Does risk management work?*

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Abstract

We examine hedge fund risk management practices and their association with performance during the 2008 financial crisis. Consistent with risk management practices reducing left-tail risk, funds in our sample that use formal models performed significantly better in the extreme down months of 2008. We find no evidence that having a dedicated head of risk management is associated with reduced left-tail risk. Funds employing VaR models had more accurate expectations of how they would perform in a short-term equity bear market.

JEL classification: G11, G23, M40.

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1 Introduction

As discussed by Kaplan (2011, p. 373), risk management is an important issue for accounting academics. There has been substantial growth in the use of formal risk management programs and practices in operating and financial firms in recent times (Miller, Kurunmaki, and O'Leary, 2008; Millo and MacKenzie, 2009; Beasley, Branson, and Pagach, 2015). Risk management supporters portray formalized risk management programs and practices in a managerial and prospective light, advocating that such systems benefit decision making and organizational outcomes (Arena, Arnaboldi, and Azzone, 2010; Burton, 2008; COSO, 2004). It is, however, unclear to what extent such programs and practices effectively mitigate "bad outcomes" or are instead used cosmetically to placate investors without any impact on organizational decisions and operations (Arena et al., 2010; Paape and Speklé, 2012; PriceWaterhouseCoopers, 2004; Van der Stede, 2011). Furthermore, scholars skeptical of the benefits of risk management cite the recent financial crisis to conclude that the recent expansion of risk measurement is dysfunctional and results in "the risk management of nothing" (Mikes, 2011; Power, 2009; Taleb, 2008). To contribute to this debate, we examine the association between hedge fund risk management practices and performance during the recent financial crisis.

To investigate this question, we use a proprietary database of due diligence reports prepared by The Hedge Fund Due Diligence Group at Analytical Research (HedgeFundDueDiligence.com). Institutional investors commissioned these reports to better understand fund operations and risk exposures in order to evaluate potential hedge fund investments. The reports provide extensive detail on fund characteristics, manager backgrounds, internal operations, and risk management practices. Specifically, the reports identify whether the fund employs formal models of portfolio risk (value at risk, stress testing, and scenario analysis), whether the fund's risk officer is dedicated solely to risk management, whether the risk officer has trading authority, and whether the fund employs limits on the concentration of investment positions. This data set addresses a major impediment to the examination of risk management practices—a lack of cross-sectional data on internal organizational practices (Tufano, 1996; Millo and MacKenzie, 2009; Van der Stede, 2011).

The timing of these reports provides a natural experiment to examine the effectiveness of risk management practices. Namely, the reports were compiled prior to 2008, thereby allowing us to examine the effect of previously implemented risk management practices on subsequent fund performance during the equity bear market of September through November 2008. The recent financial crisis provides strong motivation to look at risk management issues (Van der Stede, 2011, p. 616), particularly given criticism that existing risk management designs have let society down (Power, 2009, p. 854). For a subset of funds in our sample, the reports provide managers' expectations of how their funds would perform under extreme financial events such as a short-term equity bear market. These expectations were also elicited prior to 2008, thereby allowing us to compare expectations with actual fund performance in the equity bear market of late 2008.

First, we document significant heterogeneity in the methods that funds use to manage risk. Levered funds are more likely to use formal risk models, funds that hold large numbers of positions are more likely to have dedicated risk officers and risk officers with no trading authority, and funds that hold positions for longer durations are less likely to have position limits. Moreover, we find that the likelihood that a fund has either a dedicated head of risk management or a risk officer with no trading authority increases in the fund's proprietary capital, implying that fund managers increase risk oversight when they have more personal wealth invested in their fund.

Second, we examine the effectiveness of risk management. Stulz (1996) defines the goal of risk management as the "elimination of costly lower-tail outcomes." We therefore posit that if risk management practices are effective, then funds with more extensive risk management should perform better during extreme negative financial events. Consistent with our thesis, we find that funds using formal models of portfolio risk did relatively better in the extreme down months of 2008. The magnitude of these effects is economically significant. Controlling for size, age, investment style, and portfolio characteristics, funds in our sample that use at least one formal risk model had returns in October 2008 that were six percentage points higher than funds that did not use any type of model. Moreover, we find similar differences in performance when we limit the analysis to the most prevalent investment style, long-short equity, and when we control for risk exposures and style index returns.

We next proceed by addressing four alternative explanations for our performance returns findings. First, unobserved manager ability could determine both the use of formal risk models and fund performance in the down months of 2008. To investigate this possibility, we hand collected the educations of the management team to proxy for ability (Li, Zhang, and Zhao, 2011). Although we find some evidence that technically able managers are more likely to use risk models, our performance findings are robust in terms of both economic and statistical significance when control for ability.

A second alternative explanation is that funds select risk management practices based on their risk exposures. The weight of our evidence, however, points toward risk management practices assisting managers in reducing downside risk. Specifically, if self-selection based on risk exposures drives our results, then funds investing in riskier and more volatile assets presumably employ stronger risk management practices. In contrast, we find that the monthly returns of funds that use models have significantly *lower* volatilities. Moreover, examining the skewness of returns, we find that the October 2008 returns of funds that do not use models are more *negatively* skewed than the returns of funds that employ models of portfolio risk, suggesting that funds that do not use models face greater left tail risk and that differences in performance are not driven by a mean shift in returns.

A third potential explanation is that differences in fund quality drive the association between risk models and fund performance in the down months of 2008. If differences in fund quality drive our results, then funds using models should consistently outperform their peers. Although funds that use formal models perform better during the short-term equity bear market of 2008, we find *no* significant differences in the performance of hedge funds with different risk management practices during 2007 and the first six months of 2009.

As discussed by Arena et al. (2010), a fourth alternative explanation is that the use of models is correlated with the fund's overall risk culture. If fund risk culture drives our performance findings, we would expect to observe positive relations between other risk management practices and returns performance in extreme down months. However, we find no associations between performance and the other risk management practices besides models, suggesting that the fund's overall risk culture does not drive our results.

In our final empirical analysis we posit and examine whether risk management practices improve the fund managers' understanding of how changes in the financial environment would affect their fund's performance. Examining performance during the equity bear market that occurred from September through November 2008, we find that managers of funds that use value at risk appear to have more accurate expectations about how their fund would perform during a short term equity bear market. In contrast, we find no association between the accuracy of expectations and the other risk management practices. Overall, our results suggest that models of portfolio risk assist managers in reducing exposures to downside and increase the accuracy of managers' expectations.

It is important to relate these findings to the theory literature on risk management (Smith and Stulz, 1985; Froot, Scharfstein, and Stein, 1993). According to this literature, in equilibrium that there should be no differences in performance between funds that optimally choose to implement and to not implement risk management practices. Empirically, however, we find differences in performance for funds that choose and do not choose to use formal risk models. There are several factors that likely explain our results. First, at the time that our sample funds choose whether to implement formal risk models, the effectiveness of risk models was not clear.

In other words, given the lack of evidence (especially during our sample period) regarding the benefits of various risk management practices—some of which is reflected in the debate in the accounting academic literature—it is unlikely that all managers had the information to optimally choose risk management practices when viewed ex post.[1] Second, we find the relation between risk management and performance only for risk models. It is important to point out that risk models, unlike hedge and position limits, do not directly affect the fund's return distribution. Instead, they assist that manager in making better decisions. Hence, the role of models differs from the risk management technologies typically considered in the hedging literature that typically involve tradeoffs within the return distribution.

We make several contributions to the risk management literature. There is an extensive literature that focuses on a limited set of choices (e.g., the choice of hiring a chief risk officer and the CRO's power within the organization or the hedging of commodity prices, exchange rates, and interest rates) made by bank holding companies, regulated utilities, and other SEC registrants.[2] In contrast, our proprietary data set and empirical setting enable us to investigate a broader set of risk management practices, including specific risk practices, in a domain for which there is minimal academic research on how organizations manage risk and which suffered an almost catastrophic event.

We further contribute by examining the outcomes from risk management. Prior research on the benefits of risk management practices often uses perceptual measures of risk management effectiveness (Paape and Speklé, 2012). Other studies rely on either excess returns around the announcement of a chief risk officer (Liebenberg and Hoyt, 2003) or on the association between hedging and firm value (Guay and Kothari, 2003; Jin and Jorion, 2006). These studies rely on correctly specifying a model of expected returns or market value. In contrast, our data set

[1] Ang, Ayala, and Goetzmann (2014) make a similar point regarding endowments' investments in alternative assets: a lack of information regarding outcomes in future states inhibits optimal portfolio choices.

[2] For example, see Geczy, Minton, and Schrand (1997), Guay (1999), Allayannis and Ofek (2001), Allayannis, Ihrig, and Weston (2001), Geczy, Minton, and Schrand (2007), and Ellul and Yerramilli (2013).

provides risk management practices in place prior to the 2008 financial crisis, thereby allowing us to estimate the relation between predetermined risk management practices and subsequent performance during an extreme event. In doing so, we address Kaplan's call to investigate where risk management appears to be effective and where it has failed to inform the formulation of underlying principles of effective risk management practice.

We also contribute to the risk management literature by examining the accuracy of fund managers' expectations of future performance, and the extent to which risk management practices are associated with more accurate expectations. Outside of the management earnings forecast literature, there is minimal empirical evidence that compares managers' expectations of performance with *ex post* realizations, and no research on either hedge funds or organizational performance given changes in the economy (Cassar and Gibson, 2008). In doing so, we provide evidence of a specific benefit of better risk management practices—namely, increasing the accuracy of expectations.

While recognizing the importance of risk management to accounting scholarship (Kaplan, 2011), several scholars note the puzzling lack of focus on risk management in financial institutions given that this setting can provide insight into financial decision making and management control (Mikes, 2009, p. 19), and where the benefits of risk management are most likely experienced (Van der Stede, 2011, p. 617).

2 Sample

To investigate the effectiveness of financial institution risk management practices during the recent financial crisis, we use a proprietary database of due diligence reports prepared by HedgeFundDueDiligence.com. Institutional investors commissioned these due diligence investigations to better understand fund operations and risks in order to evaluate potential hedge fund investments. Consequently, this sample represents a set of hedge funds that were willing to accept new capital capital.[3] The vendor obtained and verified the information contained in these reports using several sources, including on-site visits and interviews with key staff, discussions with service providers, and reviews of offering memorandums.[4] The reports provide an extensive array of detail regarding fund and manager characteristics, portfolio characteristics, contract terms, performance expectations, and risk management practices. The due diligence reports provide details on the funds' portfolios that are not available in the commonly-used commercial databases of hedge fund returns.

