Supplementary Internet Appendix for

"Spillover Effects among Financial Institutions:
A State-Dependent Sensitivity Value-at-Risk (SDSVaR) Approach"

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This Internet Appendix contains the following supplementary content:

Section 1: Index Construction and Constituent List

Section 2: Properties of the HFRX Equally Weighted Hedge Fund Index

Section 3: Risk Spillovers among Individual Hedge Fund Strategies

Section 1: Index Construction and Constituent List (referring to footnote 21)

The data in this study is obtained from Thomson Financial Datastream. For hedge funds we use the original investable indices provided by Hedge Fund Research (HFR) but create own indices for commercial banks, insurance companies, and investment banks. For commercial banks and insurance companies we take the constituent list used in Acharya, Pedersen, Philippon, and Richardson (henceforth APPR) (2010), from which we slightly deviate. For instance, we classify JP Morgan as an investment bank, while this company is classified as a commercial bank in APPR (2010). We are aware of the fact that many large banks including Bank of America, Citi Group, JP Morgan, and Deutsche Bank generate income from both, commercial and investment banking. As we find little evidence for risk spillovers between these two groups, however, any overlaps appear to be of minor relevance for the results in this study. For the investment bank index we use eight of the largest institutions. The price series for Lehman Brothers is set to zero at 09/15/2008 when Lehman filed for bankruptcy. The Bear Stearns series equals zero after 05/19/2008. The index constituents and the corresponding Datastream Mnemonics are listed in Table A.1.

Table A.1: Aggregated Series/Indices and Datastream Mnemonics

Commercial Banks (26)			
Bb&T	992305	Regions Finl.	951051
Bank of America	923937	Suntrust Banks	922725
Citigroup	741344	U.S. Bancorp	951046
Comerica	922964	Wells Fargo	906195
Commerce Bcsh.	923340	Zions Bancorp.	951584
Hudson City Banc.	271662	City National	952436
Huntington Bcsh.	951068	Northern Trust	905861
Keycorp	916130	State Street	951052
M&T Bk.	951503	Synovus Finl.	510056
Marshall & Ilsley	951063	Union Bancorp	689670
Ny.Cmty.Banc.	360240	Wachovia	26611r
Pnc Finl.Svs.Gp.	944175	Washington M.	702406
Peoples United Financial	517465	Western Union	41195m
Insurance Companies (31)			
Aflac	933185	Health Net	360691
Aetna	255956	Humana	916860
Allstate	322677	Lincoln Nat.	912402
Ambac Financial	545088	Loews	922418
American Intl.Gp.	916305	Mbia	755411
Aon	922817	Marsh & Mclennan	904780
W R Berkley	906828	Metlife	286738
Berkshire Hathaway[1]	982325	Principal Finl.Gp.	14698c
Cigna	912278	Progressive Ohio	936324
Cna Financial	907737	Prudential Finl.	14861v
Chubb	916790	Torchmark	993394
Cincinnati Finl.	951545	Travelers Cos.	933974
Coventry Health Care	544665	Unitedhealth Gp.	702635
Fidelity Nat.Financial	31942e	Unum Group	741410
Genworth Financial	28367u	Wellpoint	14737p
Hartford Finl.Svs.Gp.	867871		
Investment Banks (8)			
Credit Suisse		S:CSGN	
Deutsche Bank		D:DBK	
Goldman Sachs		U:GS	

[1] This large U.S. holding company generates the majority of its profits from the insurance companies GEICO, General Re, and the Berkshire Hathaway Reinsurance Group which are 100% owned by Berkshire Hathaway. The latter company provides Super-Catastrophic (re)insurance.

