



## How stock price volatility affects stock returns and CTA returns

It is, by now, widely known that stocks do not do well when stock volatility is high. Or perhaps stock price volatility is high when stocks are not doing well. Either way, we find that stock price volatility – and the volatility of the S&P 500 in particular – looms large in stock portfolio returns. The question we want to tackle here is whether stock volatility plays a similar role in CTA returns. That is, do CTA returns, or their correlations with stock returns, depend on stock price volatility.

Among the most important of our findings – based on the data shown in Exhibit 1 – are these:

- S&P 500 returns are negatively correlated with S&P 500 price volatility.
- CTA returns are largely unrelated to S&P 500 price volatility.
- The correlation of S&P 500 returns with CTA returns, which is slightly positive when stock price volatility is normal or low, becomes negative when stock price volatility is high.

Aug. 28, 2008

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We also learned that:

- S&P 500 price volatility may be the single most important source of market volatility globally.

Taken together, these findings seem to be at odds with at least one widely held notion about CTAs – that is, that CTAs are in some sense long volatility. Their returns do not exhibit the kind of straddle shape that one would expect of a long volatility position. CTAs might, on the other hand, be considered a volatility hedge for a stock portfolio. But the sense in which they are has more to do with the shift from positive to negative correlation in returns as volatility goes from low or normal to high than it does with overall CTA returns.

### The data set (1996 through 2007)

For the purposes of this work, we look at the 12-year period from January 1996 through December 2007. This gives us a good look at two bull markets and one bear market in the U.S. stock market. We have monthly return data for 51 CTAs from which we construct an equally weighted index. And we chose

Exhibit 1

#### Net asset values for stocks and CTAs

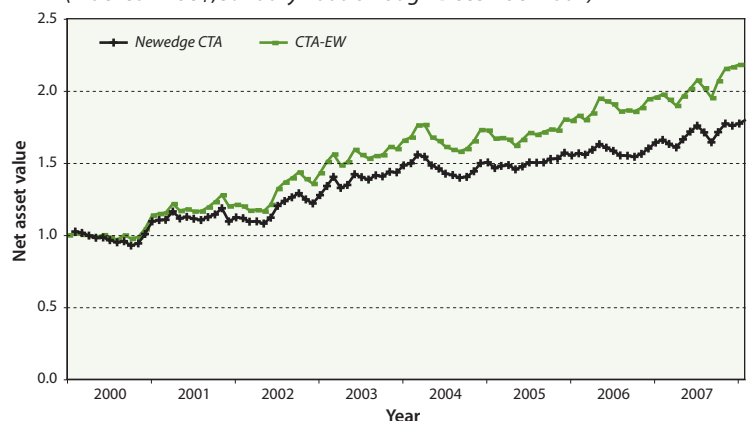
(Indexed in US\$, January 1996 through December 2007)



Exhibit 2

#### Net asset values for CTAs

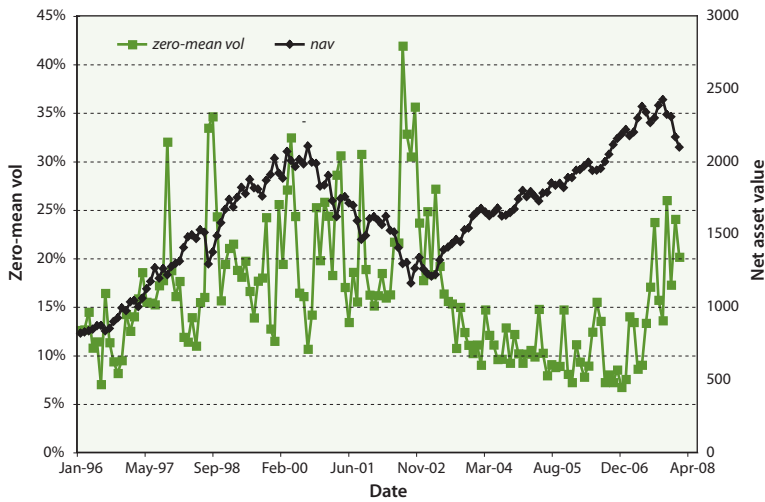
(Indexed in US\$, January 2000 through December 2007)



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**Exhibit 3**  
**S&P500 net asset value versus price volatility**



**Monthly stock returns versus monthly volatility**  
(rho = -25%)



**Quarterly stock returns versus quarterly volatility**  
(rho = -43%)



correspond to lower returns and correspondingly higher volatilities over the life of the option. And it is borne out in experience with equity index returns.

daily price data for 39 futures markets that allow us to drill down on price volatility over fairly short periods of time.

