.46	-7.17	-4.39	-2.59	-1.31	-0.41	0.31	1.07	2.52	7.01	
Return (%)	1.68	1.07	1.11	1.11	0.62	0.61	0.62	0.51	0.50	0.37	1.30***
	[3.32]	[3.03]	[4.62]	[4.75]	[3.61]	[4.07]	[5.07]	[4.26]	[3.27]	[1.64]	[2.82]
Panel B: Live funds											
Leveraged group											
MES (%)	-11.07	-5.26	-2.82	-1.56	-0.66	0.07	0.81	1.76	3.04	9.85	
Return (%)	2.09	1.51	1.06	0.78	0.95	0.91	0.90	0.71	0.81	1.00	1.09**
	[3.79]	[4.40]	[4.12]	[4.20]	[5.13]	[6.88]	[6.21]	[4.36]	[3.97]	[4.79]	[2.01]
Non-leveraged group											
MES (%)	-10.13	-5.42	-3.64	-2.38	-1.21	-0.12	0.81	1.77	3.18	6.45	
Return (%)	1.98	1.47	1.19	0.91	0.77	0.94	0.67	0.44	0.76	0.46	1.52***
	[4.55]	[4.12]	[4.76]	[3.82]	[3.91]	[5.22]	[4.82]	[2.47]	[3.82]	[1.53]	[4.01]
Panel C: Defunct funds											
Leveraged group											
MES (%)	-10.56	-4.53	-2.14	-0.97	-0.14	0.33	0.80	1.61	3.03	10.74	
Return (%)	1.09	0.68	0.73	0.50	0.52	0.40	0.12	0.21	0.57	-0.18	1.26**
	[2.57]	[2.53]	[3.00]	[2.61]	[2.71]	[2.68]	[0.65]	[1.63]	[3.22]	[-0.51]	[2.35]
Non-leveraged group											
MES (%)	-13.55	-7.73	-4.40	-2.34	-1.10	-0.32	0.33	1.02	2.29	7.33	
Return (%)	1.66	1.21	0.54	0.83	0.34	0.40	0.23	0.65	0.19	0.16	1.50***
	[3.05]	[2.59]	[2.33]	[2.85]	[1.72]	[2.73]	[0.89]	[4.30]	[1.35]	[0.65]	[2.67]

Table 13

Average returns of hedge fund portfolios for bivariate sorts, first by liquidity beta and then by MES (January 1999 to December 2008).

