Cross Asset Volatility

From Relative Value Signals to Optimal Portfolio Weights

- The aim of this report is twofold. First, we introduce the Cross Asset Relative Value (CARV) Volatility model. Second, we demonstrate how the signals can be incorporated into our hybrid portfolio framework for cross asset volatility.
- The Relative Value Volatility model (RV model) is a quantitative framework for determining the richness/cheapness of option implied volatility. In this report, we apply the model to volatility trading across a variety of asset classes, including FX, equities, credit, and commodities.
- We then demonstrate how the CARV signals can translate into portfoio weights in our cross asset optimal portfolio framework, which accounts for higher moments, maintains low turnover, and takes into account forward-looking information.

Global Quantitative and Derivatives Strategy

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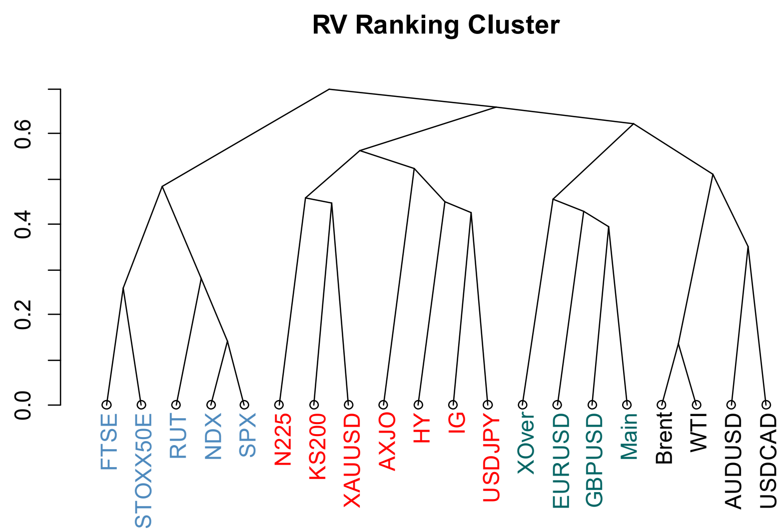
Hierarchical clusters of CARV rankings



Source: J.P. Morgan

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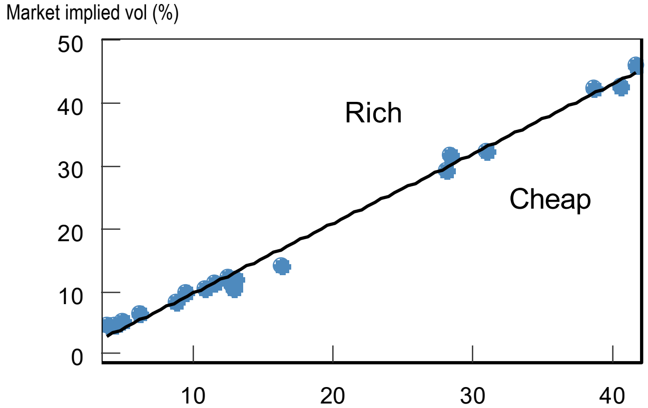
Introduction

The aim of this report is twofold. First, we introduce the Cross Asset Relative Value (CARV) Volatility model. Second, we demonstrate how the signals can be incorporated into our hybrid portfolio framework for cross asset volatility.

The Relative Value Volatility model (RV model) is a quantitative framework for determining the richness/cheapness of option implied volatility. The model aims to find relative value between underliers rather than predicting the future volatility of an underlier in isolation. The most recent iterations were developed for European single stocks in May 2016[1] and for US ETFs in Mar 2018[2].