Perhaps the best measure of CTA returns, especially those of large CTAs, is the Newedge CTA index. This index – originally published as the Carr Barclay CTA index and then as the Calyon Barclay CTA index – is based on the returns of the 20 largest CTAs that are open to investment and willing to provide daily data. The index is reconstituted annually, in January, and is free of survivorship bias.

Its history, however, begins in January 2000. To extend our look back, we turned to a set of 51 CTAs with \$50 million under management and for which we had monthly return data from January 1996. We used these histories to construct an equally weighted index of returns and net asset values. This allowed us to add another four years to the data set and to include one more bull market in stocks.

The substitute index is a good proxy for the Newedge CTA index with one caveat. As shown in Exhibit 2, the two indexes tracked one another well from 2000 through 2007. The correlation of monthly returns for the two indexes was 97 percent. The caveat is that the average returns for the substitute index were higher than for the Newedge CTA index, which could be due in part to survivorship bias. But since our research interest is not in average CTA returns by themselves, but rather in whether CTA returns depend on stock price volatility, any upward bias likely disappears when comparing any two means.

### Stock price volatility and stock returns in the S&P 500

The fact that stock returns are negatively correlated with stock price volatility is a phenomenon that has been observed for decades. It is consistent with the idea that overall leverage in equities increases as stock prices fall. It is consistent with the fact that implied volatilities for the equity options with lower strike prices (e.g., out of the money puts) are higher than those for equity options with higher strike prices (e.g., out of the money calls), as lower strikes

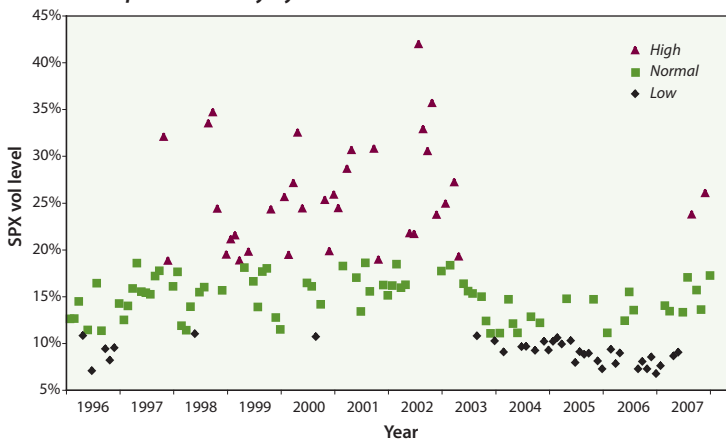
Exhibit 3 shows monthly net asset values plotted against an annualized measure of historical monthly volatility in the S&P 500 in the top panel. Throughout this note, we measure volatility as the annualized square root of the average of squared returns. This way of calculating volatility assumes a mean return of zero, which is not conventional, but which is approximately correct for daily returns and allows us to avoid understating volatility when a market or CTA is on a run, either positive or negative. In the middle panel is a scatter of monthly S&P 500 returns against monthly values of the level of stock price volatility. The correlation between the two is -0.25. The negative correlation is more pronounced if one uses quarterly returns versus quarterly measures of price volatility, as shown in the bottom panel. Here the correlation between the two is -0.43. In both cases, the negative correlations are influenced by one particular occurrence in July 2002. This is more apparent in the bottom panel where you can see one observation in the upper left hand corner that corresponds to

a loss of more than 17 percent. Without this quarter, the correlation of quarterly returns would have been -0.33. Without that month, the correlation of monthly returns would have been -0.21.

