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Viewpoint

September 2012

The Volatility Risk Premium

Elevated global macroeconomic uncertainty and bouts of extreme market turbulence have recently plagued financial markets. This environment has prompted a search for diversifying investment opportunities that lie outside the space of traditional asset classes. This article examines the performance of options strategies that aim to capture a return premium over time as compensation for the risk of losses during sudden increases in market volatility. We show that these "volatility risk premium" strategies deliver attractive risk-adjusted returns across 14 options markets from June 1994 to June 2012. Performance furthermore improves significantly after the crisis in 2008 (see Figure 1). We conclude that the risk-return tradeoff for volatility strategies compares favorably to those of traditional investments such as equities and bonds and that the strategies exhibit relatively low correlations to equity risk. Investors who want to diversify their portfolio's equity risk exposures should therefore consider making allocations to volatility risk premium strategies. However, successful implementation would require diversification across major options markets (equities, interest rates, currencies and commodities), active risk management and prudent scaling.

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FIGURE 1: IMPLIED VOLATILITY IS TYPICALLY HIGHER THAN SUBSEQUENT REALIZED VOLATILITY (AS SHOWN BY GLOBAL EQUITY, INTEREST RATE, COMMODITY AND CURRENCY MARKETS), (MAY 1994 TO JUNE 2012)

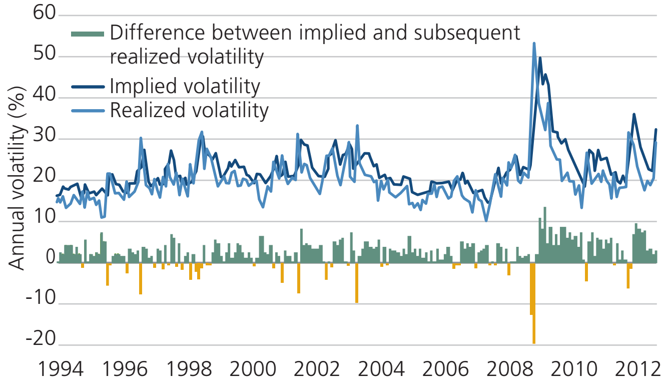


Figure 1 shows the average implied volatility, and the average subsequent realized volatility, across 14 options markets (described in Figure 2). Implied volatility is the annualized one month at-the-money implied volatility at the beginning of each month. Realized volatility is the annualized standard deviation of daily returns during each month.
Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

Perspective on the volatility risk premium

The volatility risk premium can be seen as compensation to option sellers for the risk of losses during periods when realized volatility increases suddenly; these periods tend to coincide with general market turmoil, elevated uncertainty and investor stress. The volatility risk premium causes option-implied volatility to exceed realized volatility, on average. Option-implied volatility is consequently a biased estimate of future realized volatility. And, therefore, the volatility risk premium is just another economic risk premium that investors may consider as part of their portfolios. Similar "biases" can be observed in all asset markets that expose investors to important systematic risk factors. In interest rate markets, the term premium, which can be seen as compensation for uncertainty about future inflation and monetary policy, typically causes forward rates to exceed realized interest rates. In credit markets, the credit-risk premium causes market-implied default rates to exceed realized default rates, on average, and compensates investors for the risk of losses on defaults and downgrades. Finally, the currency-carry risk premium typically causes forward exchange rates of low-yielding currencies to exceed realized exchange rates.

In addition, the observed magnitude of the volatility risk premium may be supported structurally by an imbalance in supply and demand. Buyers of options include hedgers, or speculators seeking leverage with capped downside, but there are few natural sellers of options. Imbalances between supply and demand for options may have been especially acute following the 2008 financial crisis and the subsequent sovereign debt crises. While demand for options has increased, fewer market participants are willing or able to supply options, due to increased capital requirements, higher costs and lower tolerance of leverage.