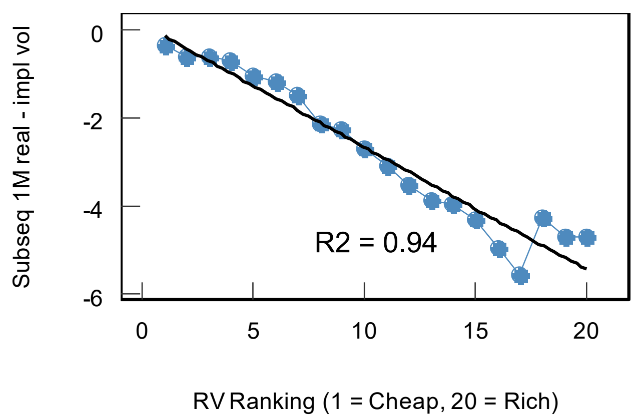
In this report, we apply the model to volatility trading across a variety of asset classes, including FX, equities, credit, and commodities. Figure 1 illustrates the output of the model from a single day, where we can compare our model implied volatility with market implied volatility, and identify the names as having rich or cheap implied vol. Figure 2 shows the relationship between the average RV ranking and the subsequent implied – realized vol spread. As the figure demonstrates, the RV ranking is successful in identifying assets with rich and cheap implied volatility.

Figure 1: Implied volatility is compared against RV model volatility on a given date



Source: J.P. Morgan

Figure 2: RV ranking is strongly correlated with subsequent implied realized volatility spread



Source: J.P. Morgan

We then demonstrate how the CARV signals can translate into portfolio weights in our cross asset optimal portfolio framework, which accounts for higher moments, maintains low turnover, and takes into account forward-looking information.

In Table 1 we find the CARV optimal portfolio weights as of Feb 3, 2020, which shows JPY and SPX vol to be the most attractive to sell and GBP and Asia Pac equity vol the most attractive to buy. The results are consistent with our other [machine learning based cross asset vol models](#).

[1] See New Relative Value Single Stock Volatility Model, 19-May-2016
[2] US ETF Relative Value Volatility Model, 27-Mar-2018

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Table 1: Current optimal portfolio

Asset	Optimal Weights	1M ATM Implied Vol	Vega Notional	Vol Direction
GBPUSD	1.343	6.2	0.217	Long
KS200	0.857	16.7	0.051	
FTSE	0.843	12.8	0.066	
N225	0.839	16.4	0.051	
AXJO	0.780	12.6	0.062	
XAUUSD	0.129	10.3	0.013	
STOXX50E	0.123	13.7	0.009	
IG	0.081	52.9	0.002	
EURUSD	0.006	3.9	0.002	
WTI	-0.002	39.6	0.000	
XOver	-0.007	42.1	0.000	
HY	-0.018	39.9	0.000	
Brent	-0.035	38.1	-0.001	
NDX	-0.059	17.8	-0.003	
AUDUSD	-0.171	7.2	-0.024	
RUT	-0.913	17.4	-0.052	
USDCAD	-0.931	4.2	-0.221	
Main	-0.941	45.8	-0.021	
USDJPY	-0.944	5.4	-0.174	
SPX	-0.980	15.2	-0.065	Short

Source: J.P. Morgan

The rest of the report is divided into three sections: we first review in detail the methodology of our model, then illustrate its uses and the back test results. Finally, we introduce the CARV signals into our cross asset volatility optimal portfolio.

Data

Using data from the last 10 years (Dec 2009 to Dec 2019), we take the historical 1M ATM implied and realized volatility of the following 20 assets in Table 2. The universe selection is not intended to be exhaustive but instead represent the assets that are the most liquid within each asset class. The historical implied vol time series can be seen in Figure 3.