Our initial sample consists of 427 funds run by 358 unique managers investigated from 2003 to 2007. Table 1 provides descriptive statistics for our sample funds used in our determinants of risk management practices tests. The mean (median) fund has $305 million ($107 million) in assets under management and is, on average, less than three years old (1,020 days) at the time of due diligence. The majority of funds (84%) are located offshore and more than half (54%) use explicit leverage, as opposed to implicit leverage arising from derivatives. In terms of typical holding period, 32% of the funds typically hold their positions for at least a year and 13% typically hold only for days. With respect to the number of positions, 41% of the funds typically hold between 1–39 investment positions at one time, while three percent typically hold thousands of positions.

To examine the effectiveness of the various hedge fund risk management practices, we merge these fund characteristics with monthly returns reported on the three major hedge fund returns commercial databases: Lipper TASS, Hedge Fund Research, and CISDM.[5] When funds report

[3]A potential concern with the database is that it consists only of funds willing to be subject to due diligence. According to the vendor, refusals of due diligence are, however, rare.

[4]As pointed out by both the data vendor and Brown, Goetzmann, Liang, and Schwarz (2012), six percent of the managers in the database misrepresent their backgrounds. Although we limit our primary analysis to measures verified on-site by the data vendor, it could be the case that the some managers are able to misrepresent their risk management practices. However, any misrepresentation of risk management practices likely biases our tests against finding significant differences between funds that do and do not implement the various risk management practices.

[5]For a discussion and comparison of these databases, see Agarwal, Daniel, and Naik (2011). Cassar and Gerakos (2010) also use HFDD funds to investigate internal controls.

to multiple databases, we obtain returns first from the Lipper TASS database and then from the Hedge Fund Research database, followed by CISDM. Of our sample funds, 123 have a full set of monthly reported returns over the period January 2007 through December 2008 on at least one of these three databases.

With respect to the representativeness of our sample, Brown et al. (2012) provide a detailed comparison of fund characteristics from HedgeFundDueDiligence.com and commercial databases in their investigation of operational risk disclosures.[6] Comparing the characteristics of the sample hedge funds that do and do not report to these three commercial databases reveals no significant statistical differences for any of the variables reported in Table 1. Although compared to prior research on hedge funds our sample is small, these 123 funds held over $49.8 billion in assets under management at the time of due diligence. Obviously, evaluation of our sample's representativeness needs to be considered in conjunction with the fact that we observe cross-sectional data on internal organizational risk management practices, a lack of which has been a critical impediment in risk management research (Tufano, 1996).

3 Risk management practices

We define risk management practices as procedures and mechanisms used to monitor and manage an organization's exposure to financial risk. Specifically, we are interested in the risks arising from the fund's investment portfolio as opposed to its operations. These risks can arise both within the fund's investment mandate and outside of the mandate. For example, risk management practices could assist the managers in maintaining the risk exposures covered in the investment mandate and at the same time assist in reducing exposures to risks that are outside the mandate.

[6]Similarly, commercial databases are likely not to be representative of the entire population of hedge funds given the voluntary choice of funds to self-report performance returns to commercial databases (Agarwal, Fos, and Jiang, 2013).

We examine several indicators of overall risk management practices: the use of formal models to quantify and evaluate portfolio risk; the presence of a dedicated head of risk management; whether the head of risk management has trading authority; the use of limits on the concentration of investment positions. Table 2 reports the descriptive statistics for these risk management practices. The due diligence firm's scope of investigation expanded during our sample period. Consequently, the number of non-missing responses varies across the risk management practices, with some responses only available for later observations. We report descriptive statistics both for the full sample used to estimate the determinants of various risk management practices and for the subset of funds that have reported monthly returns from January 2007 to December 2008. Univariate t-tests reveal no significant differences in the risk management practices between the full sample and the sub-sample with returns.

Models

The due diligence firm queried sample funds about their use of formal risk models: value at risk, stress testing, and scenario analysis. Value at risk measures the threshold expected loss that can occur over a specified period at a specified quantile (Jorion, 2000). Funds often use two additional types of models that allow managers to examine the effects of extreme events that may not be captured by value at risk. Stress testing identifies how the portfolio would respond to large shifts in relevant economic variables or risk parameters. Scenario analysis assesses how the portfolio would respond to severe but plausible scenarios, such as significant changes in interest rates or liquidity. Studying the effectiveness of these risk models is particularly appealing in financial firms given the criticism associated with their use (Van der Stede, 2011, p. 617).

We find that 43.7% of funds employ value at risk, 52.1% use stress testing, and 46.4% use scenario analysis. Over half the sample (58.3%) employ at least one modeling approach and

36.4% of all funds employ all three modeling approaches. Given the correlations among use of the three types of models, for our empirical tests we also create an indicator variable for whether the fund uses at least one model.

Head of risk management

A commonly investigated measure of risk management in firms is the presence of a chief risk officer (Liebenberg and Hoyt, 2003; Beasley, Clune, and Hermanson, 2005). The due diligence reports identify who is the fund's head of risk management. They also indicate whether this person is dedicated to risk management, whether the head of risk management is part of the primary management team, and whether the head of risk management has trading authority.

In our sample, 34.0% of funds have an executive dedicated to risk management. In the remaining 66.0% of funds, risk managers also undertook other investing or administrative functions. With respect to the extent of their trading authority, for 70.1% of the funds the head of risk management had full trading authority, while 4.2% had authority to invest only for hedging purposes. For the remaining 25.8% of the sample, the head of risk management had no trading authority.

Position limits

The due diligence reports also provide substantial detail regarding the use of investment position limits. For this practice, we focus only on the use of limits for asset classes in which the fund is actively investing. We find that 16.6% of our hedge funds have hard limits on the dollar amount or proportion of assets under management that they are allowed to hold in a specific position. We also find that 26.9% of funds, while not having hard limits, employ investment guidelines on the amount or proportion that can be invested in a given position.

The remaining 56.4% of funds have neither hard limits nor guidelines for the concentration of their investment positions.

Measures of risk management practices

For our empirical tests, we code all dichotomous responses to yes/no questions as 1 for "yes" and 0 for "no." We further rank order variables if there is a natural ordering of risk management practices. For example, we code the trading authority of the head of risk management as follows: 0 for full trading authority; 1 for hedging authority; 2 for no trading authority. To further examine the role of the head of risk management we create a variable coded as 1 if the head of risk management is dedicated and has no trading authority, and 0 otherwise. Such managers represent 22.4% of the sample. We code positions limits as follows: 0 for no limits; 1 for guidelines; 2 for hard limits. In robustness tests, we also code the risk manager's trading authority and the fund's position limits as nominal choices.

4 Determinants of risk management practices

Although hedge funds are mandated to take financial risks, funds typically attempt to limit their risk exposures only to the specific risks outlined in their offering documents. For example, some funds follow a market-neutral investment strategy, whereby managers attempt to minimize the fund's exposure to systematic risk. We posit that risk management practices assist managers in both monitoring and reducing their funds' exposures to risks that are not included in their mandates and at the same monitor and increase their funds' exposures to risks included in their investment mandates. Moreover, we posit that risk management practices assist managers in reducing overall exposures to downside risk.

Given these posited benefits, we predict that the demand for risk management practices is a function of fund characteristics including: leverage, fund size, the manager's wealth invested in the fund, and reputation. First, leverage increases the fund's exposure to changes in asset values. Large losses can lead to margin calls from lenders and investor redemptions, both of which can force the manager to quickly liquidate the portfolio at "fire sale" prices. Moreover, lenders may implicitly or explicitly require a minimum level of risk management. Therefore, *ceteris paribus*, levered funds can receive greater benefits from investments in risk management. Hence, we predict a positive association between risk management investments and leverage. To measure leverage, we include an indicator for whether the fund uses explicit leverage.[7]

Second, the cost of implementing and operating risk management practices likely decreases in fund scale. For example, dedicated risk officers and formal models involve fixed costs. Therefore, we predict that risk management practices increase with fund size. Furthermore, size can capture quality, because better performing funds generally receive higher capital flows. Size can therefore also capture the extent that higher quality funds invest more in risk management. To measure size, we use the natural logarithm of investor assets.

Third, fund managers often invest a substantial proportion of their personal wealth in their fund. Given that managers are presumably risk averse, managers with substantial wealth invested in their funds likely have incentives to implement more extensive risk management practices to better understand and monitor risk exposures. Consequently, we predict a positive association between proprietary capital and risk management practices. To measure proprietary capital, we use the natural logarithm of proprietary assets, which represents personal investments in the fund made by the managers and employees.

Fourth, managers of established funds possess valuable reputations. Therefore, they have more to lose, such as their ability to charge higher fees, start new funds, or keep existing investors, should substantial changes in the value of the fund's invested assets occur due to unexpected risk exposures. Consequently, we posit that older funds have extensive risk man-

[7]Because of differences in how the funds reported leverage levels (e.g., gross versus net leverage and typical versus maximum leverage), we use a simple indicator variable to capture whether the fund uses explicit leverage.

agement practices. Furthermore, fund age and risk management practices can be positively correlated if risk management increases the likelihood of fund survival. However, it may be the case that younger funds invest in risk management in order to signal quality. To proxy for reputation, we use the natural logarithm of the fund's age as of the date of the due diligence report.

To proxy for portfolio characteristics, we include in our empirical tests several variables taken directly from the due diligence reports. First, we include indicator variables for whether the portfolio is long or short biased. Second, we include indicator variables that capture the typical number of investment positions that the fund holds (1–39 Positions, 40–99 Positions, 100–199 Positions, 200–999 Positions, and 1000+ Positions) and the typical duration that the fund holds an investment position (Days, Weeks, Months, Quarters, and Years). These variables allow us to control for trading strategies that are likely correlated with risk management practices. For example, quantitative hedge funds typically hold thousands of positions for short periods and may be more likely to invest in risk management.