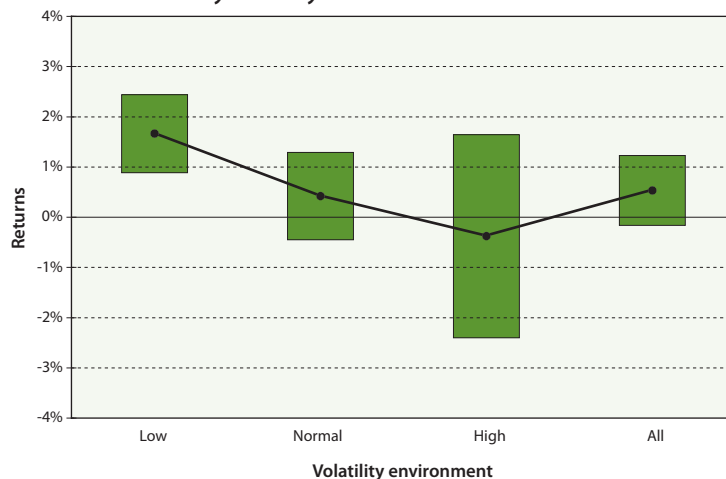
While the correlation seems weakly negative in monthly returns, the relationship seems strong enough to merit our attention. To get another perspective on the relationship, we divided the 144 months in our data set into periods of low, normal, and high volatility months. The distinction is a little arbitrary, but in this exercise, we divided up the sample period into 36 least volatile months, the 36 most volatile months, and the 72 months in between. These are illustrated in Exhibit 4 in which the calm months are those with volatility less than 10.98 percent and the volatile months are those with volatility greater than 18.75 percent.

The statistical significance of the relationship between monthly volatility and returns is illustrated in Exhibit 5, which shows, using a candlestick kind of chart, the mean return (the dot inside of each band) and a two-standard-deviation band of returns around the mean for each level of volatility. As is apparent, there is a lot of overlap. For example, it would be hard to say that stock returns are significantly lower when stocks are volatile than when stock volatility is “normal.” It is apparent, though, at least in this data set, that stock returns are significantly lower during normal or volatile periods than they are during calm periods.

**Exhibit 4**  
Stock price volatility by month



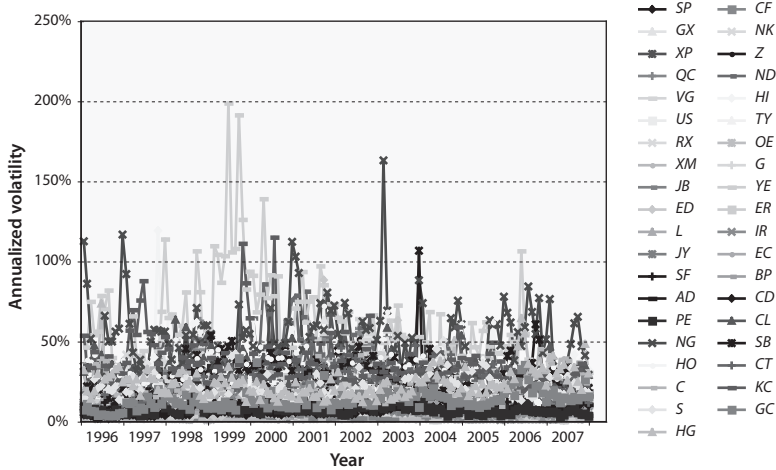
**Exhibit 5**  
Stock returns by volatility level



**S&P 500 volatility dominates market volatility**

CTAs trade a wide range of markets, so it is natural to ask whether it makes sense to expend much effort studying the relationship between price volatility in the U.S. equity market and the returns that CTAs realize. What we show here is that the answer is probably yes – that S&P 500 price volatility very likely is the single most important source of market volatility globally. Nothing can be proven,

**Exhibit 6**  
**Volatilities in 39 markets**



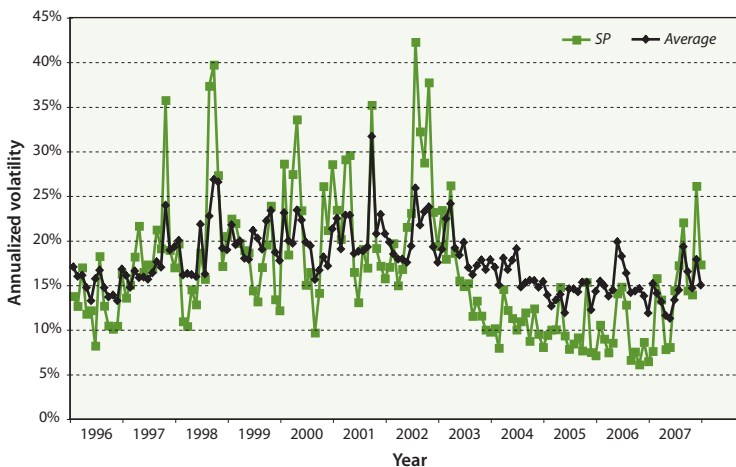
but the evidence we present here is compelling and is consistent with what many investors have known for years anyway.