Table 2: 1M volatility of the following assets are used in this study

Asset	Asset Class
AUDUSD	FX
EURUSD	FX
GBPUSD	FX
USDCAD	FX
USDJPY	FX
XAUUSD	FX
SPX	Equity
STOXX50E	Equity
NDX	Equity
RUT	Equity
FTSE	Equity
KS200	Equity
AXJO	Equity
N225	Equity
WTI	Energy
Brent	Energy
Main	Credit
XOver	Credit
IG	Credit
HY	Credit

Source: J.P. Morgan

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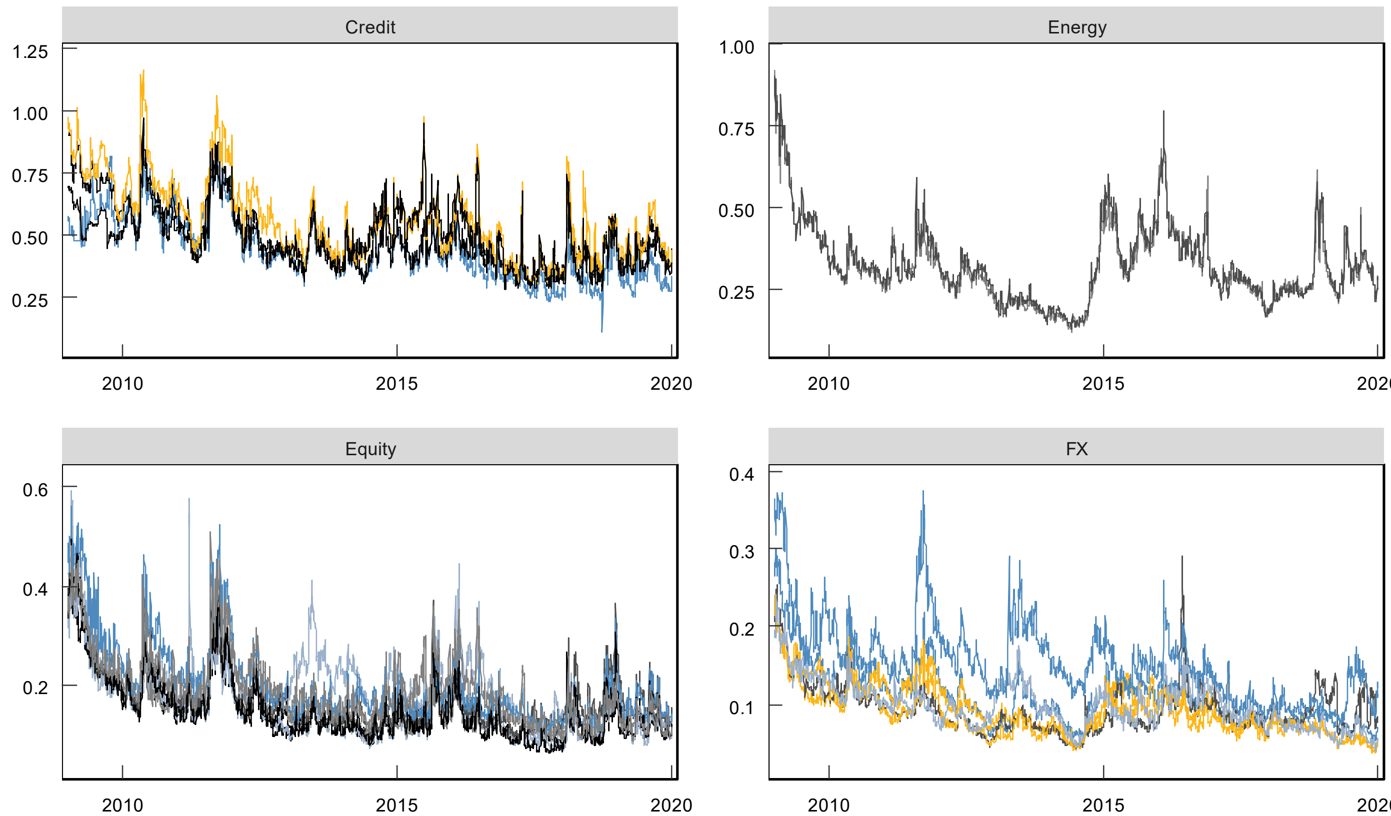
Figure 3: Implied vol history by asset class