Strategies to capture the volatility premium

Our analysis is based on data from 14 options markets, grouped into four categories:

- Equities: Equity index options (S&P 500, EURO STOXX, FTSE 100, Nikkei)
- Commodities: Commodity futures options (Oil, Gold, Natural Gas)
- Currencies: Currency forward options (EUR, GBP, JPY – each vs. USD)
- Interest rates: 10-year swaptions (USD, EUR, GBP, JPY)

As a first indication of the magnitude of the volatility risk premium in these markets, Figure 2 compares average one-month option-implied volatilities to subsequent one-month realized volatilities (options are equally weighted within each broad market). The difference is positive on average and significant – corresponding to roughly one-tenth of the implied volatility.

FIGURE 2: IMPLIED VOLATILITY VS. REALIZED VOLATILITY (JUNE 1994 TO JUNE 2012)

Option market	Average one-month implied volatility (beginning of month)	Average one-month annualized realized volatility (during month)	Difference
Equity indexes	20.3%	18.1%	2.2%
Commodity futures	37.4%	33.0%	4.4%
Currencies	10.3%	9.4%	0.9%
10y IR swaptions	23.4%	20.4%	2.9%

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

Of course, these results do not directly correspond to the returns of a tradable strategy. The simplest way to capture the volatility risk premium is to sell one-month at-the-money straddles[1] (straddles are comprised of a put and a call at the same strike and maturity). The straddles need to be hedged each day against moves in the underlying instrument ("delta-hedging"), so that they remain exposed primarily to changes in market volatility.

We calculate hypothetical monthly returns of this strategy in each of the 14 options markets, from June 1994 to June 2012. The straddles are sold on the first business day of each month and held till expiry. We include conservative trading costs on both the sale of the option and the rebalancing of the hedge[2].

FIGURE 3: HYPOTHETICAL RETURNS OF EQUAL-WEIGHTED PORTFOLIOS OF STRADDLES (JUNE 1994 TO JUNE 2012)

Option market	Average annual excess return	Annualized standard deviation of returns	Sharpe ratio
Equity indexes	3.9%	3.9%	1.0
Commodity futures	6.1%	5.2%	1.2
Currencies	1.2%	1.7%	0.7
10y IR swaptions	1.3%	1.0%	1.2

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

Figure 3 shows average excess returns, standard deviations of returns, and the associated Sharpe ratios for each option-market category. (The Sharpe ratio measures the excess return per unit of standard deviation in an investment asset or trading strategy.) We find significant positive excess returns in each market with Sharpe ratios of 1.2 for commodities and interest rates, 1.0 for equities, and 0.7 for FX.

These Sharpe ratios compare favorably with other asset classes. However, it is well-known that standard deviation alone is insufficient as a measure of riskiness of a given investment strategy. This is especially true for strategies with embedded tail risks and returns that may be skewed to the downside.

Tail risk analysis

To analyze the left tail risk in the volatility strategies, we calculate the worst returns over one-, three- and 12-month periods (Figure 4), and the number of standard deviations[3] to which these returns correspond. To summarize the right tail of the distributions, we use the same statistics for the highest returns. The last column notes the dates of the worst three-month periods.

Over short horizons, the strategies show significant negative skewed tail risk. All experience at least three- to four-sigma losses over one month vs. two- to three-sigma gains in the right tail. However, over a 12-month period the pattern is reversed: The strategies exhibit positive skew; the right tail of the distribution is more pronounced than the left tail.

These results highlight a consistent empirical characteristic of volatility strategies: they are typically subject to relatively short, sharp losses, but tend to recover quickly. This may be because implied volatility tends to overreact to shocks due to demand from risk-averse hedgers, and remains elevated for some time.

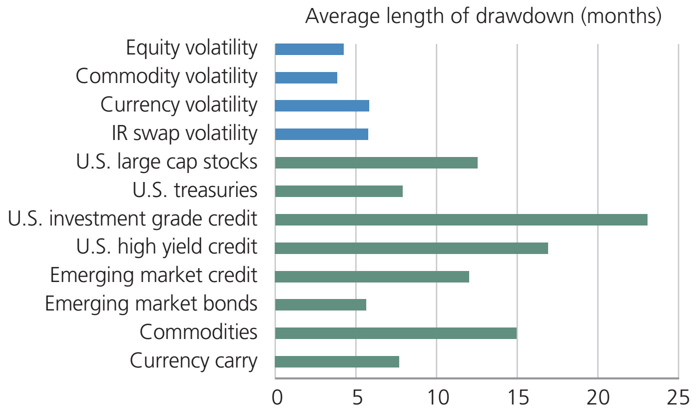
FIGURE 4: BEST AND WORST RETURNS OVER DIFFERENT HORIZONS (JUNE 1994 TO JUNE 2012)