Table 3 reports Pearson correlations among the risk management practices and the fund and investment characteristics. Many of the risk management practices are positively correlated with each other. For example, the correlations among three types of models are all greater than 0.70, and their correlations with the head of risk management measures are all greater than 0.20. There are also significant univariate correlations between the risk management practices and the independent variables. Leverage is positively and significantly correlated with models, limits on the trading authority of the head of risk management, and position limits.

We next examine the determinants of formal risk models. Table 4 presents marginal effects from estimates of probit regressions that examine the determinants of portfolio risk model use. For all approaches examined, models are more likely to be employed in funds that use leverage, engage in a long bias investment strategy, and make investments over shorter duration. These effects are economically significant. For example, funds that use leverage are 17 percentage points more likely to use at least one model and funds whose portfolios are long biased are 21 percentage points more likely to use at least one model. The association between leverage and the use of portfolio risk models is consistent with greater benefits from monitoring and understanding their portfolio risk when the fund's performance has greater exposure to changes in asset values.

Table 5 presents estimates from two probit models and an ordered probit model that examine the determinants of whether the fund's risk officer is dedicated to risk management, whether the head of risk management has trading authority, and whether the head of risk management is both dedicated and without trading authority. Holding the amount of capital provided by outside investors constant, we find that funds with greater proprietary assets are more likely to have a dedicated head of risk management and less likely to give the head of risk management trading authority. Both findings are consistent with fund managers implementing more extensive risk management practices when they have greater personal wealth invested in their fund. Moreover, we find that funds with higher levels of capital provided by outside investors are more likely to have a dedicated head of risk management who has no trading authority. In addition, younger funds and levered funds are less likely to give the trading authority to the head of risk management. Funds that typically hold large numbers of investment positions are more likely to have a dedicated head of risk management and less likely to give trading authority to the head of risk management.[8]

In Table 6 we examine the determinants of limits on the concentration of investment positions. In this ordered probit regression we find that larger funds, older funds, and off-shore funds are more likely to have position limits in place. The positive association between the use of investment position limits and both size and age is consistent with higher quality funds and funds with more valuable reputations having greater incentives to reduce exposures to risks that

[8]We find similar results when we treat the risk officer's trading authority as a nominal choice and estimate the determinants using multinomial logit.

are not in their investment mandates. In addition, funds that hold many positions and funds that hold their positions for typically more than a week are less likely to implement position limits.[9]

5 Downside risk

Evidence on risk management practices and downside risk

A critical objective of risk management is the elimination of costly lower-tail outcomes (Stulz, 1996). We therefore next examine whether there are differences in relative performance in the extreme down months of 2008 based on the risk management practices outlined in Section 3.

Tables 7 and 8 present univariate and multivariate comparisons of monthly performance in 2008 based on whether the fund uses risk models, the characteristics of the head of risk management, and the use of investment limits. In the multivariate tests, we include all of the independent variables used to model the determinants of risk management practices [Ln(Investor assets), Ln(Proprietary assets), Ln(Fund age), Leverage, Long bias, Short bias, Fund Offshore, Years, Quarters, Months, Weeks, 1000+ Positions, 200–999 Positions, 100–199 Positions, and 40–099 Positions] along with 10 indicator variables for the fund's investment style. The 10 style classifications are based on the Lipper TASS, the HFR, and the CISDM style designations and are presented in the Appendix. At the top of each table we present the month's return for the S&P 500 Index and the HFR Composite Index of hedge fund returns.

Consistent with formal risk models reducing downside risk, all of the coefficients on models are significantly positive in Table 8 for the months in 2008 in which the S&P 500 Index had a

[9]We find similar results when we treat investment limits as a nominal choice and estimate the determinants using multinomial logit.

return of less than negative five percent.[10] The magnitude of the coefficients on the indicator variables for all three types of models are economically significant. For example, the coefficient on value at risk for October 2008 is 6.4, implying that funds using value at risk had returns over 640 basis points higher than funds that do not use value at risk. Moreover, the univariate and multivariate results are similar in magnitude. For October 2008, the differences between funds using and not using models are as follows: value at risk, 6.4 (6.1) percentage points for the multivariate (univariate) test; stress testing, 6.0 (5.5) percentage points for the multivariate (univariate) test; scenario analysis, 7.7 (6.4) percentage points for the (univariate) multivariate test; at least one model, 6.0 (5.8) percentage points for the multivariate (univariate) test.

In Table 9, we present univariate comparisons of the relations between performance and the other risk management practices.[11] Inconsistent with prior research on the importance of chief risk officers in operating firms, we find no evidence that having a dedicated head of risk management reduces downside risk in our univariate of multivariate tests. We also observe no significant evidence that the extent of trading authority of the head of risk management affects downside risk. In fact, we find weak evidence that funds that give their head of risk management trading for hedging purpose only may actually perform worse during the financial crisis, although the limited number of funds that provide this specific trading authority to the risk manager limits the power of our tests. We also find little evidence that the use of investment limits lower downside risk during the equity bear market. In fact, the evidence suggests that funds with guideline limits actually performed worse than those without any investment limits during the height of the financial crisis in October 2008. Overall, we only find significant return relationships for formal risk models; none of the other practices are significantly associated with monthly performance in 2008.

[10] Even though the return on the S&P 500 Index was slightly positive and slightly negative for July and August, the coefficients on models are significantly positive for these two months. The positive and significant coefficients for July and August are, however, consistent with the fact that the return on the HFR Composite Index was negative for both months (July, −2.3%; August, −1.4%).

[11] In unreported tests, we find similar results when we carry out multivariate comparisons.

Alternative explanations

In this section, we examine several alternative explanations for the associations between the use of portfolio models and downside risk. It is important to rule out these alternative explanations given that our results contrast with predictions from the theory literature on risk management that there should no association between performance and risk management if firms are optimizing (for example, Smith and Stulz (1985) and Froot et al. (1993)).

Unobserved manager ability

The lower downside risk of hedge funds using formal models could be driven unobserved manager ability that is correlated with risk management practices. To investigate this potential explanation, we examine whether models are associated with performance during 2007 and 2009–2010. As shown in Table 10, for these periods, we find only limited associations, at best, between models and performance for these periods. Moreover, these long window results suggest that models do not represent mean positive differences in performance but instead represent differences in exposures to downside risk.[12]

To further control for unobserved ability, we hand collected data on the managers' educations. Namely, for each member of the management team we collected their degrees (bachelors, masters, and Ph.D.), whether their undergraduate and masters degrees were in technical subjects (mathematics, science, or engineering) or in business or economics, and their undergraduate institutions.[13]

Table 11 presents descriptive statistics for the managers in our sample. For the risk man-

[12]When we examine monthly performance over the period starting January 2005 through December 2010, we find limited evidence that funds using risk models perform worse in months in which the S&P 500 Index had large positive returns. For example, for months in which the S&P 500 Index gained five percent or more, funds using at least one model underperformed funds that use no models by 1.7 percentage points. These results, however, involve small sample sizes and are sensitive to the empirical specification and sample selection.

[13]Given the relatively small number of managers with Ph.D.s, we do not categorize doctorates by whether they are in technical subjects or in business or economics.

agement team and the entire management team, we present the mean percentage of the management team with the relevant degree and the percentage of funds with at least one team member with such a degree. Over half the members of the risk and management teams have undergraduate degrees in either business or economics and over 40% have masters degrees in either business or economics. With respect to science or engineering degrees, they are slightly more prevalent for the risk management team (19% with undergraduate and 7% with masters) than for the entire management team (14% with undergraduate and 4% with masters). Similar percentages have a Ph.D. (12% for the risk management team and 11% for the entire management team). We find similar but slightly higher percentages when we examine whether at least one member of the team has the relevant degree.

Table 12 presents marginal effects from probit regressions that include as independent variables the percentages of the management team with each type of degree. Consistent with more technically able managers being more likely to use risk models, the coefficients on masters degrees in science or engineering are positive and statistically significant for value at risk and scenario analysis. In unreported analyses, we find similar results when we use the education of the risk management team and when we replace the percentage of the team with a degree with an indicator variable for whether at least one member of the team has the relevant degree.

Given that we find some evidence that our ability proxies are positively correlated with the use of risk models, we next examine whether ability, as proxied by education, is a correlated omitted variable in the performance regressions. Table 13 presents performance regressions that include as independent variables the percentages of the management team with each type of degree. For brevity, we present the results for whether the fund uses at least one type of portfolio risk model. In terms of sign, significance, and magnitude, the coefficients on whether the fund uses at least one model are similar to those presented in Table 8. For example, the coefficient for October 2008 is 6.0 in Table 8 and 6.1 in Table 13. With respect to education, managers with undergraduate degrees in business or economics had significantly positive performance in October 2008.

We find similar results when we use the individual types of models, the risk management team education measures, and indicator variables for whether at least one member of the team has the relevant degrees. For managers who graduated from US undergraduate institutions, we also hand collected from US News and World Reports the first and third quartiles of the SAT scores for the incoming freshman class of 2003. The coefficients on risk models are unaffected by the inclusion of the SAT scores in the performance regressions. Overall, we conclude that ability, at least as proxied by education, is not a correlated omitted variable.

Investment style

Although the tests presented in Table 8 adjust returns for the returns on the relevant style index and include indicators for investment style, the typical holding period of an investment position, and the typical number of investment positions, our results could be driven by differences in style and risk exposure.

First, as an alternative to controlling for investment style with indicator variables, we re-estimate the regressions presented in Table 8 but replace the dependent variable with a measure of the fund's abnormal return, calculated as the difference between the fund's return and the return on the relevant Lipper TASS style index (Convertible Arbitrage, Emerging Markets, Equity Market Neutral, Event Driven, Fixed Income, Global Macro, and Long Short Equity).[14] These results are presented in Table 14. They are quantitatively and qualitatively similar to the results presented in Table 8. For example, the coefficient on value at risk for October 2008

[14] We find similar results when we adjust using the relevant HFR style index.

when we use adjusted returns is 6.8 compared to 6.4 when we control for investment style using indicators in Table 8.[15]

Second, to examine the possibility that differences in style affect our results, we limit our sample to the largest investment style in our sample, namely long-short equity funds. Given that our sample of long-short equity funds is less than 30, we present univariate tests. In Table 15, we present univariate tests that compare the monthly performance in 2008 based on whether the long-short fund uses models. For this subset of funds, we find significant differences in the down months of 2008 based on whether the fund uses models. Moreover, the magnitude of losses for funds not using models is similar to the 16.9% loss experienced by the S&P 500 Index in that month: value of risk, −18.6%; stress testing, −16.6%; scenario analysis, −16.9%; at least one model, −16.6%. In contrast, funds using models experienced significantly lower losses: value at risk, −2.1%; stress testing, −4.9%; scenario analysis, −2.6%; at least one model, −4.3%. Differences in performance are similar in the other down months of 2008.

