

Chapter 24 Financial Crises and Evaporating Diversification Benefits of Hedge Funds

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ABSTRACT

Diversification of risk is a potential benefit of investing in hedge funds. Using CSFB/Tremont hedge fund indices, this chapter shows that hedge fund strategies have different returns, volatility, and exposures to various systematic risk factors during tranquil times. This relation has led to the growth of the hedge industry and particular funds of hedge funds that provide diversification benefits by investing across different hedge fund styles. However, during financial crises, different hedge fund strategies are exposed to similar systematic risk factors. Most of the strategies become exposed to market liquidity and credit risk factors. Moreover, during the financial crises of 1998 and 2007-2008, all strategies were loading positively on the latent factor that induced positive correlation among hedge fund strategy residuals. As a result, diversification benefits incurred due to investing in different hedge fund strategies evaporated during these financial crises.

INTRODUCTION

The hedge fund industry has experienced an unprecedented growth since the 1990s. In 1990, hedge funds managed about \$39 billion in assets. Current estimates put hedge-fund assets at about \$2.5 trillion (Getmansky, Lee, and Lo 2015). Hedge funds appeal to investors due to higher risk-adjusted expected returns and greater diversification benefits across assets, styles,

and markets. Hedge fund investors are attracted by the claim of many hedge fund managers that they can generate *alpha*, which is the excess return after adjusting for investable benchmarks. Hedge fund managers are often unconstrained in their investment styles and tend to earn higher risk-adjusted returns by investing in emerging markets and exotic options, selling securities short, and engaging in arbitrage strategies. One attraction of hedge funds as investment vehicles is their perceived low exposure to market risk. Additionally, pension funds, endowments, and individuals have invested in hedge funds to diversify their portfolios. Furthermore, the proliferation of multi-strategy funds and funds of hedge funds (FOHFs) has allowed investors to diversify within the hedge fund industry (Learned and Lhabitant 2003; Amo, Harasty, and Hillion 2007).

However, the financial crisis of 2007-2008 has called into question whether hedge funds, and especially funds of funds (FOFs), provide diversification benefits. During this financial crisis, many strategies became highly correlated, greatly reducing any diversification benefits. This chapter shows that the correlation coefficient between hedge fund strategies in the sample jumped from 0.32 in August 2008 to 0.52 in September 2008, a 64 percent increase.

FOFs, which supposedly added diversification benefits for an extra fee, lost substantial amounts of value and many had to close as a result of the financial crisis of 2007-2008. As Getmansky et al. (2015) show, the number of FOHFs grew steadily through 2007 at a rate of more than 20 percent annually. By the end of 2007, 4,506 FOFs existed in the Lipper TASS database, and between 1996 and 2007 the attrition rate averaged 5 percent, lower than that of single manager hedge funds. However, the growth of the number of FOFs averaged only 8 percent annually between 2008 and 2014 and the attrition rate increased to 19 percent annually, implying a dramatic decline in this sector.

This chapter investigates why diversification benefits of hedge funds decrease during financial crises. First, hedge fund strategies that tend to load up uniquely on various risk factors and systematic risks during tranquil times tend to behave more similarly during financial crises.

Specifically, hedge fund exposures to the large-small, credit spread, and change in CBOE Volatility Index (VIX) risk factors increased for various hedge fund strategies during financial crises. Interestingly, hedge fund exposures to the S&P 500 index during crisis periods are smaller or negative compared to tranquil periods. This evidence suggests that hedge fund managers can reduce equity market exposures during financial crises.

Second, residual volatilities for different hedge fund strategies that tend to be uncorrelated or slightly correlated during tranquil times become highly correlated during crises leading to a high correlation between hedge fund returns reducing diversification benefits. This chapter investigates the dynamics of residual volatility of hedge fund returns (i.e., volatility that is captured after controlling for systematic observable factors). The chapter also highlights that residual volatility increases and residual returns are, on average, positively correlated during crisis periods. If the classical systematic hedge fund risk factors capture all common hedge fund risk exposures, then these properties of residuals should not be observed. Moreover, no evidence should exist indicating the presence of a latent factor that is a common driver of residual returns and volatilities for all hedge fund strategies.

This chapter identifies a common latent factor that induces a positive correlation among hedge fund strategy residuals during two financial crises: the Long Term Capital Management (LTCM) default in 1998 and the financial crisis of 2007-2008. As a result, the presence of the common latent factor exposure impedes diversification benefits that can usually be obtained by investing across different hedge fund strategies in tranquil times.

The chapter is organized in the following manner. The next section describes the data used in the study and main statistics for all hedge fund strategies as well as the S&P 500 index market factor. In the section that follows, the increase in variance and correlation during financial crises is decomposed into three components: (1) the increase in variance-covariance of classical systematic risk factors, (2) the increase in exposure to common systematic risk factors, and (3) the increase in idiosyncratic volatility and correlation of idiosyncratic returns

during crisis periods. The component related to the increase in exposure to common systematic risk factors is studied in the section “Increase in Exposure to Common Systematic Risk Factors.” The component related to the increase in idiosyncratic volatility and correlation of idiosyncratic returns during crisis periods is studied in the section “Increase in Correlation of Idiosyncratic Returns.” The section also identifies the presence of a common latent factor in hedge fund returns. Implications of these results for portfolio construction, diversification across different hedge fund strategies, and inferences for a well-known FOFs strategy are described in section “FOFs and Under-Diversification.” The chapter ends with a summary and conclusions.

THE STUDY

The analysis for this chapter is based on aggregate hedge fund index returns from the CSFB/Tremont database between January 1994 and December 2010. The CSFB/Tremont indices are asset-weighted indices of funds with a minimum of \$10 million in assets under management (AUM), a minimum one-year track record, and current audited financial statements. Indices are computed and rebalanced monthly and the universe of funds is redefined on a quarterly basis. This chapter uses net-of-fee monthly excess returns in excess of three-month Treasury bill rates. The database accounts for survivorship bias in hedge funds (Fung and Hsieh 2000). Table 24.1 describes the sample size, beta with respect to the S&P 500 index, annualized mean, annualized standard deviation, minimum, median, maximum, skewness, and excess kurtosis for monthly CSFB/Tremont hedge fund index returns.

(Insert Table 24.1 about here)

This chapter analyzes the following eight strategies related to the equity market: directional strategies such as dedicated short bias, long/short equity, and emerging markets, and non-directional strategies such as distressed, event driven multi-strategy, equity market neutral, convertible bond arbitrage, and risk arbitrage. One common systematic risk factor considered in the analysis is the S&P 500 index. Therefore, the chapter only concentrates on

hedge fund styles that either directly or indirectly have S&P 500 index exposure. For this reason, fixed income arbitrage and managed futures strategies are removed from the analysis.

This chapter finds that hedge fund categories greatly differ from each other. For example, annualized mean of excess returns for the dedicated short bias category is the lowest at –5.76 percent, and the annualized standard deviation is the highest at 16.99 percent. Long/short equity has the highest mean return of 9.00 percent and a relatively high standard deviation of 9.99 percent. The lowest annualized standard deviation is reported for the risk arbitrage strategy at 4.12 percent with an annualized mean of 3.66 percent.