This table presents the average value of the MES and the one-month-ahead returns for each MES portfolio for all, live, and defunct funds. The MES portfolios are formed first, sorted by three liquidity-loading groups (low, medium, and high) and then by MES. These liquidity-loading groups are constructed based on the two-year rolling liquidity beta, which is calculated using a regression of monthly hedge fund returns on the market portfolio and the Sadka (2006, 2010) factor. In any given month, we include only funds with at least 18 months of return observations over the prior 24 months. The MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the prior 60 months. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Panels A, B, and C use all, live, and defunct funds, respectively. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
Panel A: All funds											
High-liquidity-loading group											
MES (%)	-13.41	-7.93	-5.32	-3.33	-1.93	-0.78	0.24	1.35	3.07	10.31	
Return (%)	1.61	1.24	0.87	0.85	1.00	0.58	0.67	0.67	0.52	0.34	1.28**
	[2.78]	[3.03]	[2.69]	[3.02]	[3.47]	[2.34]	[3.00]	[3.21]	[2.07]	[1.05]	[2.53]
Medium-liquidity-loading group											
MES (%)	-8.11	-3.08	-1.63	-0.77	-0.16	0.29	0.67	1.19	2.27	6.47	
Return (%)	1.10	0.87	0.53	0.68	0.63	0.62	0.59	0.63	0.60	0.51	0.59
	[3.21]	[3.26]	[2.61]	[4.23]	[4.24]	[5.36]	[5.44]	[6.40]	[4.68]	[2.86]	[1.61]
Low-liquidity-loading group											
MES (%)	-10.09	-4.40	-2.38	-1.06	-0.18	0.53	1.19	2.10	3.77	10.14	
Return (%)	1.00	0.77	0.85	0.58	0.74	0.58	0.55	0.44	0.78	-0.23	1.23**
	[2.14]	[2.64]	[2.98]	[2.71]	[3.26]	[2.78]	[3.14]	[2.92]	[3.76]	[-0.72]	[2.08]
Panel B: Live funds											
High-liquidity-loading group											
MES (%)	-12.36	-7.80	-5.04	-3.01	-1.68	-0.64	0.30	1.44	2.79	7.20	
Return (%)	2.46	1.34	1.23	0.99	0.87	1.09	0.76	0.61	1.03	0.99	1.47**
	[3.26]	[3.76]	[2.89]	[2.73]	[3.47]	[3.63]	[3.08]	[2.82]	[3.70]	[2.64]	[2.18]
Medium-liquidity-loading group											
MES (%)	-6.81	-3.01	-1.88	-1.13	-0.43	0.20	0.89	1.75	2.98	7.14	
Return (%)	1.18	0.88	0.74	0.68	0.72	0.97	0.80	0.89	0.64	0.90	0.29
	[3.03]	[3.15]	[2.93]	[3.89]	[3.72]	[6.50]	[4.35]	[4.19]	[4.14]	[3.71]	[0.72]
Low-liquidity-loading group											
MES (%)	-8.17	-4.03	-2.16	-1.03	-0.05	0.75	1.50	2.41	3.98	12.25	
Return (%)	1.43	0.86	0.80	0.64	0.90	0.73	0.64	0.67	0.74	0.91	0.52
	[2.97]	[2.69]	[2.86]	[2.78]	[4.07]	[3.52]	[4.46]	[2.88]	[2.09]	[3.99]	[1.03]
Panel C: Defunct funds											
High-liquidity-loading group											
MES (%)	-13.89	-8.42	-5.57	-3.49	-1.91	-0.65	0.38	1.49	3.45	12.11	
Return (%)	1.42	0.79	0.53	0.74	0.68	0.43	0.74	0.43	0.17	-0.20	1.63***
	[2.45]	[1.84]	[1.61]	[2.45]	[2.10]	[1.50]	[3.86]	[2.00]	[0.58]	[-0.55]	[2.86]
Medium-liquidity-loading group											
MES (%)	-7.98	-2.81	-1.24	-0.43	0.04	0.35	0.66	1.09	1.87	5.90	
Return (%)	0.90	0.76	0.76	0.27	0.56	0.40	0.48	0.48	0.67	0.14	0.75*
	[2.73]	[2.90]	[3.79]	[1.39]	[4.64]	[2.62]	[4.62]	[4.53]	[5.97]	[0.50]	[1.68]
Low-liquidity-loading group											
MES (%)	-11.06	-4.55	-2.37	-0.99	-0.17	0.51	1.13	2.02	3.96	9.15	
Return (%)	0.60	0.78	0.55	0.55	0.57	0.67	-0.12	0.50	0.71	-0.67	1.27*
	[1.08]	[2.31]	[2.13]	[2.37]	[1.64]	[2.47]	[-0.34]	[2.87]	[3.07]	[-1.44]	[1.66]

Table 14
Average returns of hedge fund portfolios sorted by MES across different assigned returns (January 1999 to December 2009).

This table presents the average value of returns (in percent) for each MES portfolio. When portfolio returns are calculated, not only one-month-ahead returns but also one-quarter-ahead, two-quarter-ahead, three-quarter-ahead, and one-year-ahead returns are used. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
Assigned return	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
One-month-ahead	1.63	1.16	1.20	0.78	0.76	0.66	0.55	0.51	0.63	0.25	1.38***
	[3.59]	[4.01]	[4.90]	[4.14]	[4.68]	[5.09]	[4.29]	[4.40]	[4.42]	[1.21]	[3.23]
One-quarter-ahead	1.55	1.17	0.98	0.81	0.70	0.66	0.54	0.44	0.61	0.37	1.18***
	[3.55]	[3.97]	[3.97]	[4.18]	[4.39]	[4.71]	[4.37]	[3.70]	[4.68]	[2.02]	[2.99]
Two-quarter-ahead	1.30	1.07	1.01	0.73	0.71	0.54	0.54	0.51	0.58	0.41	0.89**
	[2.97]	[3.71]	[3.92]	[3.57]	[4.42]	[3.50]	[4.29]	[4.40]	[4.20]	[2.50]	[2.25]
Three-quarter-ahead	1.22	1.09	0.90	0.76	0.71	0.60	0.54	0.52	0.72	0.52	0.70*
	[2.84]	[3.88]	[3.18]	[3.51]	[3.93]	[4.48]	[3.96]	[4.18]	[5.41]	[2.96]	[1.76]
One-year-ahead	0.91	0.87	0.63	0.63	0.57	0.56	0.64	0.48	0.68	0.70	0.21
	[2.32]	[3.38]	[2.32]	[3.32]	[3.34]	[3.90]	[4.90]	[3.03]	[4.64]	[3.59]	[0.56]

Table 15
Average returns of hedge fund portfolios sorted by MES across different holding periods (January 1999 to December 2009).