Third, to further control for differences in risk exposure, we re-estimate the regressions presented in Table 8 including each fund's beta, estimated using monthly returns from 2004 through 2007. Once again, the results for these tests are quantitatively and qualitatively similar to those presented in Table 8. We also match funds that use models with funds that do not use models based on prior volatility and beta and then examine differences in performance over September through November 2008. Once again, we find significantly better performance over these months for funds that use formal models.

Fourth, another potential explanation for our performance results is that riskier funds choose models. Several factors point against this selection-based explanation. First, as shown in Figure 1, the returns for funds that do not use models are more negatively skewed for October 2008, suggesting that riskier funds do not select models. Moreover, it suggests that the perfor-

[15]We find similar comparisons between the univariate and multivariate estimates for the other months of 2008 in which the S&P 500 Index lost five or more percent. In addition, for the months in which the coefficients on models are statistically significant, the p-values of the regressions decrease and the Adjusted R^2s increase.

mance differences do not represent a mean shift in returns and instead reflect greater exposure to downside risk for funds that do not use models. In addition, as shown in Figure 2, the monthly return volatility over the period January 2007 through June 2009 is greater for funds that do not use models. These differences in volatility are statistically significant at the mean and median, and when we control for investment style and portfolio characteristics, further suggesting that this form of selection does not drive our results. Selection could, however, be in the opposite direction. Namely, our results could be explained by less risky funds choosing models. But models require investments of both managerial effort and financial resources. These presumably non-trivial costs raise the question of why less risky funds would be more likely to make such investments, given that the marginal benefit of such investments is likely lower for less risky funds.

Fifth, another potential explanation is that the use of derivatives determines both risk management practices and performance in the down months of 2008 (Chen, 2011). The Lipper TASS database provides indicator variables for whether funds use equity, commodity, or currency derivatives (such as futures, warrants, swaps, and options). For the funds in our sample that self-report returns to the Lipper TASS database, we included in the performance regressions these measures of derivatives usage. The associations between models and performance are unaffected by the inclusion of these measures.

Sixth, there is a possibility that models are more likely to be used by quantitative hedge funds and that quantitative hedge funds performed better in the down months of 2008. We do not believe that quantitative hedge funds drive our results for several reasons. First, our empirical tests control for investment style along with the typical duration of an investment position and the typical number of investment positions. Second, to the extent that managers of quantitative hedge funds are more likely to have degrees in science and engineering, our results are robust to controlling for such degrees.

Risk culture

A fund's use of models could proxy for a fund's overall investment in risk management. For example, the underlying risk culture at an institution could determine both the risk of the investments and the strength of the institution's risk management practices (Arena et al., 2010; Mikes, 2009; Van der Stede, 2011). As discussed by Ellul and Yerramilli (2013), if general risk culture drives our results, then there should be correlations between all of the risk management practices and performance. In fact, as discussed earlier, we find no such overall relationships. Therefore, while culture may play an important role in risk management practice, it appears unlikely that our results are driven by such an omitted correlated variable.

Investment contract

An additional possibility is that the use of models is correlated with characteristics of the investment contract. For example, heterogeneity in fee structures or investor redemption rights might lead to heterogeneity in choices of risk management practices and/or exposures to downside risk. Hence, investment contract terms can also affect incentives to take risk (Van der Stede, 2011). To investigate this possibility, in unreported tests we include the following variables in the performance regressions: the management fee, the performance fee, whether the fund has a lock up, whether the fund manager has the right to implement on gate on redemptions, and whether the fund has redemption fee. The associations between models and performance are robust to controlling for these measures.

6 Accuracy of expectations

We next examine the extent to which risk management practices are associated with the accuracy of manager expectations of how their fund will perform during periods of extreme financial events. We posit that risk management practices improve the fund managers' understanding of how their fund's performance is affected by changes in the financial environment. Moreover, increased accuracy of expectations in funds that undertake formal risk management could in part explain why some funds performed better during the short-term equity bear market of 2008.

During the due diligence process, the vendor queried managers about their expectation of their fund's performance during a short-term (one month) equity bear market, which are classified into five categories: -2 = "Down"; -1 = "Down (a little)"; 0 = "No effect"; 1 = "Up (a little)"; 2 = "Up."[16] The last due diligence report was completed in August 2007—over six months prior to the bailout of Bear Stearns and thereby allowing us to evaluate the accuracy of expectations prior to the crises of 2008.

Table 16 presents the distribution of managers' expectations and tabulates the expectations by the fund's risk management practices. As shown in the table, there are no systematic relations among the risk management practices and expectations. Moreover, Chi-square tests confirm that there are no statistically significant differences. We observe two interesting features of the hedge fund manager expectations. First, we observe substantial heterogeneity in the manager's expectations to how their fund would perform in a short-term equity bear market. For example, 27.5% (44.5%) of fund managers expect their fund performance to improve (worsen) during a one-month equity panic. Second, many (28%) hedge fund managers believe that their fund returns are neutral or not exposed to a sharp decline in financial equity markets.

To evaluate the accuracy of managers' expectations, we use the short-term equity bear market that occurred during the months of September, October, and November 2008. Over these months, the S&P 500 Index lost 9%, 17%, and 7%. We aggregate performance over these three months for two reasons. First, it is not clear that each month represents a separate

[16] Later in the sample period, HedgeFundDueDiligence.com increased the categories to include -3 "Down a lot" and $+3$ "Up a lot." We coded such responses as -2 and $+2$.

short-term equity bear market. Second, prior research finds that hedge fund managers appear to spread negative returns over several months to smooth reported performance.[17].

Figure 3 plots mean and median performance over this period grouped by expected fund performance. If fund managers had accurate expectations of their fund's performance during a short-term equity bear market, then we would observe the mean and median fund performance increasing in expected performance. In general, there is a minimal, at best, association between the manager's expectation and actual performance for the full sample.

We next examine whether models are associated with the accuracy of expectations. In Figure 4, we split the sample by whether the fund used either value at risk or stress testing. For both types of models, we compare the median performance conditional on the manager's expectation. Figure 4 shows that, in general, expectations are more accurate for funds that use value at risk and stress testing to model portfolio risk. Moreover, we find that the Spearman correlations between expected and actual performance differ based on the use of value at risk (use, $\rho = 0.466$ with a p-value of 0.002; do not use, $\rho = 0.101$ with a p-value of 0.540). Overall, these findings suggest that value at risk, and to a lesser extent stress testing, are associated with more accurate manager expectations and provide managers with information about how their funds' performance is influenced by the financial environment, including exposures to systematic risk.

Further, we examine whether the other risk management practices are associated with the accuracy of expectations. Consistent with our performance tests, we find no associations between manager accuracy and the other risk management practices. Overall, we conclude that higher levels of accuracy are only associated with models.

[17]See Bollen and Pool (2008) and Cassar and Gerakos (2011)

7 Conclusion

Using a powerful setting, we provide evidence on the effectiveness of risk management practice. By doing so, we provide the first broad empirical investigation of how hedge funds manage risk and overcome a major impediment, in general, to the examination of risk management practices—the lack of cross-sectional data on internal organizational practices.

We find that the use of risk management practices are a function of fund characteristics, such as leverage, number of positions, and the capital invested by the fund managers. In addition, we find that funds using formal models of portfolio risk did relatively better in the extreme down months of 2008. The magnitude of these effects is economically significant. Controlling for size, age, investment style, portfolio characteristics, and manager education, we find that funds in our sample that use at least one model of portfolio risk had returns in October 2008 that were six percentage points higher than funds that did not use any type of model. We do not find that having a dedicated head of risk management or instituting formal investment position limits assists in reducing costly left-tail outcomes. Moreover, we show that funds employing formal models to evaluate portfolio risk have more accurate expectations. Therefore, we provide evidence of a novel benefit of better risk management practices—namely, assisting managers in monitoring and better understanding the risks faced by their portfolio.

Overall, our results suggest that the use of formal risk models, but not the other risk management practices, assist managers in reducing exposures to downside risks and increase the accuracy of managers' expectations. In doing so, we address Kaplan's call for more accounting research on the effectiveness of risk management.

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Appendix: Style Classification

Style	Vendor Style	Vendor
Convertible Arbitrage	Convertible Arbitrage	CISDM
	Convertible Arbitrage	TASS
Emerging Markets	Emerging Markets	CISDM
	Emerging Markets	TASS
Equity Market Neutral	Equity Market Neutral	CISDM
	Market Neutral	CISDM
	Equity Market Neutral	TASS
Event Driven	Event Driven Multi-Strategy	CISDM
	Capital Structure Arbitrage	CISDM
	Merger Arbitrage	CISDM
	Option Arbitrage	CISDM
	Event Driven	HFR
	Event Driven	TASS
Fixed Income Arbitrage	Fixed Income	CISDM
	Fixed Income—MBS	CISDM
	Fixed Income Arbitrage	CISDM
	Fixed Income Arbitrage	TASS
Global Macro	Global Macro	CISDM
	Macro	HFR
	Global Macro	TASS
Long/Short Equity	Equity Long/Short	CISDM
	Equity Hedge	HFR
	Long/Short Equity Hedge	TASS
Multi-Strategy	Relative Value Multi-Strategy	CISDM
	Relative Value	HFR
	Multi-Strategy	TASS
Fund of Funds	Multi-Strategy	CISDM
	Fund of Funds	HFR
	Fund of Funds	TASS
Miscellaneous	Dedicated Short Bias	TASS
	Commodity Pool Operator	CISDM
	Managed Futures	TASS
	Equity Long Only	CISDM
	Regulation D	CISDM
	Sector	CISDM
	Single Strategy	CISDM
	Systematic	CISDM

Figure 1: Distributions of returns for October 2008

This Figure compares kernel density estimates of the distributions of returns for October 2008 for funds that use and do not use formal models of portfolio risk.