All strategies except dedicated short bias exhibit negative skewness and large excess kurtosis. The equity market neutral strategy has an unusually large negative skewness (–11.81) and excess kurtosis (155.20) during this time period. The study further investigates this anomaly and finds that in November 2008 the Madoff fraud largely affected this strategy and the index earned –40 percent during that month. When excluding Madoff funds from the analysis, the skewness and excess kurtosis of the equity market neutral strategy is –0.98 and 9.26, respectively. According to the Jarque-Bera test, which is a measure of departure from normality, based on the sample kurtosis and skewness, all hedge fund category returns are not normally distributed.

The S&P 500 index is characterized by a large annualized excess return of 6.72 percent and a relatively large standard deviation of 15.82 percent during the sample period. During this time period, not all hedge fund indices outperformed the S&P 500 index. Based on the annualized mean, only long/short equity, event driven multi-strategy, and distressed strategies outperformed the market index. Because all hedge fund strategies earn superior returns compared to the market index, hedge fund investors might seek to invest in hedge funds for other benefits such as the diversification of portfolio risk. Moreover, the distribution of the market factor is far from normal and is characterized by negative skewness.

As previously discussed, other factors besides the S&P 500 index affect hedge fund index returns. This study begins with a comprehensive set of risk factors, covering stocks, bonds, currencies, commodities, momentum factor, and volatility. Chan, Getmansky, Haas, and Lo (2006) describe these as relevant traded factors to be used for each hedge fund strategy and include the following:

- **S&P 500** is the monthly return of the S&P 500 index including dividends.
- **Large-Small** is the monthly return difference between Russell 1000 and Russell 2000 indexes.
- **Value-Growth** is the monthly return difference between Russell 1000 Value and Growth indexes.
- **USD** is the monthly return on Bank of England Trade Weighted Index.
- **Δ VIX** is the monthly first-difference in the VIX implied volatility index based on the Chicago Board Options Exchange (CBOE)'s OEX options.
- **Credit Spread** is the difference between monthly seasoned BAA and AAA corporate bond yields provided by Moody's.
- **MSCI Emerging Markets Stock Index** is a float-adjusted market capitalization index that consists of indices in 26 emerging economies: Argentina, Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Morocco, Pakistan, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, Turkey, and Venezuela.
- **Momentum Factor** is a momentum factor based on six value-weighted portfolios formed using independent sorts on size and prior returns of New York Stock Exchange (NYSE), American Stock Exchange (AMEX), and NASDAQ stocks.

In all analyses, hedge fund returns, the S&P 500 index, and U.S. dollar returns (USD) are used in excess of three-month Treasury bill rates.

Hedge Fund Risk and Correlation during Financial Crises

The hedge fund industry has not been immune to financial crises including the Asian contagion (1997), Long-Term Capital Management (1998), the bursting of the tech bubble (2001–2002), the subprime mortgage crisis (2006–2008), the global financial crisis (CFC) (2007-2008), and the European debt crisis (2010-2012). Using the Lipper TASS dataset for individual hedge funds, Getmansky et al. (2015) find that 70 percent of funds in the database show negative returns in 2008, the peak of the most recent financial crisis. In the face of such heavy losses, many investors fled from both individual hedge funds and the industry as a whole. During that period, Getmansky et al. (2015) show that the total of number of hedge funds started to decline, breaking the continuous growth trend in the number of hedge funds in the industry. Hedge fund investors started reevaluating their strategies and questioning the supposedly diversification benefits of hedge funds and FOFs. During the financial crisis, hedge fund managers rushed to exit from crowded trades and once-diversified positions became highly correlated. Moreover, once uncorrelated strategies became highly correlated, they lead to more severe losses.

This chapter investigates the sources of increased correlation of hedge fund strategy returns during financial crises. Specifically, correlation coefficients between hedge fund strategies are analyzed using a two-year rolling window (i.e., 24 observations). Figure 24.1 shows the average correlation coefficients among hedge fund strategies in Panel A between January 1994 and December 2008. This figure shows changes in correlation coefficients through time and the large increases during financial crisis periods. Specifically, during August 1998 the correlation coefficient increased by 50 percent (from 0.21 to 0.31) and during September 2008 the correlation coefficient increased by 64 percent (from 0.32 to 0.52). The average correlation coefficient increase among hedge fund strategies during all financial crises is 33 percent.

The following crises are considered in the sample: Mexican (December 1994 - March 1995), Asian (June 1997 - January 1998), Russian and LTCM (August 1998 - October 1998), Brazilian (January 1999 - February 1999), Internet Crash (March 2000 - May 2000), Argentinean (October 2000 - December 2000), September 11, 2001, drying up of merger activities, increase in defaults, and WorldCom accounting problems crises (June 2002 - October 2002), with Rigobon (2003) identifying these crisis periods, and the GFC of 2007-2008. The latter crisis is separated into two distinct episodes: the subprime mortgage crisis (August 2007 - January 2008), and the Lehman Brothers default and the collapse of other investment banks (September 2008 - November 2008). This study denotes other time periods as tranquil.

(Insert Figure 24.1 about here)

Table 24.2 shows that by splitting the sample into tranquil and crisis periods, the average annualized volatility of hedge fund strategy returns jumped by 90 percent during crises (i.e., an increase of almost a factor of two). Crises affect hedge fund strategies differently. The effect ranges from a 38 percent increase in volatility for the equity market neutral strategy to 176 percent for the convertible bond arbitrage strategy. This result is largely related to the exclusion of the Madoff effect, which biased returns of the equity market neutral strategy. However, in all cases, volatility greatly increased for hedge fund strategies during financial crisis periods.

(Insert Table 24.2 about here)

The increases in correlation and volatility can potentially be attributed to (1) the increase in variance-covariance of classical systematic risk factors, (2) the increase in exposure to common systematic risk factors, and (3) the increase in idiosyncratic volatility and correlation of idiosyncratic returns during crisis periods. The variance decomposition during tranquil and crisis periods provide detailed equations and results for this analysis. In order to analyze characteristics of hedge fund risk during financial crises for each strategy, the total change in variance in crisis periods is decomposed into the following: (1) change in monthly variance associated with an increase in variance-covariance of classical systematic risk factors, (2) the

change in variance associated with an increase in exposure to common systematic risk factors (i.e., an increase in factor loadings), and the increase in idiosyncratic variance during crisis periods.

To calculate the contribution of the variance-covariance component, for each strategy Equation 24.1 shows the difference between the systematic variance during crisis periods (i.e., the variance generated by the exposure to classical systematic risk factors assuming loadings on these factors are the same as loadings during tranquil periods) and systematic variance during tranquil periods:

$$\Delta\sigma_{VarCov}^{2Crisis} = \beta^{Tranquil} VarCov^{Crisis} \beta^{Tranquil^T} - \beta^{Tranquil} VarCov^{Tranquil} \beta^{Tranquil^T} \quad (24.1)$$

where $\beta^{Tranquil}$ is the vector of factor loadings on classical systematic risk factors during tranquil periods and $\beta^{Tranquil^T}$ is its transpose. $VarCov^{Crisis}$ and $VarCov^{Tranquil}$ are variance-covariances of classical systematic risk factors in crisis and tranquil periods, respectively.