JP Morgan	U:JPM
Morgan Stanley	U:MS
UBS	S:UBSN
Bear Stearns (until 06/19/2008)	936911
Lehman Brothers (until 09/14/2008)	@LEHMQ
Hedge Funds	
HFRX Equally Weighted Strategies	HFRXEW$
HFRX Equity Hedge	HFRXEHD
HFRX Event Driven	HFRXEVD
HFRX Relative Value Arbitrage	HFRXRVR
HFRX Macro	HFRXMAC

We generate the index weights for the commercial bank, investment bank, and insurance company indices using principal component analysis.[2] If *X* is the *TxN* matrix of returns, Ω is the sample covariance matrix, and $\Omega = \Gamma\Lambda\Gamma'$ is the spectral decomposition of Ω, then the principal components of *X* can be obtained by

$$Y = \left(X - 1_n \bar{x}'\right)\Gamma, \tag{A.1}$$

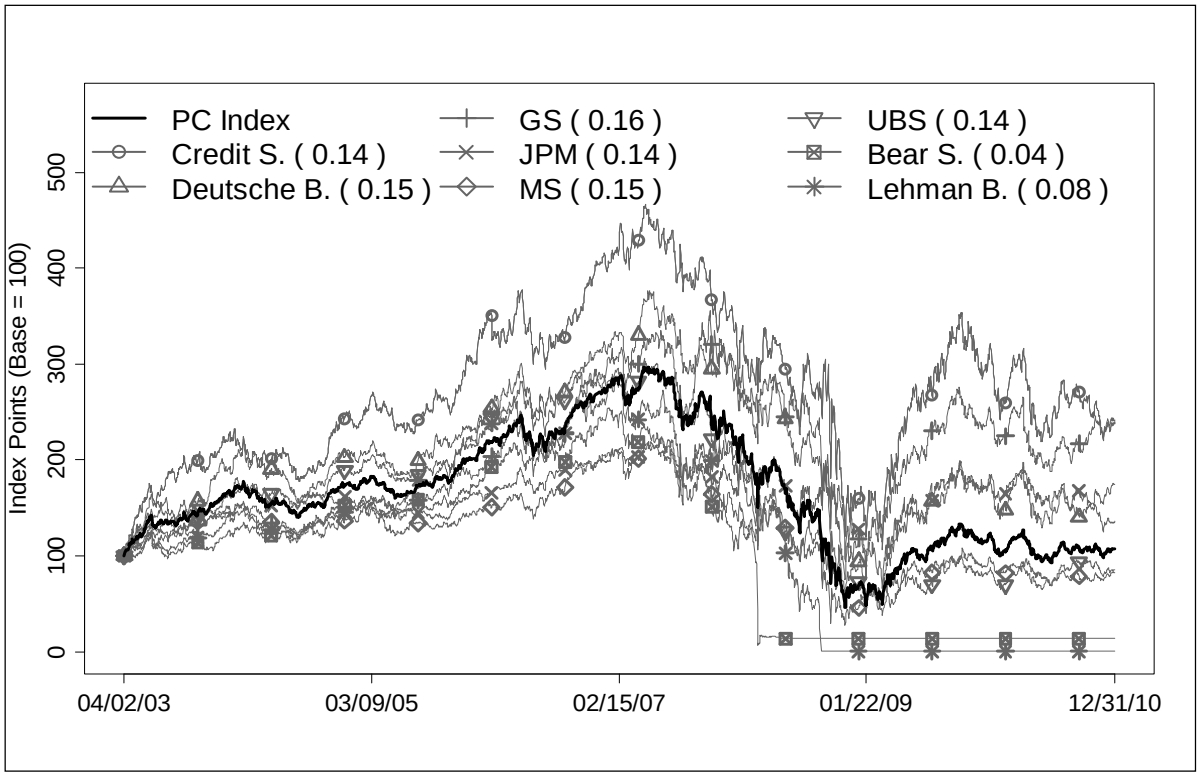
where $\left(X - 1_n \bar{x}'\right)$ is the (time) demeaned return matrix and the first column of Γ, Γ_1 contains the $N \times 1$ eigenvector that corresponds to the largest eigenvalue of Ω.[3] While this eigenvector points in the general direction of the data, its corresponding eigenvalue indicates the amount of variation that is explained by the first principal component. Figure A.1 shows the investment bank index and the corresponding index weights generated from the price series of eight of the largest investment banks. Note that at some point during 2008 Lehman Brothers and Bear

[2] Other commonly applied constituent weights are market value weights and equal weights. The former approach assigns large weights to large financial institutions such as JP Morgan (20% on average) but assigns only small weights to companies such as Bear Stearns and Lehman Brothers (about 2% and 5% on average, respectively). In the latter approach time series with higher variance have a higher influence on the index.