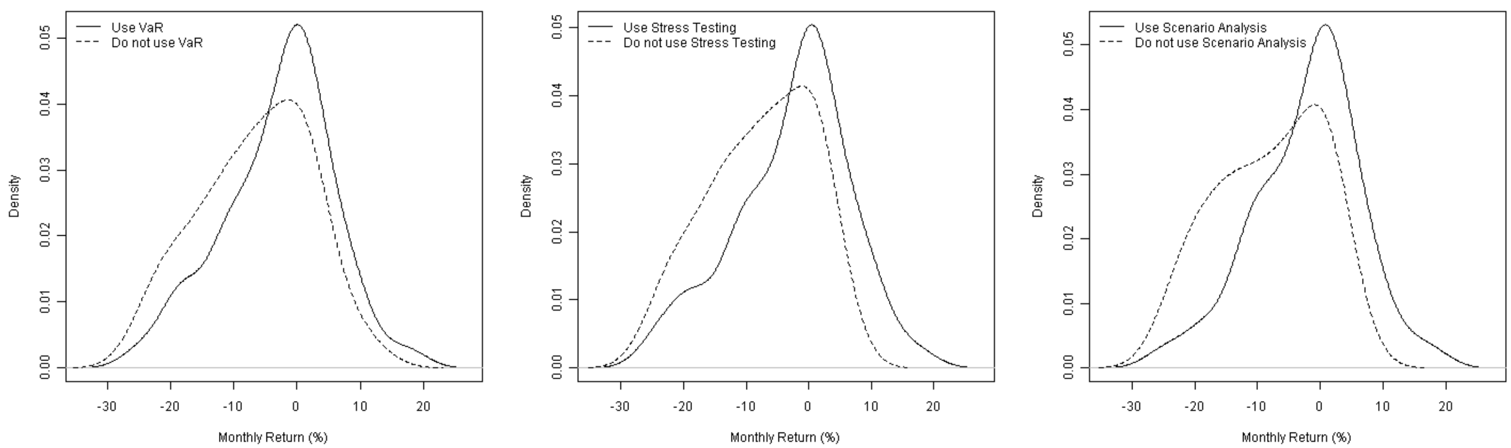


Figure 2: Annual volatilities by use of risk models

This Figure compares the distribution of annual volatilities for funds that use and do not use formal models of portfolio risk. Volatilities are estimated over the period January 2007 through June 2009 using the fund's monthly reported returns.

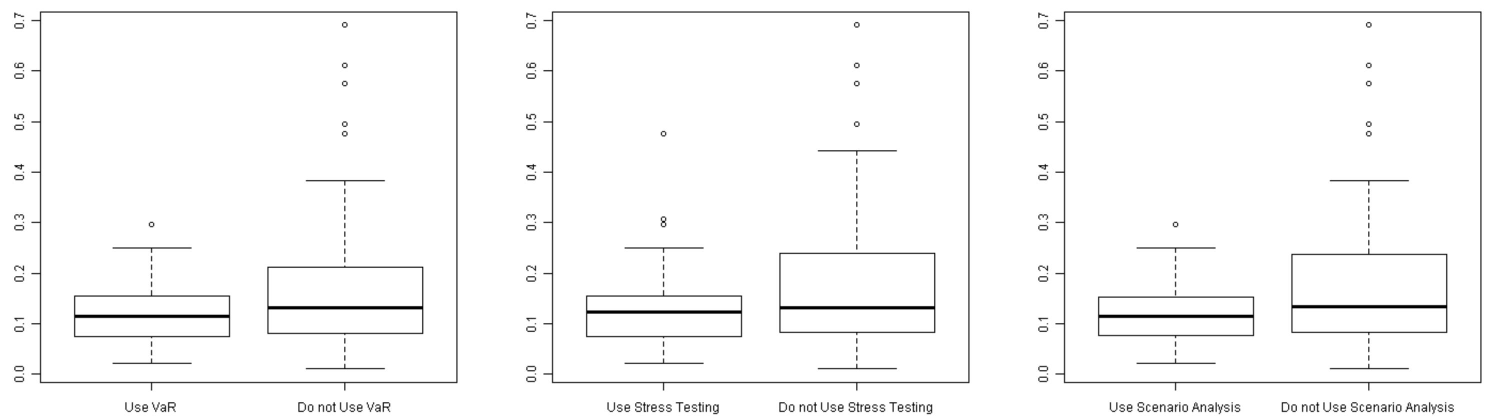


Figure 3: Accuracy of expectations of fund performance during a short-term equity bear market

This Figure plots mean and median fund cumulative performance for September through November 2008 (y-axis) against the manager's expected performance in a short-term equity bear market (x-axis) for the 90 funds with sufficient returns and expectations data. The scale for expected performance in a short-term equity bear market is as follows: −2 = "Down"; −1 = "Down (a little)"; 0 = "No effect"; 1 = "Up (a little)"; 2 = "Up."

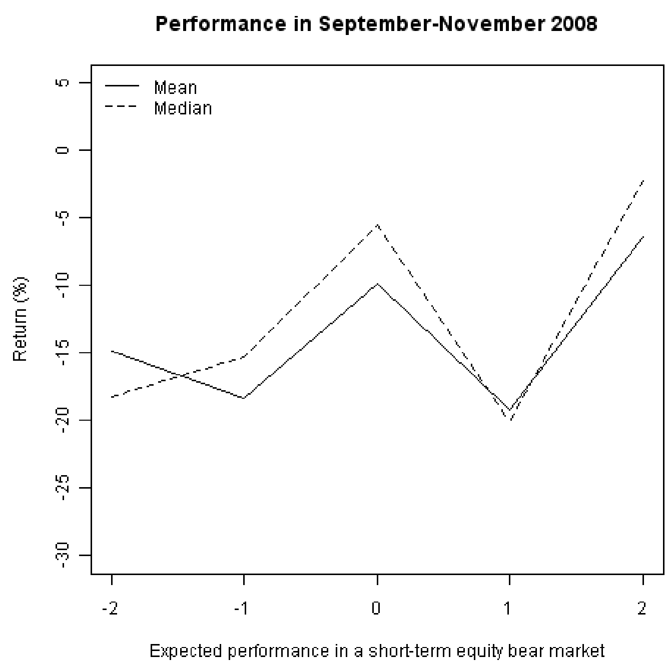
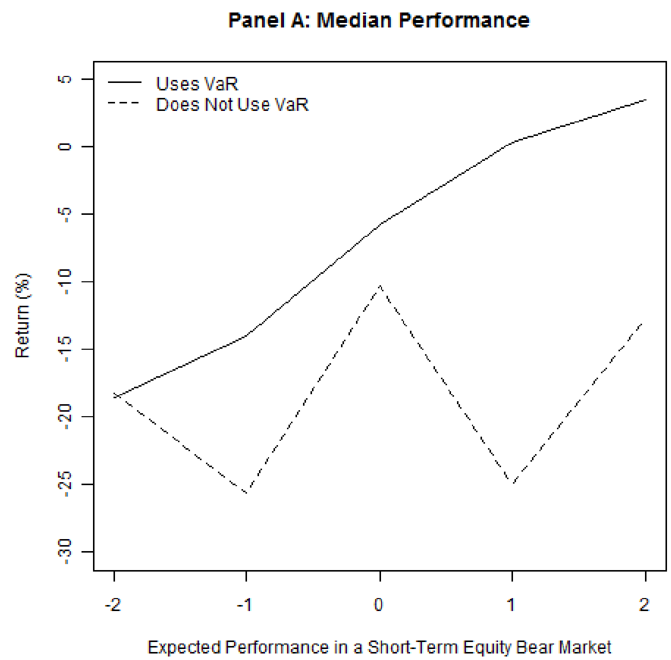


Figure 4: Models and accuracy of expectations of fund performance during a short-term equity bear market

This Figure compares the accuracy of expectations for funds that do and do not use value at risk. The plots show median fund cumulative performance for September through November 2008 (y-axis) plotted against the manager's expected performance in a short-term equity bear market (x-axis) for the 79 funds with sufficient returns, expectations, and risk management data. The scale for expected performance in a short-term equity bear market is as follows: -2 = "Down"; -1 = "Down (a little)"; 0 = "No effect"; 1 = "Up (a little)"; 2 = "Up."



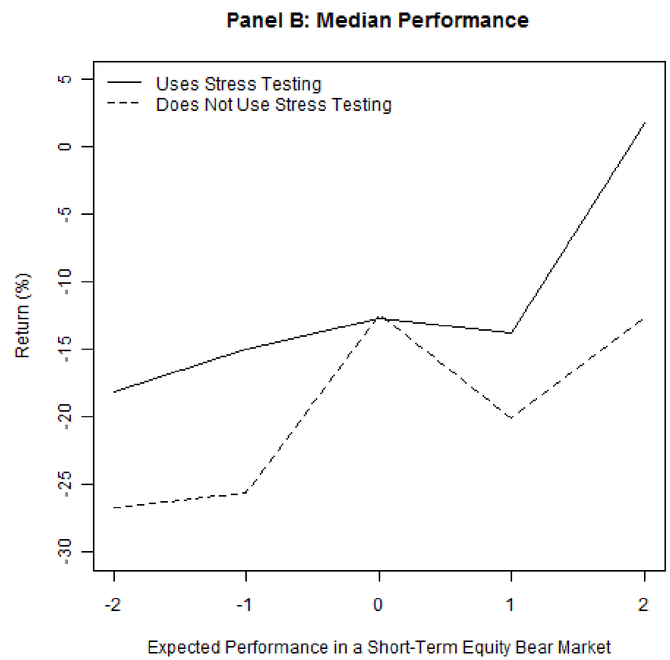


Table 1: Fund characteristics

This table presents descriptive statistics for the hedge funds in our sample. Assets under management and fund age are measured as of the date of due diligence. Assets under management is in thousands of US dollars. Investor assets represent investments by outsiders and Proprietary assets represent investments by the fund's manager and its employees. Leverage is an indicator for whether the fund uses explicit leverage. Long bias and Short bias are indicator variables for whether the fund's portfolio is tilted in either the long or short direction. Year, Quarters, Months, Weeks, and Days are indicator variables for the typical holding period of an investment position. 1000+ Positions, 200–999 Positions, 100–199 Positions, 40–99 Positions, and 1–39 Positions are indicator variables for the typical number of investment positions held by the fund.