The contribution of the increase in common systematic risk factor exposures (i.e., an increase in betas) during crisis periods is the difference between the systematic variance during crisis periods where crisis loadings are considered and the systematic variance determined considering the variance-covariance of risk factors during crisis periods and factor loadings of tranquil periods as shown in Equation 24.2:

$$\Delta\sigma_{Beta}^{2Crisis} = \beta^{Crisis} VarCov^{Crisis} \beta^{Crisis^T} - \beta^{Tranquil} VarCov^{Crisis} \beta^{Tranquil^T} \quad (24.2)$$

where β^{Crisis} is the vector of factor loadings on classical systematic risk factors during crisis periods and β^{Crisis^T} is its transpose.

Finally, Equation 24.3 shows the increase in idiosyncratic variance of hedge fund returns during crisis periods is the difference between idiosyncratic variances in crisis and tranquil periods:

$$\Delta\sigma_{Idio}^{2Crisis} = \sigma_{Idio}^{2Crisis} - \sigma_{Idio}^{2Tranquil} \quad (24.3)$$

Table 24.2 provides results for these three separate contributions to the hedge fund risk during crises for each hedge fund strategy and an average of all of these strategies. Besides the variance decomposition, percentage increases in variances in the crisis periods compared to the tranquil periods are calculated. On average, the increase in monthly variance during crisis periods, $\% \Delta \sigma^2^{Crisis}$, is 283 percent. Out of this, 42 percent is associated with an increase in variance-covariance of classical systematic risk factors, $\% \Delta \sigma_{VarCov}^2^{Crisis}$. A total of 130 percent is due to the increase in exposure to common systematic risk factors, $\% \Delta \sigma_{Beta}^2^{Crisis}$, (i.e., the increase in factor loadings). Another 111 percent is due to the increase in the idiosyncratic variance during crisis periods, $\% \Delta \sigma_{Idio}^2^{Crisis}$. In relative terms, 15 percent of the increase in total variance of hedge fund returns during crises comes from the increase in the variance-covariance of classical systematic risk factors, 46 percent is due to the increase in hedge fund exposures to common classical systematic risk factors, and the remaining 39 percent is due to the increase in the idiosyncratic variance during crisis periods. An increase in leverage during crises can potentially explain the 46 percent relative increase in variance associated with the increase in hedge fund exposures to common classical systematic risk factors. However, during crisis periods, the exposure to the S&P 500 index is reduced. If a factor exposure to the S&P 500 index proxies leverage, then leverage actually decreases during crisis periods.

To explain the increase in correlations among hedge fund strategies during crisis periods, the behavior of the fitted returns generated by a linear model is investigated with and without the crisis dummy. The average two-year rolling correlation coefficients between hedge fund strategy fitted returns for these two models are calculated as Panel B of Figure 24.1 shows. The R^2 of the regression of the two-year rolling average correlation coefficient of hedge fund strategy returns on the two-year rolling average correlation coefficient of fitted returns generated by a linear model without a crisis dummy is 34 percent.

Therefore, on average, 34 percent of the increase in correlation can be attributed to the change in variance-covariance of common classical systematic risk factors. The R^2 of the regression of the two-year rolling average correlation of hedge fund strategy returns on the two-year rolling average correlation coefficient of fitted returns generated by a linear model with a crisis dummy is 67 percent. Therefore, on average, 33 percent (67 percent – 34 percent) of the increase in the correlation coefficient can be attributed to the increase in hedge fund exposures to common classical risk factors during crisis periods. Thus, the residual 33 percent is due to the increase in correlation of the idiosyncratic returns. Additionally, the average correlation coefficient among hedge fund idiosyncratic returns during tranquil period is 0.15 and during crises period is 0.27 (i.e., the average correlation coefficient increases by 84 percent during crisis periods).

Increase in Exposure to Common Systematic Risk Factors

The previous section highlighted that the increase in hedge fund exposures to common classical risk factors during financial crisis periods can explain about a third of the increase in correlation between hedge fund styles. This section seeks to uncover such common systematic risk factors during crises. As such, for each hedge fund strategy, a linear factor model is estimated by regressing hedge fund strategy returns on risk factors previously described in section “The Study.” Additionally, all these risk factors are considered as interaction terms with a crisis dummy.

To define crisis periods, a dummy variable is assigned that is equal to one during the following crises periods: Mexican (December 1994 - March 1995), Asian (June 1997 - January 1998), Russian and LTCM (August 1998 - October 1998), Brazilian (January 1999 - February 1999), Internet Crash (March 2000 - May 2000), Argentinean (October 2000 - December 2000), September 11, 2001, drying up of merger activities, increase in defaults, and WorldCom accounting problems crises (June 2002 - October 2002), and the GFC of 2007-2008. The crisis

period is separated into two distinct episodes: the subprime mortgage crisis (August 2007 - January 2008), and the Lehman Brothers default and the collapse of other investment banks (September 2008 - November 2008).

As Table 24.3 shows, the crisis dummy variable is often significant for different risk factors. This confirms that during crisis periods risk exposures of hedge funds change. For example, during tranquil periods, the exposure of the convertible bond arbitrage strategy to credit spread is not significant, but becomes -1.47 and highly significant (i.e., the t-statistic is -2.85) during crisis periods. For the same strategy, the crisis dummy interaction with the S&P 500 index is insignificant. During tranquil times, the exposure of the emerging markets strategy is positive and significant (0.38) to the S&P 500 index factor. Yet, the total exposure is reduced almost to zero ($0.38 - 0.36$) during the crisis.

(Insert Table 24.3 about here)

Figure 24.2 depicts the number of strategies with significant factor exposures during tranquil and crisis periods. All factors introduced in the section “Description of Hedge Fund Strategies” are analyzed: S&P 500, Large-Small, Value-Growth, USD, Δ VIX, Credit Spread, MSCI Emerging Markets Stock Index, and Momentum Factor. Also included are Lehman Government Credit and Term Spread as additional explanatory variables, but both are insignificant, thus they are excluded in the final specification. Lehman Government Credit is the monthly return of the Lehman U.S. Aggregated Government/Credit index. The Barclays index is used after the discontinuation of the Lehman index in 2008 due to the Lehman Brothers collapse. Term Spread is the difference between the 10-year Treasury bond redemption yield and the 6-month LIBOR. Compared to tranquil periods, more factors are common during crisis periods. During crisis periods, common risk exposures for more than 50 percent of strategies are observed for Credit Spread, Large-Small, and S&P 500 risk factors, suggesting that these factors are important in accessing systematic hedge fund risk, especially during crises.

(Insert Figure 24.2 about here)

For most of the strategies, the exposure to the S&P 500 index during crisis periods is smaller or negative compared to tranquil periods. This suggests that hedge fund managers can time hedge market exposures, especially during financial crises. For example, the long/short equity strategy has an exposure to the S&P 500 index of 0.23 during the tranquil period, which is reduced to -0.10 ($0.23 - 0.33$) during the crisis period. This result is consistent with Brunnermeier and Nagel (2004) who show that hedge funds captured the upturn, but reduced their positions in technology stocks that were about to decline, avoiding much of the downturn during the technology bubble burst of 2000. This reduction in exposure can also be due to the decrease in leverage during crises.