**Global market volatility**

Exhibit 6 shows historical price volatility for 39 different markets including equities, interest rates, currencies, and commodities. A guide to the contracts listed in the legend is provided at the end of this note. The exhibit is a visual mess, but can be untangled in a couple of ways.

One is shown in Exhibit 7, which compares a simple average of the volatilities in Exhibit 6 with S&P 500 volatility. The two series seem to rise and fall reasonably well with one another, and the correlation between the two series is +0.81. In other words, in a simple regression of average market volatility against S&P 500 volatility, the R-squared would be somewhere around 0.64.

**Exhibit 7**  
**S&P 500 and average market volatility**



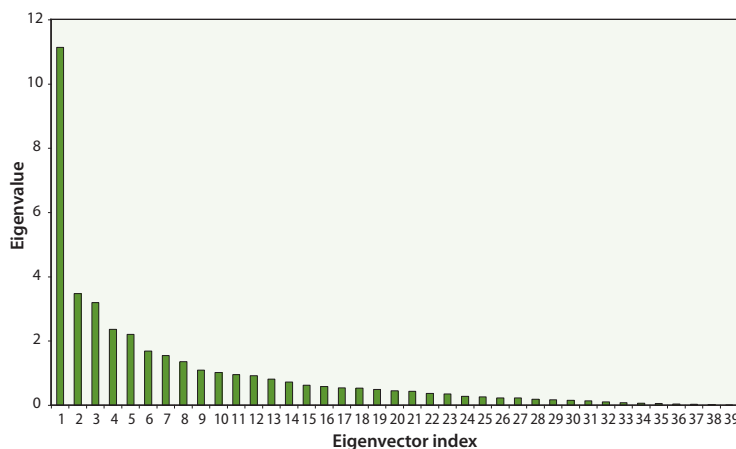
**Eigen analysis**

Another way to disentangle the forces that are behind market volatility is to calculate the eigenvalues of the 39 independent vectors needed to explain the volatility we see in these markets. These values are shown in Exhibit 8 where we find that one eigenvector alone explains 11/39ths of the variance in all of the series.

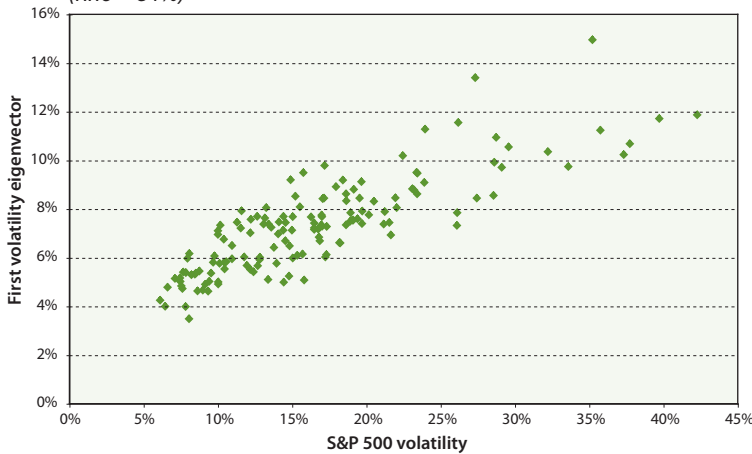
To interpret what is shown in Exhibit 8, one needs to know this about eigenvectors and eigenvalues. First, the eigenvectors themselves are the result of a computational method that finds the 39 uncorrelated or independent series that explain 100 percent of the variation in the 39 volatility series we have here. The raw materials for this kind of analysis are 39 volatility series that have been normalized so that the variance of each of the series is 1.0. In practice, then, this means that eigenvalues shed useful light on the values one sees in a correlation matrix, not in the covariance matrix. And the sum of the eigenvalues is 39, which is the sum of the variances of 39 independent time series.