	Mean	N	Std. Dev.	Q1	Median	Q3
Assets under management	304,783	423	652,378	40,000	107,000	269,000
Ln(Assets under management)	18.43	423	1.741	17.50	18.49	19.41
Ln(Investor assets)	14.46	423	7.59	16.01	17.80	19.01
Ln(Proprietary assets)	15.71	423	3.16	14.51	15.83	17.37
Age fund (days)	1,020	425	977	373	700	1,339
Ln(Age fund)	6.39	425	1.30	5.92	6.55	7.20
Leverage	0.54	425				
Long bias	0.36	421				
Short bias	0.20	421				
Fund offshore	0.84	424				
Years	0.32	424				
Quarters	0.31	424				
Months	0.15	424				
Weeks	0.09	424				
Days	0.13	424				
1000+ Positions	0.03	421				
200–999 Positions	0.08	421				
100–199 Positions	0.12	421				
40–99 Positions	0.35	421				
1–39 Positions	0.41	421				

Table 2: Portfolio risk management practices

This table presents descriptive statistics for the portfolio risk management practices used by the funds in our sample.

	Full sample		With returns & controls	
	%	N	%	N
Portfolio risk models				
Value at risk	43.7	387	41.8	110
Stress testing	52.1	380	52.7	112
Scenario analysis	46.4	364	45.2	104
At least one type	58.3	393	56.3	112
No models and testing	47.0	349	48.0	102
One type	7.7	349	6.9	102
Two types	8.9	349	9.8	102
All three types	36.4	349	35.3	102
Head of risk management				
Dedicated to risk management	34.0	262	34.5	84
No trading authority	25.8	361	21.6	102
Hedging authority only	4.2	361	3.9	102
Full trading authority	70.1	361	74.5	102
Dedicated and no trading authority	22.4	259	20.7	82
Position limits				
Hard limits	16.6	427	17.1	123
Guidelines	26.9	427	26.0	123
No limits	56.4	427	56.9	123

Table 3: Correlation matrix

		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Value at risk	1.00													
2	Stress testing	0.71	1.00												
3	Scenario analysis	0.75	0.88	1.00											
4	At least one	0.78	0.93	0.85	1.00										
5	Risk officer dedicated	0.27	0.31	0.28	0.32	1.00									
6	Risk officer trading	0.25	0.21	0.23	0.27	0.75	1.00								
7	Position limits	0.08	0.03	−0.03	0.06	0.14	0.01	1.00							
8	Ln(Investor assets)	−0.02	−0.01	0.01	−0.01	0.01	−0.01	0.11	1.00						
9	Ln(Proprietary assets)	0.11	0.08	0.12	0.10	0.23	0.17	−0.01	0.39	1.00					
11	Ln(Fund age)	0.06	0.02	0.02	0.03	0.13	-0.01	0.13	0.12	0.28	1.00				
12	Leverage	0.25	0.24	0.23	0.06	0.22	0.16	0.01	−0.08	0.10	−0.01	1.00			
13	Long bias	0.14	0.19	0.23	0.21	0.08	0.09	0.06	−0.02	0.14	0.05	0.18	1.00		
14	Short bias	−0.01	0.02	−0.01	0.02	−0.10	−0.07	−0.01	−0.02	−0.04	−0.01	0.01	−0.22	1.00	
15	Fund offshore	0.16	0.14	0.11	0.13	0.08	0.07	0.14	−0.08	0.12	−0.08	0.08	0.06	−0.10	1.00

Table 4: Models of portfolio risk

This table presents results from tests of the determinants of portfolio risk models. The columns present marginal effects from probit regressions in which the dependent variable is coded as 1 if the fund uses the model type, and 0 otherwise. Standard errors are in parentheses.

	Predicted sign	Value at risk	Stress testing	Scenario analysis	At least one
Ln(Investor assets)	+	0.001	0.003	−0.000	0.002
		(0.004)	(0.004)	(0.004)	(0.004)
Ln(Proprietary assets)	+	0.010	0.008	0.008	0.012
		(0.010)	(0.010)	(0.010)	(0.010)
Ln(Fund age)	+/-	0.008	−0.017	−0.011	−0.007
		(0.023)	(0.023)	(0.023)	(0.022)
Leverage	+	0.184***	0.142**	0.152***	0.170***
		(0.057)	(0.059)	(0.057)	(0.055)
Long bias		0.137**	0.231***	0.194***	0.210***
		(0.062)	(0.061)	(0.059)	(0.056)
Short bias		−0.012	0.027	0.052	0.050
		(0.073)	(0.075)	(0.071)	(0.068)
Fund offshore		0.233***	0.129	0.158**	0.162**
		(0.068)	(0.079)	(0.078)	(0.077)
Years		−0.221**	−0.151	−0.149	−0.214**
		(0.091)	(0.097)	(0.098)	(0.098)
Quarters		−0.186**	−0.086	−0.041	−0.120
		(0.090)	(0.096)	(0.097)	(0.098)
Months		0.017	0.112	0.082	0.018
		(0.110)	(0.111)	(0.107)	(0.108)
Weeks		0.070	0.062	0.113	0.074
		(0.126)	(0.133)	(0.128)	(0.120)
1000+ Positions		0.147	0.256	0.102	0.134
		(0.202)	(0.187)	(0.190)	(0.183)
200–999 Positions		0.172	0.140	0.297***	0.224***
		(0.109)	(0.111)	(0.087)	(0.086)
100–199 Positions		0.237***	0.189**	0.205**	0.172**
		(0.089)	(0.093)	(0.083)	(0.077)
40–99 Positions		0.165**	0.108	0.096	0.113*
		(0.064)	(0.065)	(0.063)	(0.060)
Year fixed effects		Included	Included	Included	Included
Observations		369	350	364	376
p-value		0.000	0.000	0.000	0.000
Log likelihood		-216.513	-212.639	-221.037	-220.190

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 5: Head of risk management characteristics and responsibilities

This table presents results from tests of the determinants of characteristics and responsibilities of the head of risk management. The first column presents marginal effects from a probit regression in which the dependent variable is coded as 1 if the head of risk management is dedicated to risk management, and 0 otherwise. The second column presents coefficients from an ordered probit regression in which the dependent variable is coded as 2 if the head of risk management has no trading authority, 1 if the head has hedging authority, and 0 if the head has full trading authority. The third column presents coefficients from a probit regression in which the dependent variable is coded as 1 if the head of risk management is dedicated and has no trading authority, and 0 otherwise. Standard errors are in parentheses.

	Predicted sign	Dedicated	Trading	Dedicated and no trading
Ln(Investor assets)	+	0.007	0.013	0.008*
		(0.006)	(0.011)	(0.005)
Ln(Proprietary assets)	+	0.056***	0.113***	0.039**
		(0.020)	(0.038)	(0.016)
Ln(Fund age)	+/-	0.005	−0.137**	−0.015
		(0.031)	(0.069)	(0.026)
Leverage	+	0.085	0.283*	0.022
		(0.068)	(0.164)	(0.058)
Long bias		−0.022	0.008	0.010
		(0.071)	(0.164)	(0.059)
Short bias		−0.085	−0.177	0.004
		(0.077)	(0.201)	(0.068)
Fund offshore		0.035	0.124	0.068
		(0.092)	(0.228)	(0.071)
Years		0.068	0.209	0.039
		(0.124)	(0.266)	(0.106)
Quarters		0.295**	0.353	0.186
		(0.124)	(0.257)	(0.115)
Months		0.347**	0.535*	0.188
		(0.145)	(0.294)	(0.149)
Weeks		0.385**	0.074	0.098
		(0.152)	(0.351)	(0.154)
1000+ Positions		0.514***	0.658*	0.160
		(0.156)	(0.390)	(0.181)
200–999 Positions		0.239*	0.541*	0.183
		(0.142)	(0.280)	(0.133)
100–199 Positions		0.031	0.104	−0.011
		(0.106)	(0.245)	(0.084)
40–99 Positions		0.060	0.338*	0.053
		(0.078)	(0.179)	(0.068)
Year fixed effects		Included	Included	Included
Observations		256	344	252
p-value		0.000	0.001	0.003
Log likelihood		−131.978	−231.738	−114.615

* p <0.1, ** p<0.05, *** p<0.01, two-sided test

Table 6: Limits on investment positions

This table presents results from tests of the determinants of position limits. It presents coefficients from an ordered probit regression in which the dependent variable is coded as 0 if the fund has no position limits, 1 if it has position guidelines, and 2 if it has hard limits. Standard errors are in parentheses.