[3] See Härdle and Simar (2007) for further reference. Note that in this study, we further use the correlation matrix *R* instead of the covariance matrix in order to prevent overweighting institutions with a higher variance.

Stearns drop out of the index and the weights of the remaining 6 companies are readjusted to sum to unity.

Figure A.1: Investment Bank Index



Section 2: Properties of the HFRX Equally Weighted Hedge Fund Index

(referring to footnote 23)

The HFRX hedge fund index is not fully representative of the entire hedge fund universe. Yet, it is the only hedge fund index that is also available on a daily frequency. In this section, we compare the distributional properties of the HFRX index with those of the entire, and thus representative, hedge fund industry. Differences in variance, asymmetry, and fat tails may be used to infer the size and the direction of a possible bias from using the HFRX index. We thereby compare the return properties using *monthly* returns since our representative hedge fund index is only available at a monthly frequency. Because our empirical findings are obtained from daily data, an implicit assumption with this approach is that the relation between both return distributions that we find using monthly data also holds if we compared the return distributions using daily data.

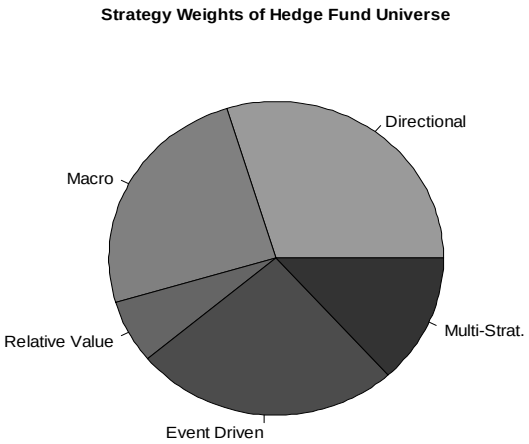
The HFRX index is an investable index. In general, investable indices suffer from the same biases (e.g., survivorship bias, instant history bias) than their non-investable counterparts. Investable indices represent passively managed fund of funds net of all fees and expenses. However, in order to avoid self-reporting bias and to reduce other biases which dominate non-investable hedge fund indices, daily data on single hedge fund basis is taken from managed accounts. In particular, the instant history bias and survivorship bias is of lower relevance due to the fact that in the case of bankruptcy or the addition of a fund the constant track record does not change. The HFRX Equally Weighted Index consists of 47 funds from all major investment strategies. This index suffers from the selection bias and only includes open funds.

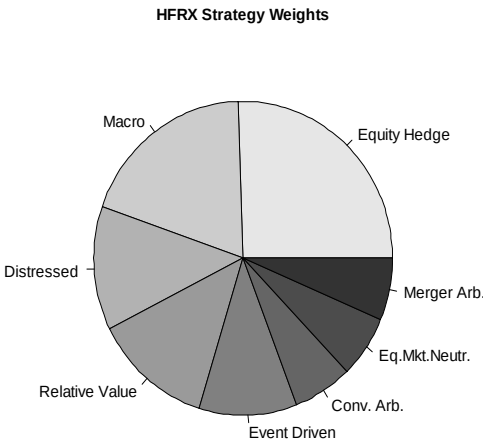
In contrast, the overall hedge fund universe which is taken to be a representative benchmark is represented by all operating and defunct funds that report to the TASS database adjusted for onshore duplicates and multiple currency versions of a fund (10,556 Funds).