This table presents the average value of various holding period returns (in percent, annualized) for each MES portfolio. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. The portfolios use non-overlapping returns, for example, the three-month holding period sorts hedge funds in the beginning of January, April, July, and October. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	MES deciles										
Holding period	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
One month	21.43	14.84	15.40	9.72	9.46	8.19	6.79	6.27	7.80	3.01	17.93***
	[3.59]	[4.00]	[4.90]	[4.14]	[4.69]	[5.09]	[4.29]	[4.40]	[4.42]	[1.21]	[3.23]
Three months	24.15	16.56	15.09	10.99	10.27	8.77	7.04	6.73	8.32	3.28	20.38***
	[3.08]	[3.52]	[3.95]	[3.58]	[3.83]	[4.07]	[3.70]	[3.50]	[3.83]	[1.21]	[2.87]
Six months	21.97	15.81	15.55	11.77	9.64	8.72	8.36	6.87	8.26	4.88	16.70***
	[3.39]	[3.48]	[3.71]	[3.42]	[3.24]	[4.59]	[4.08]	[3.11]	[3.79]	[1.70]	[3.86]
12 months	21.89	17.45	17.94	11.35	11.32	9.07	9.54	7.87	10.77	6.93	14.96*
	[2.54]	[2.64]	[2.41]	[2.37]	[2.84]	[3.12]	[3.22]	[2.95]	[4.19]	[2.02]	[1.97]

Table 16
Average returns of hedge fund portfolios sorted by MES over crisis and noncrisis periods (January 1999 to December 2009).

This table presents the average value of the returns (in percent) for each MES portfolio over the entire sample period, as well as separately for crisis and noncrisis periods. Crisis periods are August–October 2007 (the quant crisis) and September–November 2008 (the U.S. subprime crisis). Panel A reports the monthly returns for portfolios rebalanced monthly, and Panel B reports the three-month non-overlapping cumulative returns for portfolios rebalanced quarterly. The quarterly returns of the noncrisis quarters include all calendar quarters non-overlapping with crisis periods. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period. When we calculate the MES of each hedge fund, we do not perform any sign conversion. This table also reports the average return differential between deciles 1 and 10. *T*-statistics are reported in square brackets. Here *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

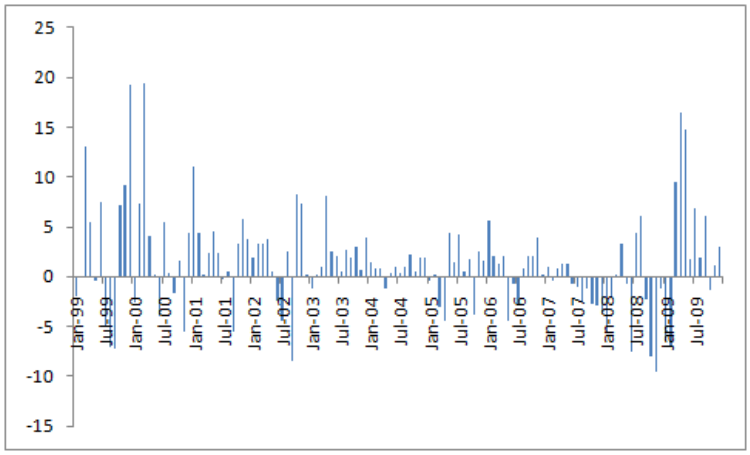
Panel A: Monthly returns

		MES deciles										
Period	Months	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
All	132	1.63	1.16	1.20	0.78	0.76	0.66	0.55	0.51	0.63	0.25	1.38***
		[3.59]	[4.00]	[4.90]	[4.14]	[4.69]	[5.09]	[4.29]	[4.40]	[4.42]	[1.21]	[3.23]
Noncrises	126	1.94	1.42	1.39	0.96	0.90	0.72	0.64	0.59	0.69	0.28	1.66***
		[4.39]	[5.57]	[6.04]	[6.09]	[6.37]	[5.68]	[5.48]	[5.87]	[5.17]	[1.48]	[3.86]
Crises	6	-4.84	-4.34	-2.75	-3.05	-2.23	-0.58	-1.41	-1.17	-0.63	-0.46	-4.38**
		[-1.68]	[-1.53]	[-1.47]	[-1.49]	[-1.36]	[-0.59]	[-1.18]	[-0.87]	[-0.44]	[-0.21]	[-3.07]
Quant crisis	3	1.18	1.59	0.90	1.22	0.85	0.84	0.77	1.03	1.53	3.30	-2.12**
		[0.67]	[0.88]	[0.77]	[1.07]	[0.82]	[0.62]	[0.83]	[1.17]	[1.05]	[1.97]	[-4.33]
U.S. subprime crisis	3	-10.86	-10.27	-6.41	-7.32	-5.30	-1.99	-3.60	-3.37	-2.78	-4.22	-6.64*
		[-7.54]	[-7.99]	[-3.83]	[-6.29]	[-3.10]	[-2.04]	[-2.85]	[-1.80]	[-1.54]	[-1.60]	[-3.03]