	Predicted sign	Limits
Ln(Investor assets)	+	0.022**
		(0.009)
Ln(Proprietary assets)	+	−0.002
		(0.023)
Ln(Fund age)	+/-	0.135**
		(0.055)
Leverage	+	0.028
		(0.128)
Long bias		0.186
		(0.135)
Short bias		−0.013
		(0.158)
Fund offshore		0.566***
		(0.180)
Years		−0.457**
		(0.214)
Quarters		−0.319
		(0.210)
Months		−0.781***
		(0.247)
Weeks		-0.331
		(0.274)
1000+ Positions		−1.327***
		(0.467)
200–999 Positions		−0.254
		(0.246)
100–199 Positions		−0.007
		(0.201)
40–99 Positions		0.178
		(0.140)
Year fixed effects		Included
Observations		407
p-value		0.000
Log likelihood		−372.333

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 7: Univariate tests of association between portfolio risk models and performance in 2008

This table compares monthly mean performance in 2008 for funds that do and do not use portfolio risk models. Differences are tested using two-sided t tests.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Composite	−2.69	1.50	−2.24	1.63	1.87	−1.33	−2.29	−1.44	−6.13	**−6.84**	−2.67	0.15
Value at risk												
Use	−0.273	2.355	−1.912	1.079	1.390	0.632	−1.609	−0.718	−3.591	**−2.256**	−1.906	−0.030
Do not use	−1.334	1.519	−1.647	0.804	1.614	−0.661	−2.539	−1.423	−5.190	**−8.334**	−3.723	−1.829
p-value	0.225	0.332	0.392	0.665	0.659	0.082	0.199	0.358	0.246	**0.003**	0.094	0.037
Observations	110	110	110	110	110	110	110	110	110	**110**	110	110
Stress testing												
Use	−0.424	2.110	−1.498	0.559	1.347	0.876	−1.450	−0.785	−3.092	**−3.734**	−2.246	−0.650
Do not use	−1.697	1.540	−2.280	1.184	1.988	−1.032	−3.192	−1.591	−6.846	**−9.227**	−3.969	−1.905
p-value	0.157	0.522	0.263	0.325	0.248	0.016	0.028	0.350	0.008	**0.010**	0.110	0.218
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112
Scenario analysis												
Use	−0.330	2.166	−1.611	0.534	1.403	0.838	−1.630	−0.800	−2.927	**−2.801**	−2.233	−0.304
Do not use	−1.782	1.558	−2.012	1.370	1.812	−0.920	−2.749	−1.453	−6.192	**−9.241**	−4.136	−1.971
p-value	0.112	0.470	0.563	0.205	0.427	0.024	0.141	0.432	0.026	**0.002**	0.089	0.066
Observations	104	104	104	104	104	104	104	104	104	**104**	104	104
At least one model												
Use	−0.338	2.063	−1.524	0.658	1.353	0.819	0.353	−0.748	−3.002	**−3.525**	−2.092	−0.669
Do not use	−1.827	1.380	−2.134	1.296	1.843	−1.147	0.707	−1.574	−6.837	**−9.318**	−4.279	−2.087
p-value	0.105	0.446	0.381	0.299	0.370	0.018	0.039	0.360	0.006	**0.006**	0.048	0.167
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112

Table 8: Multivariate tests of association between portfolio risk models and performance in 2008 using raw returns

This table presents ordinary least squares regressions that test the association between portfolio risk models and monthly performance in 2008. The dependent variable in each regression is the fund's return for the month. The control variables include the independent variables presented in Tables 4, 5, and 6 along with indicator variables for the fund's investment style, which are presented in the Appendix. Standard errors are in parentheses.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Composite	−2.69	1.50	−2.24	1.63	1.87	−1.33	−2.29	−1.44	−6.13	**−6.84**	−2.67	0.15
Value at risk	2.210**	0.394	0.275	−0.159	−0.608	2.036**	1.866**	1.968**	2.671*	**6.417*** **	1.659	1.433
	(0.919)	(0.957)	(0.760)	(0.741)	(0.559)	(0.840)	(0.825)	(0.928)	(1.461)	**(2.108)**	(1.194)	(1.012)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	110	110	110	110	110	110	110	110	110	**110**	110	110
p-value	0.004	0.157	0.201	0.776	0.036	0.030	0.061	0.181	0.008	**0.001**	0.107	0.368
Adj. R^2	0.211	0.070	0.057	−0.055	0.134	0.141	0.113	0.063	0.187	**0.241**	0.089	0.020
Stress testing	1.792**	0.328	1.206	−0.848	−0.980*	2.388***	2.406***	1.401	4.403***	**6.041*** **	1.908*	1.433
	(0.867)	(0.943)	(0.741)	(0.715)	(0.558)	(0.778)	(0.792)	(0.885)	(1.403)	**(2.126)**	(1.107)	(1.012)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112
p-value	0.001	0.174	0.174	0.719	0.036	0.010	0.023	0.178	0.002	**0.005**	0.050	0.368
Adj. R^2	0.237	0.064	0.064	-0.043	0.132	0.176	0.148	0.062	0.223	**0.200**	0.119	0.020
Scenario analysis	2.842***	0.640	1.113	−1.454*	−0.642	2.869***	1.750**	1.235	5.271***	**7.686*** **	2.432**	1.600
	(0.891)	(0.988)	(0.753)	(0.735)	(0.556)	(0.854)	(0.848)	(0.964)	(1.386)	**(2.090)**	(1.218)	(1.042)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	104	104	104	104	104	104	104	104	104	**104**	104	104
p-value	0.001	0.611	0.098	0.485	0.024	0.023	0.077	0.191	0.001	**0.001**	0.088	0.356
Adj. R^2	0.278	−0.025	0.099	-0.002	0.159	0.160	0.111	0.064	0.307	**0.285**	0.104	0.023
At least one model	2.237**	0.428	1.114	−0.955	−0.820	2.532***	2.481***	1.629*	4.475***	**5.999*** **	2.247*	0.370
	(0.990)	(0.954)	(0.752)	(0.710)	(0.544)	(0.797)	(0.785)	(0.910)	(1.417)	**(2.131)**	(1.143)	(1.170)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112
p-value	0.002	0.148	0.261	0.650	0.030	0.008	0.018	0.227	0.002	**0.005**	0.060	0.650
Adj. R^2	0.230	0.072	0.041	-0.030	0.138	0.182	0.156	0.049	0.220	**0.197**	0.115	-0.030

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 9: Univariate tests of association between other risk management practices and performance in 2008

This table compares monthly mean performance in 2008 for funds that do and do not use the other risk management practices. Differences are tested using two-sided t tests. For trading authority and position limits we find no significant differences when we carry out multiple comparison tests.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Composite	−2.69	1.50	−2.24	1.63	1.87	−1.33	−2.29	−1.44	−6.13	**−6.84**	−2.67	0.15
Dedicated head of risk management												
Yes	−1.493	0.713	−1.325	1.363	1.253	−0.302	−1.938	−0.354	−4.134	**−5.512**	−2.719	−1.909
No	−1.368	1.898	−1.520	0.467	1.637	−0.24	−2.352	−2.204	−5.024	**−5.708**	−1.715	−0.709
p-value	0.91	0.14	0.80	0.25	0.51	0.95	0.65	0.07	0.62	**0.93**	0.32	0.26
Observations	84	84	84	84	84	84	84	84	84	**84**	84	84
Trading authority												
None	−0.431	2.288	−1.873	1.582	1.416	−0.779	−1.550	−1.766	−5.528	**−3.171**	−2.742	0.075
Hedging only	−2.683	2.725	−3.262	−2.117	3.980	1.036	−6.026	−2.881	−10.219	**−15.670**	−4.150	−3.213
Full	−1.456	1.135	−1.399	1.019	1.419	−0.295	−1.939	−0.517	−4.415	**−6.128**	−2.962	−1.798
Observations	102	102	102	102	102	102	102	102	102	**102**	102	102
Position limits												
Hard	−1.468	1.544	−2.746	0.391	0.850	0.372	−1.703	−0.807	−3.530	**−6.654**	−2.368	−3.077
Guidelines	−1.657	1.609	−1.671	0.993	1.428	−0.982	−2.566	−1.873	−5.530	**−8.204**	−3.988	−1.220
None	−0.530	1.908	−1.444	0.919	1.873	0.248	−2.015	−0.827	−4.349	**−4.463**	−2.374	−0.601
Observations	123	123	123	123	123	123	123	123	123	**123**	123	123

Table 10: Multivariate tests of association between portfolio risk models and performance in 2007 & 2009–2010

This table presents ordinary least squares estimations of the association between fund performance in 2007 and 2009–2010 and the portfolio risk models used by the fund. The dependent variable is the average monthly return over the period. The control variables include the independent variables presented in Tables 4, 5, and 6 along with indicator variables for the fund's investment style. Standard errors are in parentheses.

	Jan.–Dec. 2007	Jan. 2009–Dec. 2010
Value at risk	−0.422	-0.382
	(0.319)	(0.432)
Control Variables	Included	Included
Observations	110	73
p-value	0.663	0.612
Adj. R^2	−0.033	0.322
Stress testing	−0.002	−0.617
	(0.304)	(0.403)
Control Variables	Included	Included
Observations	112	74
p-value	0.667	0.265
Adj. R^2	−0.033	0.073
Scenario analysis	−0.279	−0.764*
	(0.334)	(0.432)
Control Variables	Included	Included
Observations	104	69
p-value	0.707	0.278
Adj. R^2	−0.044	0.075
At least one model	−0.104	−0.701
	(0.313)	(0.425)
Control Variables	Included	Included
Observations	112	75
p-value	0.649	0.511
Adj. R^2	−0.030	−0.008

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 11: Descriptive statistics for manager education

This table presents descriptive statistics for manager education. Team (%) presents the mean for the percentage of the management team or the risk management team with the relevant degree. At least one (%) presents the percentage of funds in which at least one member of either the management team or the risk management team has the relevant degree.

	Risk management team		Management team	
	Team (%)	At least one (%)	Team (%)	At least one (%)
Undergraduate degree in either business or economics	57	60	54	83
Undergraduate degree in science or engineering	19	22	14	36
Masters degree in either business or economics	43	45	41	71
Masters degree in science or engineering	7	8	4	12
Ph.D.	12	13	11	27
Number of funds	233		399	

Table 12: Models of portfolio risk controlling for education

This table presents results from tests of the determinants of portfolio risk models. The columns present marginal effects from probit regressions in which the dependent variable is coded as 1 if the fund uses the model type, and 0 otherwise. The control variables are the same independent variables used in Table 4. Standard errors are in parentheses.