For example, if all 39 of our volatility series were completely uncorrelated with one another, all 39 eigenvalues would be 1.0, and all of the off-diagonal elements of the correlation matrix would be zero. That is, each series would explain itself and nothing else. On the other hand, if all 39 of our

**Exhibit 8**  
**Eigenvalues for 39 market volatilities**

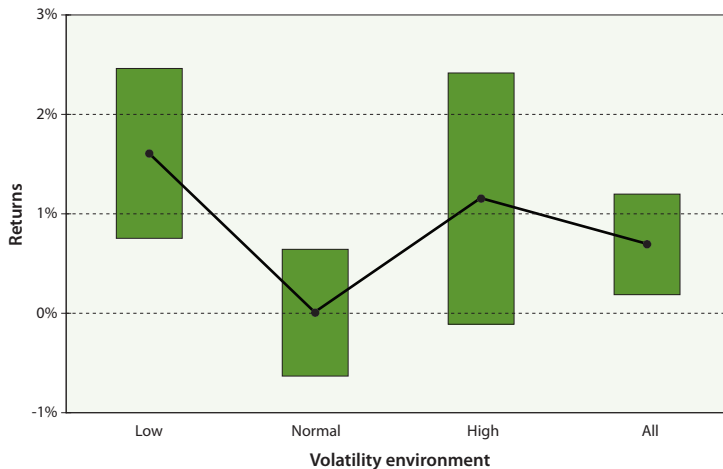


**Exhibit 9**  
**First eigenvector versus SPX volatility**  
*(Rho = 84%)*

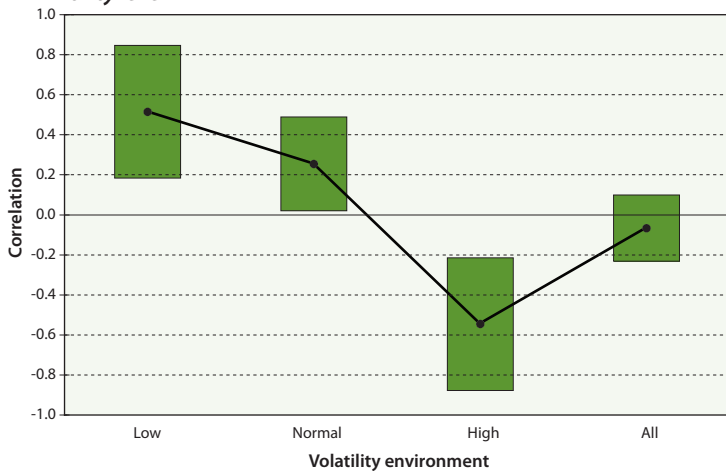


that the vectors themselves represent anything that we observe in the markets. In this case, though, our inclination is to think that it might be related to stock price volatility. And, as we see in Exhibit 9, the correlation between the 144 values that make up the first eigenvector and the 144 monthly observations of S&P 500 price volatility line up remarkably well.

**Exhibit 10**  
**CTA returns by stock price volatility level**



**Exhibit 11**  
**Correlation between S&P 500 and CTA returns by stock price volatility level**



volatility series were perfectly correlated, the first eigenvalue would be 39, all the rest would be zero, and the off-diagonal elements of the correlation matrix would be 1.0.

Here, the fact that the highest eigenvalue is 11 means that there is enough overall correlation among the 39 volatility series that more than 25 percent of their variability can be explained by a single force (whatever that force may be). After the first eigenvalue, things drop off pretty quickly. The next four values are greater than 2, and the five after that are greater than 1, so it is apparent that there are other forces at work, but not as influential.

Finally, because eigenvectors are simply the result of a computational technique, there is no guarantee that the vectors themselves represent anything that we observe in the markets. In this case, though, our inclination is to think that it might be related to stock price volatility. And, as we see in Exhibit 9, the correlation between the 144 values that make up the first eigenvector and the 144 monthly observations of S&P 500 price volatility line up remarkably well. The correlation between the two series is 0.84, which reinforces our notion that volatility in the U.S. stock market is probably the most compelling force driving global market volatility.

**CTA returns and correlations**

Against this backdrop, we turn now to the question of whether CTA returns or their correlations with S&P 500 returns are related to volatility.