Option market	One month		Three months		12 months		Worst three months
	Best	Worse	Best	Worse	Best	Worse	(Inclusive)
Equity indexes	5.8% (3σ)	-5.3% (-4σ)	7.1% (2σ)	-11.2% (-5σ)	15.1% (2σ)	-8.1% (-2σ)	Sep '08 to Nov '08
Commodity futures	4.3% (3σ)	-8.5% (-4σ)	7.4% (4σ)	-8.0% (-2σ)	18.0% (3σ)	-8.2% (-1σ)	Oct '96 to Dec '96
Currencies	1.4% (2σ)	-1.9% (-4σ)	3.3% (3σ)	-3.2% (-4σ)	8.7% (4σ)	-3.1% (-2σ)	Aug '08 to Oct '08
10y IR swaptions	1.2% (3σ)	-0.8% (-3σ)	2.4% (3σ)	-1.5% (-3σ)	5.4% (5σ)	-1.9% (-2σ)	Aug '98 to Oct '98

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

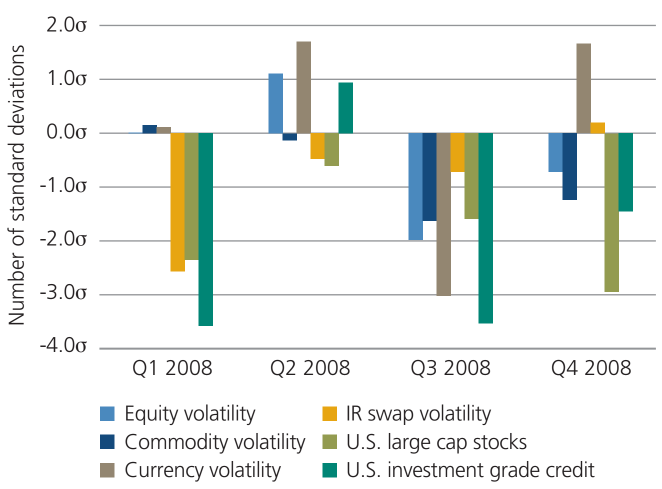
Since the strategies sell short-dated options, they monetize this excess risk aversion. To further illustrate this effect, Figure 5 shows the average length of drawdowns of the volatility strategies compared with investments in other classic risk premium strategies[4]. Drawdowns are measured by the average number of months taken for a strategy to recover a previous peak. The volatility strategies exhibit relatively short drawdowns of about five months, compared with an average of more than one year for the U.S. large cap stocks, for example.

FIGURE 5: AVERAGE LENGTH OF DRAWDOWNS, FROM PEAK TO SUBSEQUENT RECOVERY (JUNE 1994 TO JUNE 2012)



Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

FIGURE 6: QUARTERLY RETURNS, EXPRESSED AS THE NUMBER OF STANDARD DEVIATIONS, FOR SIX VOLATILITY PREMIUM STRATEGIES DURING 2008



Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

Figure 6 highlights the quarter-by-quarter performance during 2008, compared with U.S. large cap stocks and U.S. investment grade credit. As in Figure 4, quarterly returns are expressed as the number of standard deviations. The volatility strategies experience smaller negative shocks than investment grade credit, and comparable or smaller negative shocks than stocks. The third quarter of 2008, which includes the sharp sell-off in September, is the only quarter when all four volatility strategies have negative returns. By the fourth quarter, the volatility strategies start to recover as they monetize the higher implied volatility.

How much return is attributable to equity risk?