	Value at risk	Stress testing	Scenario analysis	At least one
Undergraduate degree in either business or economics	0.055	−0.011	−0.043	−0.026
	(0.096)	(0.097)	(0.094)	(0.092)
Undergraduate degree in science or engineering	0.134	0.176	0.120	0.076
	(0.148)	(0.153)	(0.150)	(0.145)
Masters degree in either business or economics	0.072	0.023	0.019	0.058
	(0.090)	(0.093)	(0.090)	(0.086)
Masters degree in science or engineering	0.453*	0.649**	0.447	0.387
	(0.274)	(0.301)	(0.299)	(0.279)
Ph.D.	0.103	0.235	0.215	0.156
	(0.149)	(0.150)	(0.146)	(0.143)
Control variables	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Observations	346	329	343	353
p-value	0.000	0.000	0.000	0.000
Log likelihood	−195.443	−192.437	−204.982	−204.051

* $p<0.1$, ** $p<0.05$, *** $p<0.01$, two-sided

Table 13: Multivariate tests of association between portfolio risk models and performance in 2008 controlling for education

This table presents ordinary least squares regressions that test the association between portfolio risk models and monthly performance in 2008 controlling for manager education. The dependent variable in each regression is the fund's return for the month. The control variables include the independent variables presented in Tables 4, 5, and 6 along with indicator variables for the fund's investment style, which are based on the Lipper TASS and HFR style designations. Standard errors are in parentheses.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Composite	−2.69	1.50	−2.24	1.63	1.87	−1.33	−2.29	−1.44	−6.13	**−6.84**	−2.67	0.15
At least one model	3.184***	0.137	1.503*	−1.372	−1.226*	2.753***	2.795***	1.610	5.607***	**6.052****	2.709**	0.070
	(1.025)	(1.080)	(0.848)	(0.848)	(0.622)	(0.843)	(0.909)	(1.025)	(1.592)	**(2.447)**	(1.225)	(1.386)
Under. bus. or econ.	2.145	−2.809	4.879***	−0.403	0.116	1.843	1.179	1.723	2.613	**8.598***	1.708	0.992
	(1.960)	(2.067)	(1.623)	(1.622)	(1.190)	(1.612)	(1.739)	(1.962)	(3.046)	**(4.681)**	(2.343)	(2.653)
Under. science	2.595	−6.116*	5.746**	−0.647	−1.861	−0.435	5.013*	4.364	5.145	**6.817**	2.199	0.452
	(3.024)	(3.189)	(2.503)	(2.502)	(1.836)	(2.488)	(2.684)	(3.027)	(4.700)	**(7.222)**	(3.615)	(4.092)
Masters bus. or econ.	−3.840**	−4.073**	0.041	1.517	−1.734	−1.453	2.022	0.868	-1.022	**−2.579**	−4.263**	−2.376
	(1.775)	(1.871)	(1.469)	(1.468)	(1.077)	(1.460)	(1.575)	(1.776)	(2.758)	**(4.237)**	(2.121)	(2.401)
Masters science	2.001	−2.239	−2.856	0.911	−1.718	−7.635	−0.639	2.096	−12.254	**-3.491**	−22.499***	3.120
	(6.506)	(6.860)	(5.385)	(5.381)	(3.948)	(5.351)	(5.772)	(6.511)	(10.110)	**(15.534)**	(7.775)	(8.803)
Ph.D.	−0.249	−1.404	1.814	1.364	1.577	3.133	−0.348	0.987	7.475*	**10.489**	0.910	6.156*
	(2.696)	(2.843)	(2.232)	(2.230)	(1.636)	(2.218)	(2.392)	(2.698)	(4.190)	**(6.438)**	(3.222)	(3.648)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	96	96	96	96	96	96	96	96	96	**96**	96	96
p-value	0.018	0.827	0.141	0.476	0.143	0.101	0.140	0.399	0.005	**0.032**	0.040	0.797
Adj. R^2	0.216	−0.093	0.107	−0.068	0.106	0.128	0.107	0.022	0.271	**0.190**	0.179	−0.083

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 14: Multivariate tests of association between portfolio risk models and performance in 2008 using adjusted returns

This table presents ordinary least squares regressions that test the association between portfolio risk models and monthly performance in 2008. The dependent variable in each regression is the fund's return for the month minus the return for the relevant Lipper TASS style index. The control variables include the independent variables presented in Tables 4, 5, and 6. Standard errors are in parentheses.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Composite	−2.69	1.50	−2.24	1.63	1.87	−1.33	−2.29	−1.44	−6.13	**−6.84**	−2.67	0.15
Value at risk	1.703*	0.699	−0.407	−0.073	−0.614	1.898**	1.309*	1.313	2.301	**6.810*** **	0.063	1.016
	(0.903)	(0.975)	(0.777)	(0.670)	(0.541)	(0.817)	(0.787)	(0.878)	(1.401)	**(2.069)**	(1.989)	(0.957)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	110	110	110	110	110	110	110	110	110	**110**	110	110
p-value	0.141	0.999	0.355	0.630	0.235	0.28	0.255	0.409	0.17	**0.013**	0.071	0.789
Adj. R^2	0.061	−0.127	0.016	−0.023	0.038	0.029	0.034	0.008	0.053	**0.142**	0.087	-0.046
Stress testing	0.947	0.311	1.15	-0.752	-0.902	2.164***	2.287***	1.345	4.172***	**6.604*** **	3.160*	0.155
	(0.892)	(0.976)	(0.777)	(0.666)	(0.548)	(0.779)	(0.760)	(0.852)	(1.383)	**(2.107)**	(1.739)	(1.095)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112
p-value	0.214	0.996	0.319	0.419	0.203	0.137	0.036	0.349	0.041	**0.019**	0.015	0.901
Adj. R^2	0.041	-0.113	0.022	0.006	0.044	0.06	0.109	0.017	0.104	**0.129**	0.135	-0.066
Scenario analysis	1.804**	0.448	0.646	-1.284*	-0.736	2.321***	1.698**	1.095	4.498***	**7.718*** **	1.71	1.263
	(0.905)	(0.962)	(0.799)	(0.674)	(0.542)	(0.834)	(0.790)	(0.922)	(1.369)	**(2.087)**	(1.74)	(1.007)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	104	104	104	104	104	104	104	104	104	**104**	104	104
p-value	0.075	0.999	0.309	0.241	0.125	0.169	0.062	0.478	0.006	**0.004**	0.043	0.864
Adj. R^2	0.091	-0.132	0.026	0.039	0.07	0.056	0.098	-0.002	0.172	**0.187**	0.111	-0.064
At least one model	1.306	0.385	0.856	-0.866	-0.824	2.182***	2.188***	1.361	4.064***	**6.461*** **	2.654	0.134
	(0.910)	(0.978)	(0.769)	(0.648)	(0.531)	(0.788)	(0.748)	(0.859)	(1.370)	**(2.076)**	(1.771)	(1.105)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Yes**	Yes	Yes
Observations	112	112	112	112	112	112	112	112	112	**112**	112	112
p-value	0.215	0.998	0.337	0.441	0.209	0.142	0.036	0.39	0.036	**0.021**	0.022	0.917
Adj. R^2	0.041	-0.118	0.019	0.003	0.042	0.059	0.108	0.011	0.109	**0.125**	0.124	-0.071

* p<0.1, ** p<0.05, *** p<0.01, two-sided test

Table 15: Univariate tests of association between portfolio risk models and performance in 2008 for long-short equity hedge funds

This table compares monthly mean performance in 2008 for long-short equity hedge funds that do and do not use portfolio risk models. Differences are tested using two-sided t tests.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	**Oct**	Nov	Dec
S&P 500	−6.12	−3.48	−0.01	4.75	1.01	−8.60	−0.99	1.22	−9.08	**−16.94**	−7.48	0.78
HFR Equity Hedge (Total)	−4.47	1.31	−2.84	2.44	2.38	−2.44	−2.84	−2.17	−8.14	**−9.46**	−3.77	0.22
Value at risk												
Use	−2.091	3.578	−1.494	2.015	3.686	0.707	−0.499	−0.878	−2.736	**−2.114**	−0.373	0.919
Do not use	−6.917	1.010	−7.016	2.097	1.683	−4.911	−7.247	−6.200	−11.648	**−18.586**	−4.006	−0.565
p-value	0.038	0.334	0.009	0.966	0.309	0.036	0.005	0.112	0.021	**0.009**	0.176	0.568
Observations	27	27	27	27	27	27	27	27	27	**27**	27	27
Stress testing												
Use	−3.653	1.639	−1.830	2.047	2.177	1.045	−0.785	−1.442	−3.302	**−4.682**	−1.400	0.543
Do not use	−5.165	3.052	−6.669	1.099	3.691	−4.835	−7.444	−5.503	−12.222	**−16.574**	−3.159	0.267
p-value	0.472	0.560	0.018	0.627	0.433	0.015	0.004	0.186	0.017	**0.043**	0.471	0.908
Observations	29	29	29	29	29	29	29	29	29	**29**	29	29
Scenario analysis												
Use	−3.372	1.264	−1.914	2.259	1.845	0.884	−0.914	−1.165	−3.900	**−2.626**	−0.900	0.844
Do not use	−6.219	3.281	−6.444	1.921	3.359	−4.344	−6.706	−5.642	−10.544	**−16.887**	−3.659	−0.554
p-value	0.191	0.408	0.022	0.855	0.413	0.041	0.009	0.151	0.072	**0.016**	0.272	0.560
Observations	26	26	26	26	26	26	26	26	26	**26**	26	26
At least one model												
Use	−3.024	1.524	−1.740	1.911	2.019	0.989	−0.800	−1.286	−2.883	**−4.283**	−1.231	0.458
Do not use	−6.251	2.699	−6.944	2.085	3.364	−6.021	−7.541	−5.970	−12.693	**−16.635**	−3.687	−0.131
p-value	0.168	0.670	0.023	0.932	0.523	0.011	0.009	0.195	0.017	**0.049**	0.393	0.834
Observations	29	29	29	29	29	29	29	29	29	**29**	29	29

Table 16: Expected performance during a short equity bear market

This table presents the distribution of the managers' expected performance during a short-term equity bear market. It further classifies expected performance by the funds' risk management practices and presents p values from Chi-square tests of whether there is a relation between expectations and risk management practices.

		−2 Down a lot	−1 Down a little	0 No effect	+1 Up a little	+2 Up a lot	Total	p-value
All funds		46	59	66	26	39	236	
Value at risk	Yes	19	27	26	12	21	105	
	No	23	21	31	12	15	102	0.640
Stress testing	Yes	26	23	29	13	17	108	
	No	15	24	25	11	19	94	0.629
Scenario analysis	Yes	19	22	27	11	12	91	
	No	18	21	26	11	23	99	0.526
At least one model	Yes	29	26	34	14	21	124	
	No	15	20	24	10	17	86	0.733
Risk officer	Yes	17	14	15	9	14	69	
dedicated	No	25	40	46	15	23	149	0.312
Risk officer	Yes	29	44	50	18	26	167	
trading authority	No	13	9	11	7	11	51	0.312
Position limits	Hard limits	10	10	8	4	5	37	
	Guidelines	12	16	16	11	10	65	
	No limits	24	33	42	11	24	134	0.633