Panel A in Figure A.2 shows the strategy weights of the whole hedge fund industry as well as the weights in the HFRX Equally Weighted Index. Although comparison is complicated by the fact that strategy classification is not consistent over different data providers the main strategies Equity Hedge, Macro, as well as Event Driven and Distressed Securities are presented in similar proportions in both indices. Panel B in Figure A.2 shows some descriptive statistics and distribution plots of the equally weighted indices constructed from the TASS and HFRX constituents, respectively. In terms of asset under management (AUM), funds in the HFRX index are on average larger than funds from the TASS database. However, because variation of AUM values among funds is substantial, the *t*-test cannot reject the null hypothesis of equal means (t = 1.36). The same applies for funds' age. The annualized mean return values of the HFRX index are higher than in the TASS index. The HFRX return distribution however exhibits slightly more extreme returns which are also reflected in higher minimum and maximum values and excess kurtosis. Thus, the distributional characteristics in the left tail are similar but somewhat more pronounced than in the total hedge fund universe. If we consider the TASS index to be representative of the hedge fund industry, the observed risk spillovers to other financial institutions have therefore been achieved with less extreme returns.

Figure A.2: Comparison of the HFRX Index with the Total Hedge Fund Universe (2003–2009)

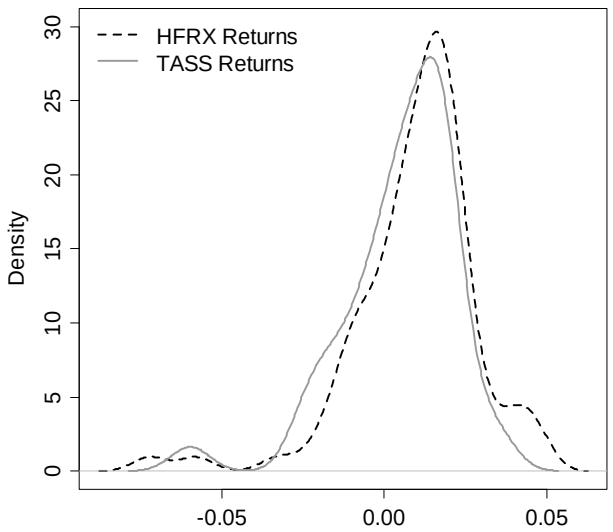
Panel A: Representative and HFRX Equally Weighted Index Strategy Weights



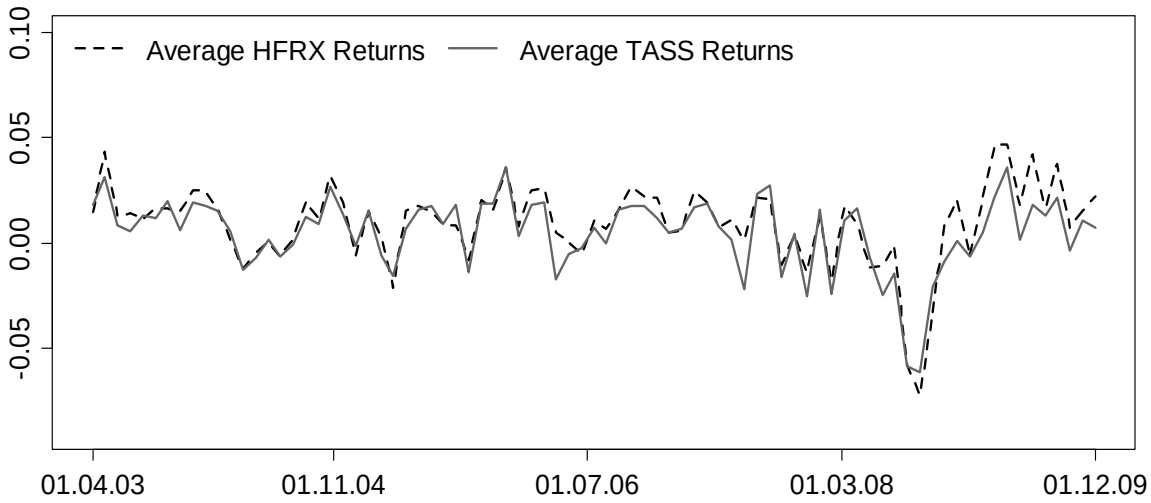


Panel B: Descriptive Statistics and Distribution

	HFRX	*TASS*
Median AUM	*146m*	*17m*
Mean AUM	*877m*	*117m*
Age [years]	*13.78*	*14.67*
Mean return	*11.52%***	*6.01%*
Min return	*-0.072*	*-0.061*
Max return	*0.047*	*0.036*
Volatility	*6.65%*	*6.04%*
Skewness	*-1.37*	*-1.31*
E-Kurtosis	*4.202*	*2.77*
Jarque-Bera	*91.37***	*52.86***