Next, the study investigates whether hedge fund managers can reduce hedge fund exposures to other risk factors during financial market distress or whether some common systematic factors are present for most hedge fund strategies during financial crises. According to Figure 24.2, the reduction in risk exposure is not achieved for any other risk factors during the crisis periods. The exposure to most risk factors actually increased during the crisis periods. For example, all hedge fund strategies have significant exposure to the Large-Small factor except the long/short equity strategy. This result suggests that the Large-Small variable may potentially capture a common factor in the hedge fund industry. Large-Small can serve as a market liquidity proxy (Amihud 2002; Acharya and Pedersen 2005). Small stocks have greater sensitivity to market illiquidity than large stocks, meaning that they have greater liquidity risk. The results show that liquidity is highly relevant for hedge funds. This result is consistent with the potential interpretation of Acharya and Schaefer (2006) that the “illiquidity” prices in capital markets exhibit different regimes. Specifically, in a tranquil regime, hedge funds are well capitalized and liquidity effects are minimal. However, in the “illiquidity” regime usually related to crises, hedge funds are close to their collateral constraints and “cash-in-the-market” pricing exists (Allen and Gale 1994, 1998).

Credit Spread is another common risk factor prevalent during crisis periods. Credit Spread exposure is negative and significant during tranquil times for only three strategies: dedicated short bias, equity market neutral, and event driven multi-strategy. However, during crisis periods, the exposure to Credit Spread is negative and statistically significant for five out of eight strategies. As Table 24.3 shows, credit spread exposures double or triple during crisis periods. The Credit Spread variable is a proxy for credit risk (Longstaff, Mithal, and Neis 2005) and funding liquidity risk (Brunnermeier 2009; Boyson, Stahel, and Stulz 2010). In times of uncertainty, the rate on low-credit illiquid investments such as BAA corporate bonds increases. At the same time, the demand for high-credit liquid investments such as AAA corporate bonds increases, leading to the increase in credit spread. Adverse shocks to funding liquidity accompanied by an increase in credit spreads lead to an increase in margins, de-leveraging, and margin calls, causing the unwinding of illiquid positions, generating further losses and margin calls, and finally culminating in hedge funds' collapse. During crisis periods, hedge funds face sudden liquidation and margin calls (Khandani and Lo 2007). This finding is consistent with the results in this chapter.

For many strategies some systematic risk exposures were absent (or exposure was positive) during tranquil times, but appeared during crisis periods. That is, volatility risk exposure for convertible bond arbitrage, equity market neutral, and event driven multi-strategy, and credit risk exposure for convertible bond arbitrage and emerging markets, long/short equity, distressed, and event driven multi-strategy were absent during tranquil periods but became significant negative during crises.

In conclusion, during crisis periods the effects of liquidity and credit risks on hedge funds are much higher compared to tranquil periods. Therefore, the exposures to Large-Small (market liquidity risk proxy) and Credit Spread (credit risk and funding liquidity proxy) are common across different hedge fund strategies.

Increase in Correlation of Idiosyncratic Returns

As previously identified, an increase in the correlation coefficient of idiosyncratic returns accounts for about one-third of the increase in the correlation coefficient between hedge fund styles. This section explores whether the presence of a latent factor drives this increase in correlation. If classical systematic hedge fund risk factors capture all common hedge fund risk exposures, then a common latent factor exposure should not exist across all hedge fund strategies.

To investigate the presence of the latent factor in hedge fund strategy returns requires analyzing the idiosyncratic returns of different hedge fund strategies. More specifically, for each hedge fund strategy, idiosyncratic returns and idiosyncratic volatility are calculated using the methodology developed by Billio, Getmansky, and Pelizzon (2015). The authors find that two different regimes with “high” and “low” volatilities characterize the idiosyncratic volatility of hedge fund strategy returns. Also, hedge fund indices that are in a “high” volatility regime tend to exhibit lower returns. As a result, for each strategy the latent factor contributes to an increase in idiosyncratic volatilities and a reduction in idiosyncratic returns. Khandani and Lo (2007) find that forced liquidations, the inability to maintain leverage and arbitrage positions, and margin calls are sources of increases in idiosyncratic volatility and reduction in idiosyncratic returns.

To capture the latent factor, the joint filtered probability of being in the high volatility regime is calculated for all hedge funds and plotted in Figure 24.3. The joint filtered probability jumps from approximately 0 percent in May 1998 to 62.80 percent in August 1998, the month of the LTCM collapse, to 81.57 percent in September 1998 and starts to subside in October 1998. The peak in the joint probability coincides with the liquidity crisis precipitated by the collapse of LTCM. Similar behavior is observed for the GFC in September 2008. The joint probability that idiosyncratic volatilities of hedge fund returns for all eight strategies are in a high volatility state is 64.20 percent in September 2008, the month of the Lehman Brothers' bankruptcy. As a result, both LTCM and the September 2008 crises exhibit similar patterns of behavior. Therefore,

similar shocks could affect both events. The next section provides a discussion of such potential shocks and common factors.

(Insert Figure 24.3 about here)

In conclusion, both systematic and latent risk factor exposures contribute greatly to volatility and correlation of hedge fund strategy returns. As a result, hedge fund risk modeling should include both common systematic and latent factors. Omitting the latent risk factor exposure significantly underestimates the impact of financial crises on hedge fund risk and correlation among strategies.

Funds of Funds and Under-Diversification

The proliferation of multi-strategy funds and FOFs since the mid-1990 helped investors to diversify within the hedge-fund industry (Learned and Lhabitant 2003; Amo et al. 2007). However, the financial crisis of 2007–2008 calls into question the view that hedge funds are really “hedged” and that diversification across hedge-fund styles is beneficial. Figure 24.1 captures large increases between hedge fund strategies during financial crisis periods. Specifically, during August 1998 the correlation coefficient increased by 50 percent (from 0.21 to 0.31) and during September 2008 the correlation coefficient increased by 64 percent (from 0.32 to 0.52). At the same time, the average hedge fund returns declined substantially.

The evidence shows a strong presence of a common (i.e., across all hedge fund strategies) latent risk factor exposure in August-October 1998 (during the LTCM/Russian crisis) and in August-September 2008 (during the GFC). The peak in the “commonality” measure coincides with the peak of both crises. Specifically, Figure 24.3 shows that the joint probability of a high idiosyncratic volatility regime among hedge-fund strategies jumped from about 0 percent in May 1998 to 81.57 percent in September 1998 and to 64.20 percent in September 2008. This finding provides evidence that even after accounting for market and other classical systematic factor exposures, during the LTCM and the GFC, a common latent factor affected

the hedge fund industry. We capture this common latent factor that induces a positive correlation among hedge fund strategy residuals during these two crises. This factor cannot be captured with classical risk factors used in hedge fund risk models.