Market volatility tends to rise rapidly at times of overall market stress. As such, short-volatility strategies would be expected to lose money when equities sell off, and especially during equity tail events. Are returns of these strategies simply due compensation for exposure to equity risk and to equity tail risk in particular? To answer this, we decompose returns into a component attributable to broad equity beta, and a component attributable to exposure to equity tail risk[5].

FIGURE 7: RETURN ATTRIBUTABLE TO EQUITY BETA AND EXPOSURE TO EQUITY TAIL RISK (JUNE 1994 TO JUNE 2012)

Option market	Average annual excess return	Excess return attributable to equity beta	Excess return attributable to equity tail risk	Proportion of return unexplained by equity risk
Equity indexes	3.9%	0.8%	1.5%	43.3%
Commodity futures	6.1%	0.4%	-0.3%	97.1%
Currencies	1.2%	0.1%	0.3%	63.7%
10y IR swaptions	1.3%	0.1%	0.0%	97.4%

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

Figure 7 shows the proportion of the return that cannot be attributed to either equity beta or to equity tail risk. Equity volatility strategies, unsurprisingly, contain a substantial component of equity risk. Nearly 60% of returns are attributable to broad-equity and tail-equity risk. Currency volatility strategies also have a significant equity-risk component, contributing nearly 40% of returns. Commodities and interest rate volatility strategies do not have substantial exposure to equity risk.

These results highlight that the majority of the strategy returns (more than 75% on average across asset classes) cannot be explained by their exposure to equity risk. This supports the hypothesis of a distinct volatility risk premium and/or the existence of persistent structural supply-demand imbalances in the options market.

Is there a role for these strategies in portfolios?

The performance of the volatility strategies suggests that they may be attractive on a stand-alone basis. To evaluate their contribution potential in an asset allocation context, we next compare their risk, return and correlation with other risk premiums.

Figure 8 compares realized Sharpe ratios of the volatility strategies with the classic risk premium strategies (see appendix for details) across four historical periods. The four periods cover the pre-crisis era (June 1994 to June 2007), the crisis (July 2007 to March 2009), the sharp recovery (April 2009 to March 2010) and the sovereign-crisis period (April 2010 to June 2012). The volatility strategies perform relatively well across each of these four periods, with notably strong performance during the two most recent periods.

Finally, Figure 9 shows a monthly correlation matrix of the four volatility strategies with each other, and with the other risk premiums. Although the correlations between the volatility strategies in the full sample are positive, they are generally fairly low (around 20%-30%) with the exception of the equity volatility strategies (which are as high as 63%). Correlations do, however, increase across the board during the financial crisis, as shown in the lower part of Figure 9.

Conclusion

This article examines the historical performance of simple tradable strategies that are designed to capture the volatility risk premium over time. The empirical analysis shows that the strategies deliver significant positive risk-adjusted returns across 14 options markets over a sample period from June 1994 to June 2012. The strategies experience drawdowns during spikes in market volatility and exhibit fatter left tails than normal distributions, but rebound fairly rapidly following such episodes. Overall, the risk-return tradeoff for the volatility premium compares favorably to other sources of risk premiums such as equity and credit.

FIGURE 8: SHARPE RATIOS OF VOLATILITY STRATEGIES AND CLASSIC RISK PREMIUM STRATEGIES BY SUB-PERIOD (JUNE 1994 TO JUNE 2012)

	Pre-crisis (Jun ‘94 - Jun ‘07)	Financial crisis (Jul ‘07 - Mar ‘09)	Recovery (Apr ‘09 - Mar ‘10)	Sovereign crisis (Apr ‘10 - Jun ‘12)
Equity volatility	1.50	-0.09	4.44	0.39
Commodity volatility	1.10	0.22	3.45	1.68
Currency volatility	0.43	0.18	3.56	1.67
IR swap volatility	0.96	0.62	6.65	1.90
U.S. large cap stocks	0.56	-1.61	3.13	0.60
U.S. treasuries	0.49	1.44	-0.28	1.74
U.S. inv. grade credit	0.18	-1.41	3.35	0.01
U.S. high yield credit	0.18	-1.17	3.35	0.45
Emerging mkt. equity	0.91	-0.79	2.54	0.08
Emerging mkt. bonds	0.67	-0.28	4.24	1.08
Commodities	0.42	-0.75	1.21	0.15
Currency carry	1.21	-0.71	3.29	0.23