Panel C: Descriptive Statistics and Distribution



The representative *hedge fund strategy weights* are taken from the Dow Jones Credit Suisse Hedge Fund Index. All weights were valid as of 2010Q3. The representative *hedge fund returns* encompass all operating and defunct funds that report to the TASS database and is thus unaffected by the survivorship bias. The database is adjusted for onshore duplicates and multiple currency versions of a fund and includes 10,566 funds in total. *AUM* stands for asset under management, Min and Max return are the minimum and maximum return, and *E-Kurtosis* denotes excess kurtosis. The paired *t*-test is used to test for differences in means. The Fligner-Keleen test is used to test for differences in variances. The values for mean and volatility are annualized. The Jarque-Bera statistics test the null of normally distributed TASS and HFRX returns. ** denotes rejection of the null hypotheses at the 1% significance level.

Finally, Panel C of Figure A.2 shows the development of the equally weighted returns of all 10,556 operating and defunct funds of the TASS database (solid line) as well as the average returns of the 47 constituents of the HFRX index from 04/2003 to 12/2009 (dashed line). Both indices are showing a very similar pattern although the HFRX index experienced higher losses during the crisis but also has recovered more quickly. The correlation coefficient for the period 04/2003 to 12/2009 is 0.89.

In conclusion, the HFRX index and the representative hedge fund index from the TASS database exhibit very similar distributional properties. In addition, both indices show a similar development over time. Thus, if the use of the HFRX index introduces a bias it is likely to be small.

Section 3: Risk Spillovers among Individual Hedge Fund Strategies
(referring to footnote 31)

In this section, we examine whether these large spillover effects are due to a convergence of hedge fund strategies in volatile times or whether we can isolate differential effects across different hedge fund strategies. The previous literature has emphasized the high "degree of connectedness" among different hedge fund strategies (see, e.g., Khandani and Lo, 2007, Dudly and Nimalendran, 2009, and Boysen, Stahel, and Stulz, 2010). In this context, the relationship between market liquidity and funding liquidity is regarded as one key component. For instance, Brunnermeier and Pedersen (2009) show that hedge funds are an important source of market liquidity if funding liquidity is high, but traders are less willing to hold high margin positions once funding liquidity declines. King and Maier (2009) stress excessive leverage in combination with herding behavior as an important source of intra hedge fund spillovers. With high leverage, even moderate price swings can force hedge funds to liquidate positions in order to meet margin calls. The high levels of leverage and similarity in investment strategies set off a feedback loop where adverse price moves result in liquidations (Danielsson and Shin, 2003).

In this section, we therefore analyze how VaR adjusts by accounting for spillover effects at a disaggregated level, i.e. at the hedge fund style level. We use a similar dataset as in our empirical estimations above with daily data from the beginning of the HFR hedge fund strategy series, 04/02/2003 to 12/31/2010 (2,023 observations). We follow the HFR classification and use the strategies equity hedge (EH), event driven (ED), relative value arbitrage (RV), and global macro (GM). Table A2 shows the response of financial institutions to the four hedge fund strategies as well as the spillover effects among the hedge fund strategies. The spillovers are estimated in a seven-equation system based on System (5) in which the overall hedge fund index and the three control variables are replaced by our four hedge fund strategies.