The failure of financial institutions precipitated both crises: LTCM in 1998 and Lehman Brothers in 2008. These large companies were not too big to fail contrary to popular opinions and market expectations. As a result, these failures exacerbated the fragility of other financial institutions, especially hedge funds, leading to runs on hedge funds, massive redemptions, credit freeze, and subsequently poor performance and failure of many hedge funds. Faced with redemptions, restrictions on short selling, increases in funding costs, and inability to obtain leverage, many hedge funds across different strategies could not maintain their arbitrage positions and engage in eliminating price inefficiencies in the system.

Investors who hoped to obtain diversification benefits by investing in multiple hedge fund strategies or in FOFs experienced large losses due to positive correlation among seemingly unrelated strategies. The common latent factor includes a positive correlation among hedge fund strategy residuals during financial crises. As a result, the presence of the common latent factor exposure impedes diversification benefits that can usually be obtained by investing across different hedge fund strategies in tranquil times.

In tranquil times hedge fund investors often obtain diversification benefits. Cumming, Dai, and Shawky (2012) show that FOFs are generally more diversified compared to individual hedge funds. They find that FOFs diversify across different sectors and geographic areas, and this leads to an increased performance. They also find that on average diversification leads to a larger probability of fund survival.

In documenting the performance of the hedge-fund industry from 1995 to 2004, Fung, Hsieh, Naik, and Ramadorai (2008) find that, on average, FOFs deliver alpha only in the period between October 1998 and March 2000, although a subset of FOFs seem to have a consistent alpha. According to Brown, Gregoriou, and Pascalau (2011), a significant competitive

advantage exists to large FOFs resulting from due diligence expenses. The authors find significant economies of scale for FOFs—the larger the FOFs, the better is its performance.

According to HFR (2013), in the fourth quarter of 2013, 63 percent of FOFs experienced fund outflows but only 45 percent of single-fund manager funds did. Using the Lipper TASS database, Getmansky et al. (2015) show that FOFs grew significantly through 2007 with the number of funds growing by more than 20 percent every year. However, the fund formation rate in 2008 through 2014 was, on average, only 8 percent annually, and the attrition rate leapt to an average of 19 percent annually, implying a marked decline in this sector. This finding is consistent with the general decline in the number of FOFs, which is attributable to their fees, competition from multi-strategy funds, and general inability to avoid losses during the GFC.

Brown, Goetzmann, and Liang (2004) conclude that fees are especially relevant for FOFs. The authors show that FOFs charge two layers of fees to their investors. The first layer of fees is charged by all the constituent funds and the second layer of fees is charged by FOFs, typically a 1 percent fixed fee and a 10 percent incentive fee. As a result, authors find that individual funds dominate FOFs in terms of net-of-fee returns and Sharpe ratios, which they attribute to the double fees implicit in fund-of-funds compensation structures.

In conclusion, investors are willing to pay for diversification benefits and due-diligence provided by FOFs, but the results show that during financial crises such benefits evaporate subsequently leading to withdrawal of FOF investment, attrition in FOFs, and decline of the sector. During financial crises, diversification benefits that are often provided by FOFs decline and investors are unwilling to pay an extra layer of fees if their investments are not really “hedged.”

SUMMARY AND CONCLUSIONS

The last couple of decades have seen a large growth of hedge funds and FOFs. Investors choose this alternative asset class due to its superior returns, alphas delivered by some

managers, and ability to diversify risk. FOFs are especially attractive as they offer diversification benefits by investing in multiple strategies while conducting due-diligence on individual hedge fund managers. However, the recent financial crisis shows that such diversification benefits can quickly evaporate, and seemingly unrelated strategies suddenly become highly correlated.

This chapter decomposes the increase in individual strategy and average strategy variance as well as average correlation coefficient of hedge fund strategy returns during financial crises into three components: (1) change in variance-covariance of common classical systematic factors, (2) increase in hedge fund exposures to common classical risk factors, and (3) increase in correlation of the idiosyncratic returns. Each component contributes equally to the increase in correlation coefficient among hedge fund strategies during the financial crisis.

In terms of systematic exposures, most hedge fund strategies increase the loadings on asset liquidity and credit risk factors during crisis periods. Surprisingly, idiosyncratic risk is not independently distributed across different strategies. The increase in correlation of the idiosyncratic returns contributes, on average, 33 percent of the increase in the correlation coefficient between hedge fund strategy returns. The average correlation coefficient among hedge fund idiosyncratic returns during tranquil periods is 0.15 and during crises periods is 0.27 (i.e., the correlation coefficient increases by 84 percent during crisis periods). Therefore, crisis times greatly reduce the diversification benefits achieved by investing in hedge funds during tranquil times.

The chapter also explores the common driver of residual returns and volatilities for all hedge fund strategies. This study captures the latent factor and shows that this common latent factor induces a positive correlation among hedge fund strategy residuals during two financial crises: LTCM in 1998 and the financial crisis of 2007-2008. As a result, during these crises periods, diversification benefits evaporated. Thus, analyzing both common systematic and latent factors during both tranquil and crisis periods when making hedge fund investment decisions is

important. Not accounting for latent factors in understanding portfolio volatility and correlation can lead to unrealistic diversification expectations.

DISCUSSION QUESTIONS

1. Discuss why hedge funds are attractive investments.
2. Explain the causes of increased correlations among hedge fund strategies during crisis periods.
3. Discuss common classical risk factors during crises.
4. Discuss conditions under which diversification benefits evaporate.
5. Discuss whether hedge funds are really “hedged” during crisis periods.

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Table 24.1 Summary Statistics

This table presents summary statistics for monthly CSFB/Tremont hedge fund index excess returns and the S&P 500 index excess returns from January 1994 to December 2008. All returns are in excess of three-month Treasury bill rates. N is the number of observations. $\beta_{S\&P500}$ is contemporaneous market beta. Annual Mean Return is the annualized mean return, and Annual Standard Deviation is the annualized standard deviation. Minimum Return, Median Return, and Maximum Return are minimum, median, and maximum monthly returns, respectively. The returns are in percentage terms. The Jarque-Bera statistic has an asymptotic chi-squared distribution with two degrees of freedom and can be used to test the null hypothesis that the data are from a normal distribution. The data exclude the equity market neutral category all Madoff funds.

Strategy	N	$\beta_{S\&P500}$	Annual Mean Return (%)	Annual Standard Deviation (%)	Minimum Return (%)	Median Return %	Maximum Return %	Skewness	Excess Kurtosis	Jarque-Bera p-value
Convertible bond arbitrage	204	0.16	4.55	7.05	-12.63	0.69	5.80	-2.58	15.11	0.00
Dedicated short bias	204	-0.82	-5.76	16.99	-11.29	-1.03	22.31	0.69	1.42	0.00
Emerging markets	204	0.52	5.79	15.24	-23.43	1.07	16.04	-0.82	4.87	0.00
Equity market neutral	204	0.18	2.42	10.53	-40.45	0.40	3.65	-11.81	155.20	0.00
Long/short equity	204	0.15	9.00	9.99	-11.90	0.82	10.16	-0.12	3.43	0.00
Distressed	204	0.23	6.52	6.52	-11.92	0.63	4.77	-1.83	9.49	0.00
Event driven multi-strategy	204	0.25	7.53	6.59	-12.85	0.86	4.14	-2.28	12.14	0.00
Risk arbitrage	204	0.13	3.66	4.12	-6.55	0.33	3.38	-1.14	5.41	0.00
S&P 500	204	1.00	6.72	15.82	-16.69	1.05	9.50	-0.65	0.80	0.00

Table 24.2 Variance Decomposition During Crisis Periods

Increase in variance during financial crises is decomposed into three components: (1) the increase in variance-covariance of classical systematic risk factors, (2) the increase in exposure to common systematic risk factors, and (3) the increase in idiosyncratic volatility and correlation of idiosyncratic returns during crisis periods. Decomposition is calculated for each hedge fund strategy and on average.