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

FIGURE 9: MONTHLY EXCESS RETURN CORRELATIONS OF THE FOUR VOLATILITY STRATEGIES WITH EACH OTHER AND OTHER CLASSIC RISK PREMIUMS

	Equity volatility	Commodity volatility	Currency volatility	IR swap volatility	U.S. large cap stocks	U.S. treasuries	U.S. Inv. grade credit	U.S. High yield credit	Emerging Mkt. equity	Emerging Mkt. bonds	Commodities	Currency carry
Full period (June 1994 to June 2012)												
Equity volatility	–	18%	27%	20%	50%	-15%	57%	57%	63%	42%	29%	50%
Commodity volatility	18%	–	18%	17%	22%	-11%	28%	24%	34%	8%	13%	13%
Currency volatility	27%	18%	–	32%	22%	-4%	30%	24%	32%	18%	9%	28%
IR swap volatility	20%	17%	32%	–	15%	-6%	27%	23%	22%	16%	10%	20%
Financial crisis (July 2007 to March 2009)												
Equity volatility		26%	62%	41%	57%	6%	67%	71%	66%	76%	40%	70%
Commodity volatility	26%		34%	25%	5%	-37%	48%	36%	30%	21%	46%	37%
Currency volatility	62%	34%		48%	25%	10%	64%	37%	50%	58%	25%	68%
IR swap volatility	41%	25%	48%		17%	-24%	58%	53%	29%	41%	-6%	19%

Source: Bloomberg, Barclays, JP Morgan, PIMCO, as of 30 June 2012

As always, there is a limit to conclusions that can be drawn based solely on historical-return analysis. Some potential risks may not have been realized during the sample period. However, given the economic rationale for the existence of a volatility risk premium, and the supportive supply-demand situation that emerged following the 2008 financial crisis, we believe an allocation to volatility strategies could enhance portfolio efficiency. An allocation should not be sized solely on historical-return statistics, however, but on conservative estimates of potential future returns. Volatility strategies are complex to implement, so both active portfolio and risk management are critical to their successful implementation in portfolios.

[1]Straddles are comprised of an at-the-money put and call with the same expiry date. On the day the straddle is sold, the value of the option has close to zero sensitivity ("zero delta") to changes in the price of the underlying. During the month, the delta may become positive or negative as the underlying moves, potentially leading to option gains and losses driven by market direction rather than the volatility premium. To neutralize this we simulate daily delta-hedging – taking an offsetting position in the underlying market – at the market close. The payoff of a delta-hedged straddle is closely related to the difference between initial implied volatility and subsequent realized volatility.

[2]A bid-offer of between 0.4% and 1.0% of the implied volatility is assessed on the sale of the option each month, and a bid-offer of between 0 bps and 2 bps is assessed daily on the notional required to rebalance the hedges. These bid-offers are further scaled up in periods of increased volatility, representing a reduction in liquidity in stressed periods. See appendix for additional details.

[3]To reflect the changing magnitudes of returns through time we measure standard deviations using a 36-month look-back window ending in the same month as the return-observation window, and then scale to match the return-window length. For example, if the worst three-month return is from September 2008 to November 2008, inclusive, the standard deviation is measured by monthly returns from December 2005 to November 2008, inclusive, and multiplied by the square root of three to scale to a three-month standard deviation.

[4]Classic risk premium strategies are defined as follows: U.S. large cap stocks, measured as the total return of the S&P 500 minus the total return of the Barclays Capital U.S. 1-3 Month T-Bill Index; U.S. Treasuries, measured as the total return of the Barclays U.S. Treasury Index minus the total return of the Barclays 1-3 Month T-Bill Index; U.S. investment grade credit, measured as the excess return of the Barclays U.S. Corporate Index over duration-matched treasuries; U.S. high yield credit, measured as the excess return of the Barclays U.S. High Yield Index over duration-matched treasuries; emerging market equity, measured as the total return of the MSCI Emerging Markets Index minus the total return of the Barclays Capital 1-3 Month T-Bill Index; emerging market bonds, measured as the excess return of the J.P. Morgan EMBI Global Index over duration-matched treasuries; commodities, measured as the total return of the Dow Jones UBS Commodity Index minus the total return of the Barclays 1-3 Month T-Bill Index; currency carry, measured as the return of investing in the three highest-yielding currencies, and going short the three lowest-yielding currencies each month, as per the Bloomberg function FXFB.