**Volatility and returns**

The relationship between CTA returns and S&P 500 return volatility is shown in Exhibit 10. What we find there is that CTA returns tend to be slightly higher both when stocks exhibit low and high volatility than when stock price volatility falls in the normal range. This seems at odds with the notion that CTAs are in some sense long volatility. At least it appears that CTA returns are largely independent of stock price volatility.

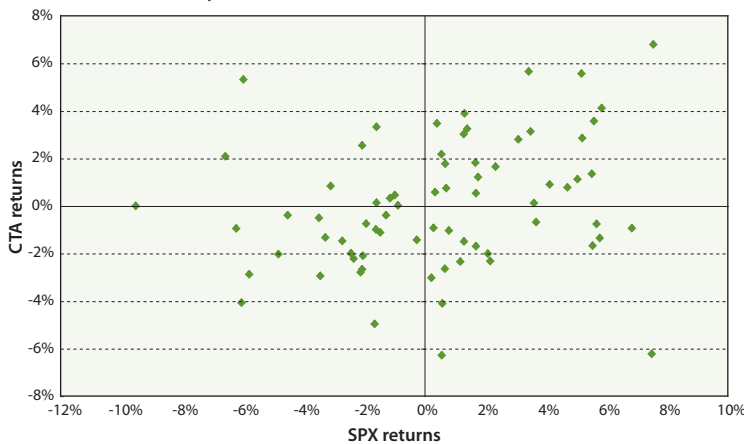
**Volatility and correlations**

The more interesting relationship is found in Exhibit 11, which shows how the correlation between CTA and S&P returns behaved during low, normal and high volatility periods. Overall, if we did not differentiate between low, normal and high volatility periods,

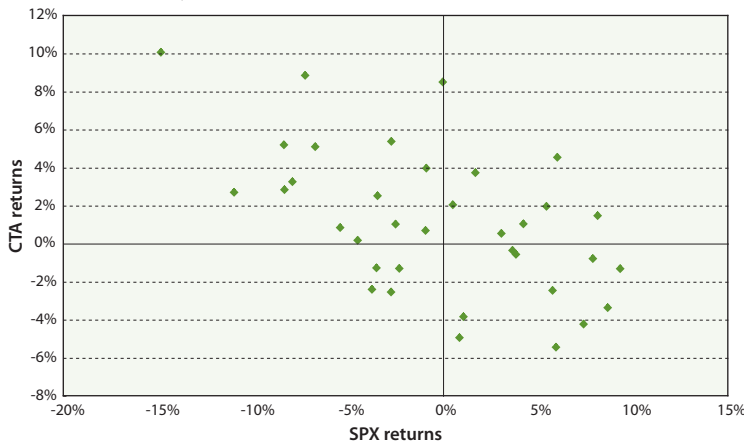
**Exhibit 12**  
*CTA returns versus stock returns*  
*Low volatility*



*Normal volatility*



*High volatility*



we would find that the correlation of CTA and S&P returns was very slightly negative and very close to zero. During low volatility and normal periods, however, the correlation of the two return series was slightly positive: 0.52 on average during low volatility months and 0.25 on average during normal months. In contrast, during high volatility months, the average correlation of the two returns was -0.55.

**What does it matter?**

Is there any value in these findings for a portfolio manager? The answer is most likely no if the manager’s hope or intent is to use the knowledge to improve portfolio performance. Unless the results were persistent and reliable, and unless the different volatility states could be anticipated reliably and in time to do something useful in response, the fact that correlations or returns might depend on stock price volatility does not affect the overall performance of a portfolio. Our own work on transition probabilities suggests that the volatility states are hard to predict and that even if we knew what they would be, very little could be gained by adjusting asset mixes through time. And, as a practical matter, the mix of assets in institutional portfolios is influenced by a host of constraints and cost considerations that tend to retard the speed with which investment reallocations take place.

**Conditional gains and losses**

A more valuable application of these findings likely is in the way managers evaluate the performance of alternative investments against the performance of their other assets. Exhibit 12 provides scatter plots of S&P and CTA returns for the three volatility levels and illustrate the practical differences between fairly positive (low volatility), slightly positive (normal volatility) and fairly negative (high volatility) correlations.