	Convertible Bond Arbitrage	Dedicated Shortseller	Emerging Markets	Equity Market Neutral	Long/Short Equity	Distressed	Event Driven Multi- Strategy	Risk Arbitrage	Average
Ann. σ^{Tranquil}	4.24	15.12	12.83	2.60	9.23	4.46	4.43	3.22	7.01
Ann. σ^{Crisis}	11.70	21.92	20.45	3.58	14.17	10.33	9.81	6.33	12.29
Ann. $\Delta\sigma^{\text{Crisis}}$	7.46	6.80	7.62	0.98	4.94	5.88	5.38	3.11	5.27
Ann. $\%\Delta\sigma^{\text{Crisis}}$	176%	45%	59%	38%	54%	132%	121%	97%	90%
$\sigma^2_{\text{Tranquil}}$	1.50	19.04	13.73	0.56	7.09	1.66	1.63	0.86	5.76
σ^2_{Crisis}	11.41	40.05	34.86	1.07	16.73	8.90	8.01	3.34	15.55
$\Delta\sigma^2_{\text{Crisis}}$	9.91	21.00	21.13	0.50	9.63	7.24	6.38	2.48	9.79
$\%\Delta\sigma^2_{\text{Crisis}}$	662%	110%	154%	90%	136%	437%	391%	287%	283%
$\sigma^2_{\text{Beta}} \text{Tranquil} \text{VarCov}^{\text{Tranquil}}$	0.29	14.52	3.24	0.07	1.14	0.58	0.49	0.21	2.57
$\sigma^2_{\text{Beta}} \text{Tranquil} \text{VarCov}^{\text{Crisis}}$	1.42	28.73	6.34	0.16	2.98	1.82	0.99	0.36	5.35
$\Delta\sigma^2_{\text{Beta}} \text{Crisis} \text{VarCov}^{\text{Crisis}}$	1.13	14.21	3.10	0.09	1.84	1.24	0.49	0.15	2.78
$\%\Delta\sigma^2_{\text{Beta}} \text{Crisis} \text{VarCov}^{\text{Crisis}}$	75%	75%	23%	16%	26%	75%	30%	18%	42%
$\sigma^2_{\text{Beta}} \text{Tranquil} \text{VarCov}^{\text{Crisis}}$	1.42	28.73	6.34	0.16	2.98	1.82	0.99	0.36	5.35
$\sigma^2_{\text{Beta}} \text{Crisis} \text{VarCov}^{\text{Crisis}}$	5.44	27.30	14.46	0.47	4.74	5.34	4.53	2.16	8.06
$\Delta\sigma^2_{\text{Beta}} \text{Crisis}$	4.03	-1.43	8.11	0.30	1.77	3.53	3.54	1.79	2.71
$\%\Delta\sigma^2_{\text{Beta}} \text{Crisis}$	269%	-7%	59%	54%	25%	213%	217%	208%	130%
$\sigma^2_{\text{Idio}} \text{Tranquil}$	1.21	4.53	10.49	0.49	5.96	1.07	1.14	0.65	3.19
$\sigma^2_{\text{Idio}} \text{Crisis}$	5.97	12.74	20.40	0.60	11.98	3.55	3.48	1.18	7.49
$\Delta\sigma^2_{\text{Idio}} \text{Crisis}$	4.75	8.22	9.92	0.11	6.02	2.48	2.34	0.53	4.30
$\%\Delta\sigma^2_{\text{Idio}} \text{Crisis}$	317%	43%	72%	19%	85%	150%	143%	62%	111%

Table 24.3 Linear Factor Model with a Crisis Dummy

This table presents results for the regression of the CSFB/Tremont hedge fund index strategy returns on the S&P 500 index, Large-Small, Value-Growth, USD, Change in VIX, Credit Spread, and Momentum Factor, and interactions of these risk factors with a crisis dummy. The crisis dummy is equal to one when the Mexican, Asian, Russian and LTCM, Brazilian, Internet Crash, Argentinean, September 11, 2001, Defaults/WorldCom, subprime, and the Global financial crises are observed and zero otherwise. Hedge fund returns, S&P 500, and USD are used in excess of three-month Treasury bill rates. Parameters that are significant at the 10 percent level are shown in bold type.

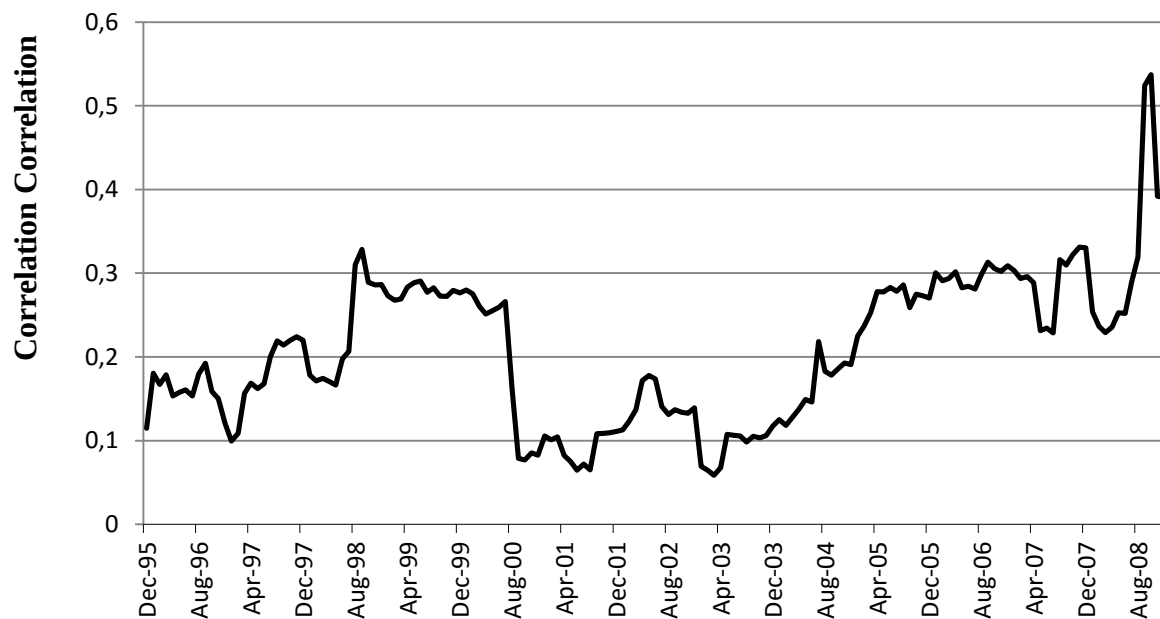
Variable/ Strategy	Convertible Bond Arbitrage		Dedicated Shortseller		Emerging Markets		Equity Market Neutral		Long/ Short Equity		Distressed		Event Driven Multi- Strategy		Risk Arbitrage	
	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat	Estimate	t-stat
a_0	0.28	0.82	1.13	2.48	-0.07	-0.13	1.43	3.01	0.84	1.75	0.77	3.25	1.10	4.80	0.23	1.44
b_0 (SP)	0.09	1.83	-0.92	-13.00	0.38	4.64	0.08	1.16	0.23	3.15	0.16	4.24	0.15	4.14	0.09	3.80
b_1 (LS)	0.08	1.70	-0.62	-9.36	0.24	3.15	0.02	0.37	-0.05	-0.82	0.14	4.02	0.11	3.40	0.10	4.26
b_2 (VG)			0.16	2.49									0.08	2.54		
b_3 (USD)									0.31	2.86	-0.13	-2.27	-0.08	-1.54	-0.11	-2.83
b_5 (TS)	-0.17	-1.34														
b_6 (dVIX)	0.00	-0.05	-0.15	-1.89	0.22	2.30	-0.02	-0.20	0.11	1.39	0.03	0.82	0.02	0.41	0.03	1.07
b_7 (CS)	0.58	1.51	-0.80	-1.65	0.20	0.35	-1.03	-2.06	-0.35	-0.69	-0.29	-1.14	-0.50	-2.05	0.05	0.29
b_{10} (MSCIEMS)					0.61	6.76			0.33	4.18	0.09	2.16	0.14	3.74		
b_{11} (UMD)							-0.03	-0.82	0.09	2.53						