[5]The return attributable to equity beta is computed by regressing monthly returns of the volatility strategy on the monthly excess returns of the S&P 500 Index and multiplying the beta of this regression by the average annual excess return of the S&P 500 Index. The return attributable to equity and equity tail risk is computed by regressing monthly returns of the volatility strategy jointly on the monthly excess returns of the S&P 500 Index and the monthly excess returns of a short 5% out-of-the-money one-month S&P 500 Index put. The return is then computed by summing the betas from this regression multiplied by average annual excess returns of the S&P 500 Index and the short puts respectively. All calculations are based on data from June 1994 to June 2012.

Appendix: Transaction cost assumptions and data sources

The transaction cost assumed on the sale of the straddle is calculated as:

$$Option\ Transaction\ Cost = \frac{1}{2} \times Vega_t \times OptionTC_i \times max\left(0.5, \frac{\sigma_t^{Implied}}{\bar{\sigma}^{Implied}}\right)$$

where the first three terms of the expression on the right-hand side of the above equation approximate the bid-mid spread of the straddle in price terms and the last term captures the effect of increasing transactions costs in periods of high volatility (while not reducing them excessively when volatility is low).

FIGURE 10: TRANSACTION COST ASSUMPTIONS AND DATA SOURCES

Option underlying	Source for implied volatility	Data history begins	Assumed median historical implied volatility	Option bid-offer (volatility points) $OptionTC_i$	Delta bid-offer (bp) $DeltaTC_i$
S&P 500	J.P. Morgan / Bloomberg	Jun '94	20%	1.0%	1
EuroStoxx 50	Bloomberg	Feb '99	20%	1.0%	1
FTSE 100	Bloomberg	Feb '00	20%	1.0%	1
Nikkei 225	Bloomberg	Feb '01	20%	1.0%	1
Oil 1st future	Bloomberg	Jun '94	30%	1.0%	2
Gold 1st future	Bloomberg	Jan '00	20%	1.0%	2
Natural gas 1st future	Bloomberg	Jun '94	50%	1.0%	2
EURUSD FX	Barclays/ Bloomberg	Jun '94	10%	0.4%	0
JPYUSD FX	Barclays/ Bloomberg	Jun '94	10%	0.4%	0
GBPUSD FX	Barclays/ Bloomberg	Jun '94	10%	0.4%	0
USD 1m10y swap	Barclays	Jun '94	10%	0.5%	1
Euro 1m10y swap	Barclays	Feb '99	10%	0.5%	1
GBP 1m10y swap	Barclays	Feb '98	10%	0.5%	1
JPY 1m10y swap	Barclays	Feb '96	10%	0.5%	1

Data as of 30 June, 2012

The costs of daily delta hedging is modeled as:

$$Delta\ Transaction\ Cost = |Delta_t - Delta_{t-1}| \times Fwd_t \times DeltaTC_i \times max\left(0.5, \frac{\sigma_t^{Implied}}{\bar{\sigma}^{Implied}}\right)$$

where $\sigma_t^{Implied}$ is the current implied volatility, $\bar{\sigma}^{Implied}$ is the median historical implied volatility, $Vega_t$ is the current sensitivity of the price of the option to changes in the implied volatility, and $OptionTC_i$ is a constant varying across markets representing the bid-offer of the option in volatility points as per Figure 10. $Delta_t$ is the delta of the option on day t, Fwd_t is the forward price of the underlying on day t and $DeltaTC_i$ is a constant varying across markets as per Figure 10. Note that for swaps, the $DeltaTC_i$ is in yield terms.

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