Table A2: Coefficients of the Static SDSVaR Models for Different Hedge Fund Strategies

from... / to…	Spillover Coefficient B_θ							Lag
	Insurance Companies	**Commercial Banks**	**Investment Banks**	**Equity Hedge**	**Event Driven**	**Relative Value**	**Global Macro**	
				Tranquil				
Insurance Companies	-	0.006***	0.000	-0.011	0.014	0.027***	0.003	0.934***
Commercial Banks	-0.003**	-	0.003*	0.012*	-0.002	0.012**	-0.002	0.958***
Investment Banks	-0.005**	0.004***	-	0.027***	-0.020*	0.016**	0.013**	0.945***
Equity Hedge	0.001	0.000	0.000	-	-0.004	0.002	0.003**	0.897***
Event Driven	-0.001***	0.001**	0.001**	-0.001	-	-0.001	0.005***	0.917***
Relative Value	0.000	0.001*	0.000	-0.001	0.004	-	0.002*	0.910***
Global Macro	0.002*	-0.001	0.000	0.005	-0.007	-0.004	-	0.936***
				Normal				
Insurance Companies	-	0.019***	0.003	-0.025	0.018	0.067***	0.001	0.932***
Commercial Banks	-0.007**	-	0.006*	-0.010	0.044**	0.017	-0.004	0.975***
Investment Banks	0.005	0.003	-	0.039**	-0.014	0.017	0.023**	0.952***
Equity Hedge	0.000	0.000	0.001	-	-0.013*	0.002	0.010***	0.922***
Event Driven	-0.001	0.000	0.001	-0.005	-	0.003	0.009***	0.943***
Relative Value	0.000	0.001	-0.001	0.006	0.009	-	0.009***	0.931***
Global Macro	0.001	0.000	-0.001	0.007	-0.018	0.012	-	0.964***
				Volatile				
Insurance Companies	-	0.041***	-0.001	-0.117	0.073	0.197***	0.032	1.023***
Commercial Banks	0.048***	-	0.029**	-0.195***	0.042	0.070	0.155***	0.999***
Investment Banks	0.024	0.030**	-	-0.074	0.130	0.214***	0.182***	0.972***
Equity Hedge	-0.017**	0.015***	-0.008	-	0.090**	0.075***	0.034*	1.020***
Event Driven	-0.001	0.001	-0.001	0.026*	-	0.011	0.028***	1.038***
Relative Value	0.007**	-0.006***	0.005**	-0.019	0.014	-	0.024***	1.037***
Global Macro	0.001	0.000	-0.001	-0.017	0.044	0.006	-	1.034***

This table shows the spillover coefficient estimates $\mathbf{B}_\theta$ from System (5) that are obtained by replacing the equally weighted hedge fund index and the control variables by the four strategies equity hedge, event driven, relative value, and global macro. Institutions at the top of the table denote the origin of the shock while the institutions in table rows denote the responding institution. Coefficients are estimated for tranquil, normal, and volatile market states. Market states are measured by the 75%-, 50%-, and 12.5%-quantile of the value-at-risk distribution of the responding institution, respectively. For instance, a one percentage point increase in the VaR of the global macro strategy increases the VaR of investment banks by 0.023 percentage points during normal market times. The same shock, however, increases the VaR of the investment bank industry by 0.182 percentage points during volatile market phases. The estimation period is 04/02/2003 – 12/31/2010 (2,023 obs.).

In line with our previous results, the spillover effects are small and close to zero for tranquil market periods and increase strongly during volatile market periods. First note that spillover effects between commercial banks, investment banks, and insurance companies are robust to including hedge fund strategies separately. The coefficients reported in Table 2 in the paper and those reported here are quite similar and tend to be estimated with somewhat higher precision.

We show in Table A2 that while spillover effects among different hedge fund strategies do increase in volatile periods, they increase less than spillover effects from individual hedge fund strategies to other financial institutions. The substantial spillovers from the hedge fund sector to other institutions estimated in the four equation model in volatile times (Table 2) do not arise from a convergence of hedge fund styles, but rather reflect differential effects of different styles on different institutions. For example, relative value funds appear to generate strong externalities in crisis times for insurance companies and investment banks, but show little spillovers to commercial banks. In contrast, the VaR of commercial banks is strongly reduced in crisis times if equity hedge strategies experience difficulties, but the equity hedge index does not generate spillover effects to investment banks or insurance companies. Funds following an equity hedge strategy indeed seem to operate as somewhat of a hedge in crisis times at least with respect to financial institutions.