b ₀ (SP) dummy	-0.10	-1.13	-0.04	-0.35	-0.36	-2.55	0.31	2.61	-0.33	-2.66	-0.01	-0.21	0.02	0.39	-0.05	-1.13
b ₁ (LS) dummy	-0.14	-1.66	0.29	2.50	-0.21	-1.52	0.23	1.90	0.06	0.47	-0.04	-0.65	-0.01	-0.13	-0.02	-0.44
b ₂ (VG) dummy			0.08	0.60									-0.20	-3.14		
b ₃ (USD) dummy									-0.21	-1.04	0.55	5.30	0.33	3.25	0.16	2.20
b ₅ (TS) dummy	0.41	1.30														
b ₆ (dVIX) dummy	-0.20	-2.32	-0.02	-0.16	-0.05	-0.37	0.41	3.56	-0.13	-1.04	-0.06	-0.90	0.02	0.38	-0.18	-4.56
b ₇ (CS) dummy	-1.47	-2.85	-0.86	-2.19	-1.30	-2.79	-0.78	-1.90	-0.40	-0.95	-0.33	-1.54	-0.56	-2.81	-0.12	-0.86
b ₁₀ (MSCIEMS) dummy					0.26	1.71			-0.03	-0.21	0.13	1.97	0.07	1.14		
b ₁₁ (UMD) dummy							-0.30	-3.18	0.17	1.84						
w ₀	1.79	6.04	2.42	4.34	2.82	3.38	2.47	4.21	2.44	4.30	1.26	7.21	1.19	7.31	0.87	7.37
Adj. R ²	0.21		0.74		0.57		0.30		0.28		0.56		0.62		0.46	
Pseudo. R ²	-0.08		-0.07		-0.16		-0.65		-0.32		-0.07		-0.05		-0.06	
LogLikelihood	595.55		657.52		688.75		661.72		658.70		524.67		513.08		449.62	

Figure 24.1 Rolling Correlation Among Hedge Fund Strategies

Panel A depicts two-year rolling window average correlation coefficients among hedge fund strategy returns. Panel B shows two-year rolling window average correlation coefficients among hedge fund strategy fitted returns generated by a linear model with and without a crisis dummy. Convertible bond arbitrage, equity market neutral, long/short equity, dedicated short bias, emerging markets, distressed, event driven multi-strategy, and risk arbitrage strategies are analyzed.

Panel A Average Rolling Correlation Correlations among Hedge Fund Strategy Returns



Panel B Average Rolling Correlation Coefficients among Hedge Fund Strategy Fitted Returns Generate by a Linear Model with and without a Crisis Dummy

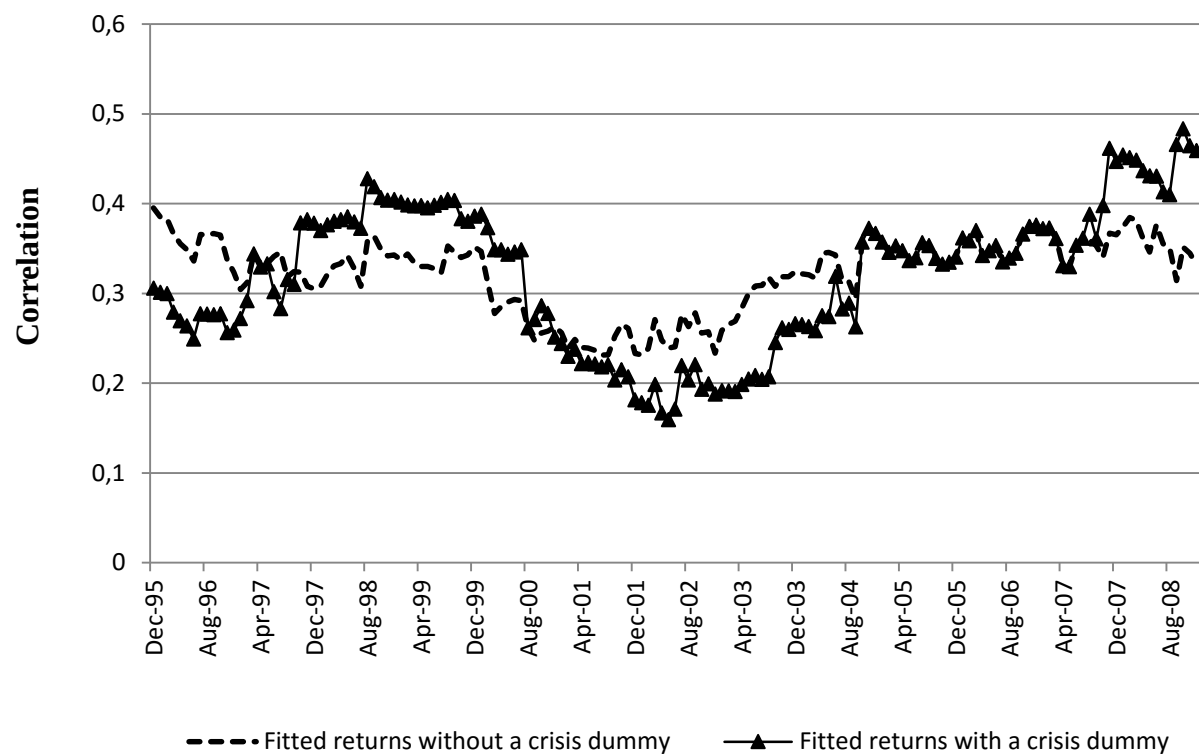


Figure 24.2 Number of Strategies with Significant Factor Exposures for the Linear Factor Model with a Crisis Dummy

This figure depicts the number of strategies with significant factor exposures during tranquil and crisis periods. The linear factor model with a crisis dummy is analyzed. The following factors are considered: S&P 500, Large-Small, Value-Growth, USD, Change in VIX, Credit Spread, and Momentum Factor. Eight is the maximum number of strategies.