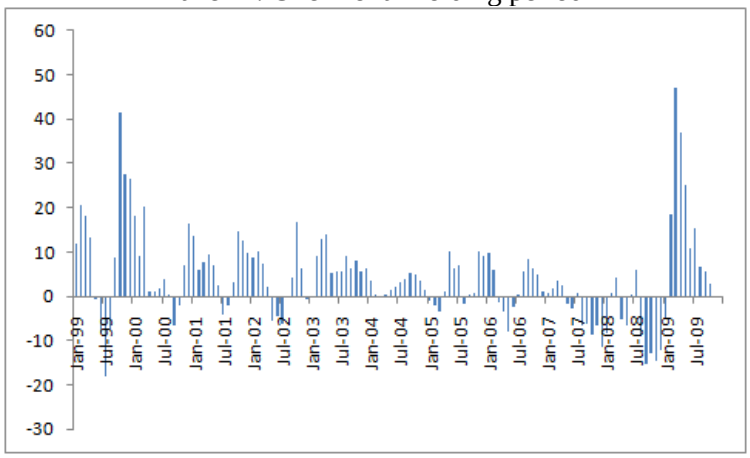
Panel B: Three-month cumulative returns

		MES deciles										
Period	Quarters	1 (low)	2	3	4	5	6	7	8	9	10 (high)	1-10
All	44	5.56	3.90	3.58	2.64	2.47	2.12	1.72	1.64	2.02	0.81	4.75***
		[3.08]	[3.52]	[3.95]	[3.58]	[3.83]	[4.07]	[3.70]	[3.50]	[3.83]	[1.21]	[2.87]
Noncrises	40	6.77	4.94	4.38	3.27	3.16	2.50	2.12	2.15	2.52	1.17	5.60***
		[3.70]	[4.94]	[5.09]	[4.95]	[5.80]	[4.78]	[4.94]	[5.98]	[5.72]	[2.12]	[3.24]
Crises	2	-13.25	-10.00	-7.18	-6.76	-5.91	-2.00	-2.99	-3.83	-1.83	-2.34	-10.91
		[-0.84]	[-0.65]	[-0.75]	[-0.63]	[-0.67]	[-0.49]	[-0.51]	[-0.59]	[-0.29]	[-0.21]	[-2.44]
Quant crisis	1	2.56	5.40	2.37	4.05	2.96	2.05	2.84	2.66	4.56	9.00	-6.44
U.S. subprime crisis	1	-29.07	-25.40	-16.73	-17.56	-14.78	-6.05	-8.82	-10.32	-8.22	-13.68	-15.39

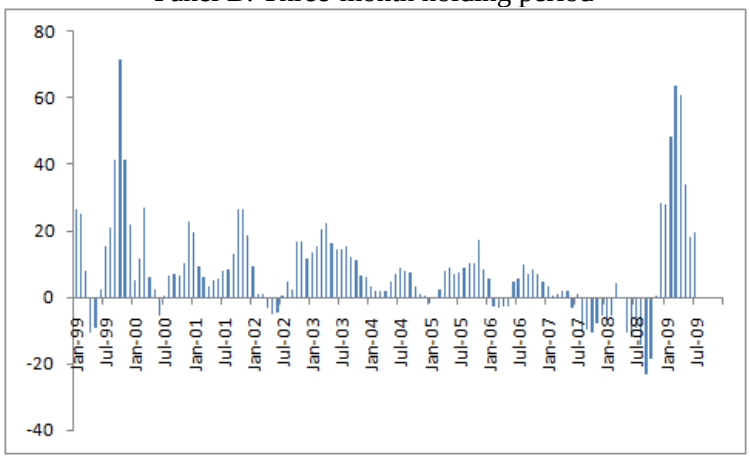
Fig. 1. Time series of the low-minus-high MES portfolio returns across different holding periods (January 1999 to December 2009). This figure plots the low-minus-high MES portfolio returns for periods of one (Panel A), three (Panel B), and six months (Panel C) after portfolio formation. For example, Panel C plots the six-month cumulative return for the low-minus-high portfolio while keeping the funds fixed for six months, and the portfolio is re-formed in each month. The MES portfolios are formed based on the MES, where the MES is that when the market return is below its fifth percentile. The MES of each fund is calculated using nonmissing return observations over the past 60 months. In any given month, we include only funds with at least 24 months of return observations over the estimation period.



Panel A: One-month holding period



Panel B: Three-month holding period



Panel C: Six-month holding period