The return data in these scatters is organized slightly differently in Exhibit 13, which shows the numbers of months that the S&P and CTAs were making or losing money in the three volatility environments. In the bottom panel, which shows gains and losses for all conditions, one can see that both assets made money during most months in the sample period. The stock portfolio made money in 86 out of 144 months. The CTA portfolio made money in 81 out of 144 months. Also, the likelihood that CTAs would make money during those months when stocks were making money was only slightly higher [ 63% = 54/86 ] than the

**Exhibit 13**  
**Distributions of monthly gains and losses**  
*(Number of months, January 1996 through December 2007)*

Low volatility		S&P500		
		loss	gain	total
CTAs	gain	4	22	26
	loss	5	5	10
	total	9	27	36
Normal volatility		S&P500		
		loss	gain	total
CTAs	gain	8	25	33
	loss	22	17	39
	total	30	42	72
High volatility		S&P500		
		loss	gain	total
CTAs	gain	15	7	22
	loss	4	10	14
	total	19	17	36
All settings		S&P500		
		loss	gain	total
CTAs	gain	27	54	81
	loss	31	32	63
	total	58	86	144

overall probability [ 56% = 81/144 ]. The number of months in which S&P and CTA returns were in the same direction was also 85 out of 144. So for the sample period as a whole, the conditional probability that CTAs would make money in any given month was not really different from the overall probability that they would make money. That is, the two return series appear to be uncorrelated.

But the conditional probabilities for CTAs making or losing money change dramatically when one subdivides the sample period according to stock volatility levels. As shown in the top panel, which covers the low volatility month, stocks made money in 27 out of 36 months, and during these months, CTAs made money 22 times, or 81 percent [ = 22/27 ] of the time. Also, S&P and CTA returns were in the same direction 27 times out of 36, or 75 percent [ = 27/36 ] of the time.

During high volatility months, though, the picture is very different. Here, stock and CTA returns went in opposite directions in 25 of the 36 months. We also see that CTAs were less likely (7 times out of 17) to make money when stocks were up than they were (15 times out of 19) to make money were stocks were down.

**Guide to the legend for Exhibit 6**

Equity	SP	S&P 500
	CF	CAC 40
	GX	DAX 30
	NK	NIKKEI 225
	XP	AUSSIE SPX
	Z	FTSE 250
	QC	SWEDISH OMX
	ND	NASDAQ 100
	VG	DJ EURO STOXX
	HI	HANG SENG
Interest Rates	US	US 30 YEAR
	TY	US 10 YEAR
	RX	GERMAN BUND
	OE	GERMAN BOBL
	XM	AUSSIE 10 YEAR
	G	UK 10 YEAR GILT
	JB	JAPAN 10 YEAR
	YE	JAPAN 3 MONTH
	ED	US 3 MONTH
	ER	EUROPE 3 MONTH
Foreign Exchange	L	UK SHORT STERLING
	IR	AUSSIE 3 MONTH
	JY	JAPANESE YEN
	EC	EURO
	SF	SWISS FRANC
	BP	BRITISH POUND
	AD	AUSTRALIAN DOLLAR
	CD	CANADIAN DOLLAR
	PE	MEXICAN PESO
	Commodity	CL
NG		NATURAL GAS
SB		SUGAR
HO		HEATING OIL
CT		COTTON
C		CORN
KC		COFFEE
S		SOYBEANS
GC		GOLD
HG		COPPER

**Conclusions**

The research for this note began in a search for market regimes that might help us understand the circumstances under which different assets make and lose money and to use this understanding to help us improve the mix of assets in broadly diversified portfolios. Most of what we found in that work was inconclusive, but the results reported here seem to stand out from the rest.

Among other things, our findings support the idea that the U.S. stock market is a major force in market volatility globally. It is the kind of thing that many people know or suspect, but it was interesting for us to find the prejudice borne out in the data. The same is true, we suspect, for the finding that returns in the stock market are negatively correlated with the level of stock price volatility.

The more surprising results are that CTA returns seem to be unrelated to market volatility – at least to stock market volatility – and that the correlation of stock and CTA returns is very different in high and low volatility markets. The first of these is at odds with the idea that CTAs are, in some sense, long volatility. The second suggests that the expectations that investors have for CTA returns should be conditioned on the level of market volatility.

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*The research basis for the AlternativeEdge Short-Term Traders Index*
- **How stock price volatility affects stock returns and CTA returns**

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