Overall, the relative value strategy (in which investments are based on valuation discrepancies), and the global macro strategy (in which investments are based on movements in underlying economic variables) show the largest spillovers to the three sets of financial institutions, often with coefficient values being roughly ten times the size of their normal condition counterparts.[4]

[4] One could interpret these findings in the light of the fact that both, insurance companies and investment banks act as hedge funds' main securities lenders and that the relative value strategy in particular is based on extensive short selling combined with high leverage. In contrast, the equity hedge strategy which focuses on market neutral investments that can profit from increasing but also decreasing market movements, shows a very different behavior, and spillovers, when significant, tend to go in the opposite direction.

Table B.1: HFRX Investable Equally Weighted Hedge Fund Index and Hedge Fund Strategies

Equally Weighted Index
The HFRX Equally Weighted Hedge Fund Index is comprised of all eligible hedge fund strategies; including but not limited to convertible arbitrage, distressed securities, equity hedge, equity market neutral, event driven, macro, merger arbitrage, and relative value arbitrage.
Hedge Fund Strategies
Equity Hedge
Equity Hedge strategies maintain positions both long and short in primarily equity and equity derivative securities. A wide variety of investment processes can be employed to arrive at an investment decision, including both quantitative and fundamental techniques; strategies can be broadly diversified or narrowly focused on specific sectors and can range broadly in terms of levels of net exposure, leverage employed, holding period, concentrations of market capitalizations and valuation ranges of typical portfolios. Equity Hedge managers would typically maintain at least 50%, and may in some cases be substantially entirely invested in equities, both long and short.
Event Driven
Event Driven Managers maintain positions in companies currently or prospectively involved in corporate transactions of a wide variety including but not limited to mergers, restructurings, financial distress, tender offers, shareholder buybacks, debt exchanges, security issuance or other capital structure adjustments. Security types can range from most senior in the capital structure to most junior or subordinated, and frequently involve additional derivative securities. Event Driven exposure includes a combination of sensitivities to equity markets, credit markets and idiosyncratic, company specific developments. Investment theses are typically predicated on fundamental characteristics (as opposed to quantitative), with the realization of the thesis predicated on a specific development exogenous to the existing capital structure.
Macro
Macro strategy managers which trade a broad range of strategies in which the investment process is predicated on movements in underlying economic variables and the impact these have on equity, fixed income, hard currency and commodity markets. Managers employ a variety of techniques, both discretionary and systematic analysis, combinations of top down and bottom up theses, quantitative and fundamental approaches and long and short term holding periods. Although some strategies employ RV techniques, Macro strategies are distinct from RV strategies in that the primary investment thesis is predicated on predicted or future movements in the underlying instruments, rather than realization of a valuation discrepancy between securities. In a similar way, while both Macro and equity hedge managers may hold equity securities, the overriding investment thesis is predicated on the impact movements in underlying macroeconomic variables may have on security prices, as opposes to EH, in which the fundamental characteristics on the company are the most significant and integral to investment thesis.
Relative Value
Relative Value investment managers who maintain positions in which the investment thesis is predicated on realization of a valuation discrepancy in the relationship between multiple securities. Managers employ a variety of fundamental and quantitative techniques to establish investment theses, and security types range broadly across equity, fixed income, derivative or other security types. Fixed income strategies are typically quantitatively driven to measure the existing relationship between instruments and, in some cases, identify attractive positions in which the risk adjusted spread between these instruments represents an attractive opportunity for the investment manager. RV position may be involved in corporate transactions also, but as opposed to ED exposures, the investment thesis is predicated on realization of a pricing discrepancy between related securities, as opposed to the outcome of the corporate transaction.

Source: Hedge Fund Research (HFR)