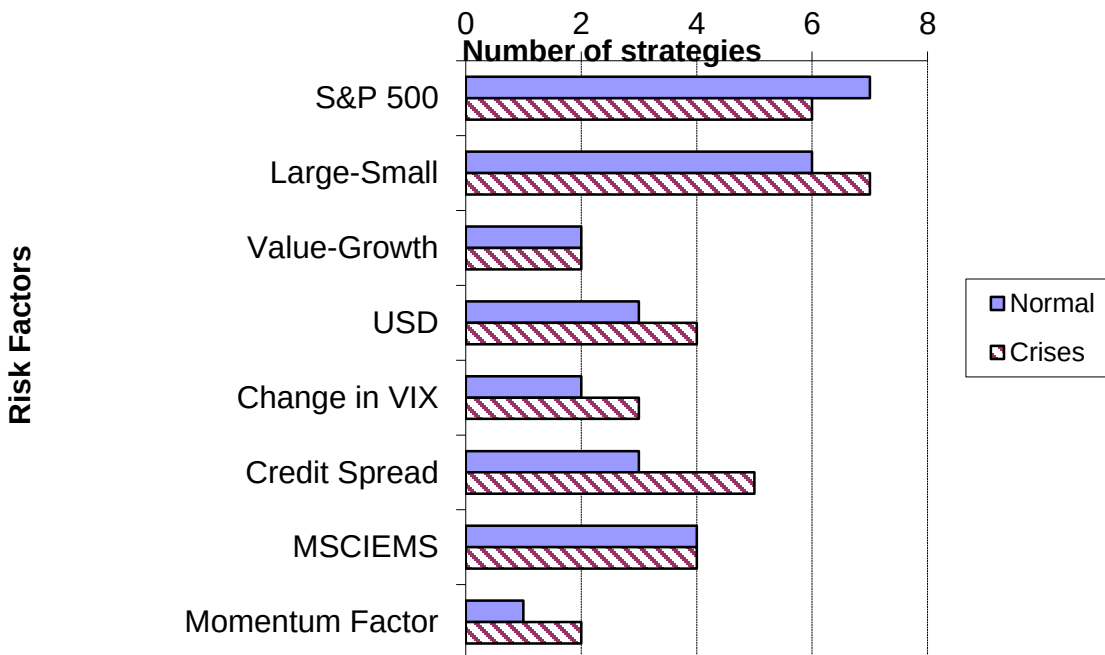
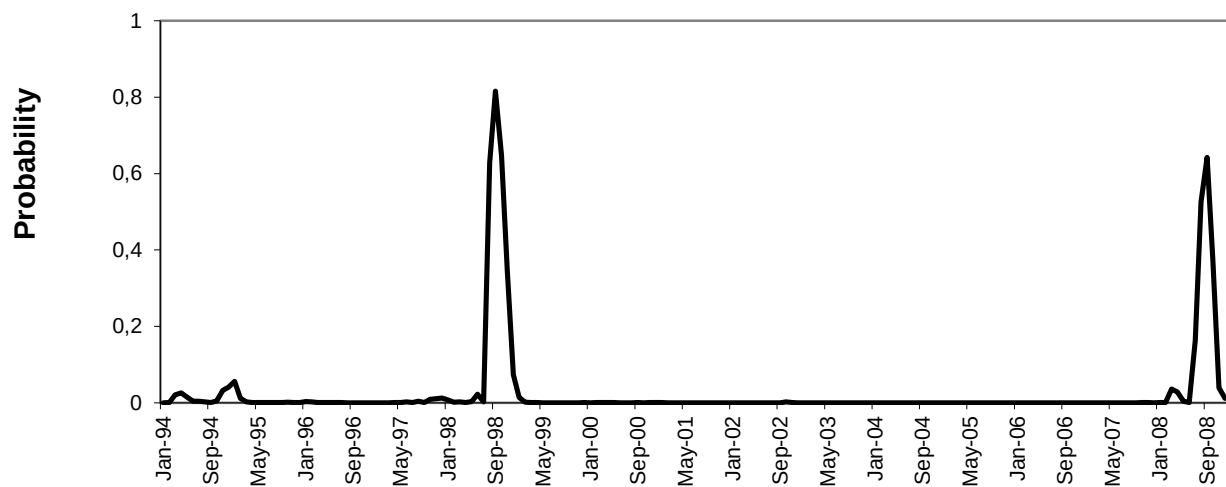


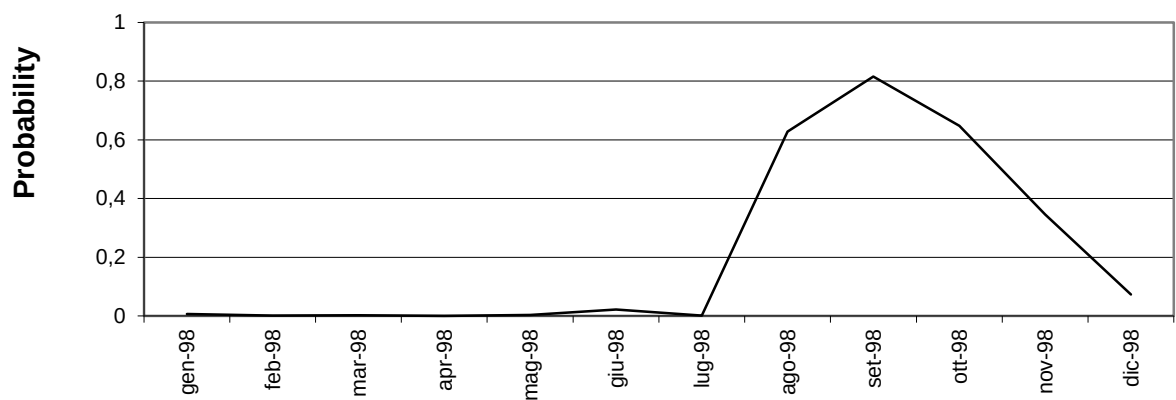
Figure 24.3 Common Exposure to a Latent Factor for All Hedge Fund Strategies

Panel A presents the joint probability of a high idiosyncratic volatility regime for all CSFB/Tremont hedge fund index strategies from January 1994 to December 2008. Panel B concentrates on the joint probability of a high idiosyncratic volatility regime in 1998, around the time of the Long-Term Capital Management (LTCM) crisis. Panel C concentrates on the Global Financial Crisis of 2008.

Panel A The Joint Probability of High Idiosyncratic Volatility Regime for All Hedge Fund Strategies: January 1994 to December 2008



Panel B The Joint Probability of High Idiosyncratic Volatility Regime for all Hedge Fund Strategies: LTCM Crisis of 1998



Panel C The Joint Probability of High Idiosyncratic Volatility Regime for All Hedge Fund Strategies: Global Financial Crisis of 2008