1M ATM implied vol



Source: J.P. Morgan

CARV Model Methodology

The main idea behind our RV model is to compare the current implied volatility with model volatility across names at one point in time. In order to estimate the model volatility, we propose the following regression:

$$iv = \alpha_j + \beta_{1j} ewma + \beta_{2j} r + \epsilon \qquad [1]$$

$$CARV_i = \widehat{iv_i} - iv_i \qquad [2]$$

Where iv is the (natural) log of the ATMF implied variance (volatility squared), $ewma$ is the log of the exponentially weighted moving average variance, and r is the last 3M asset return. The coefficients are estimated by ordinary least squares. A positive value of CARV indicates that the market implied vol is cheaper than the model fair value, and a negative value indicates that the market implied vol is richer.

We discuss our model specification below:

Why cross sectional and not time series analysis?

Although it may sound counterintuitive, cross-sectional models are generally better at capturing long-term relationships than time series models. For instance, a typical daily cross-sectional sample in 2019 contains 1M implied vol observations ranging from 4.0 (CAD) to 40 (CDX IG). In 2010, the one-day cross section covers a range between 17 (JPY) and 117 (iTraxx Main). We therefore have the opportunities to observe the relationship between implied and realized volatility over a broad range of risk profiles. In contrast, time series analysis on an individual underlier may only reveal such information with a very long observation window.

Modelling the natural log of implied vol

There are several advantages of modeling the natural log instead of raw values of implied volatility. Numerically, doing so restricts all volatility forecasts to be positive. Moreover, the distribution of volatility levels more closely resembles log normal than normal. Economically, there is an important advantages as well. By taking the natural log we turn the regression residuals into ratios between market and fair values. This makes intuitive sense as we believe a 1 vol residual on a 5 vol asset is more important than a 2 vol residual on a 50 vol asset.

Exponentially weighted moving average volatility (EWMA)

Realized volatility is typically defined as the standard deviation of returns over an observation period. The standard deviation gives equal importance to the returns on every day of the time period. In financial asset volatility, however, we observe a very high degree of persistence. In other words, days of high volatility tend to be followed by more days of high volatility, and days of low volatility tend to be followed by more days of low volatility. Therefore, recent observations should be given more weight.

On the other hand, we also observe that the implied volatility market has a long memory. When an asset experiences a sharp move on one day, its implied volatility will usually stay elevated for a long period of time relative to its realized vol, even after the sharp move has dropped out of the observation period.

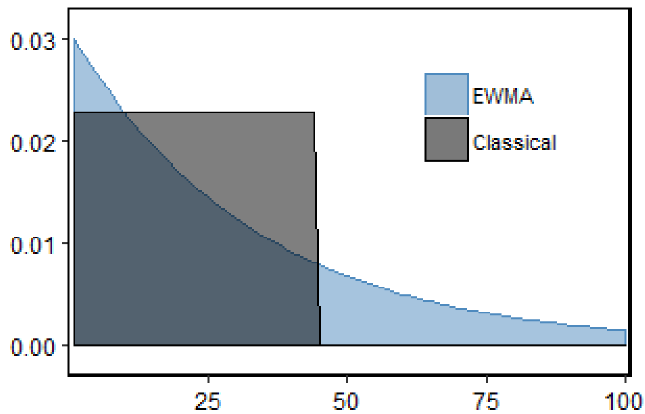
Based on the two observations above, we can improve the measurement of realized volatility by using a measure that gives more importance to the very recent returns, without chopping off its observation window after a set period of time. The Exponentially Weighted Moving Average (EWMA) volatility serves this dual purpose. There are two equivalent definitions of the EWMA volatility:

$$EWMA_t^2 = \lambda \cdot EWMA_{t-1}^2 + (1-\lambda)r_t^2 \quad [3]$$

$$EWMA_t^2 = (1-\lambda)r_t^2 + \lambda(1-\lambda)r_{t-1}^2 + \lambda^2(1-\lambda)r_{t-2}^2 + \cdots \quad [4]$$

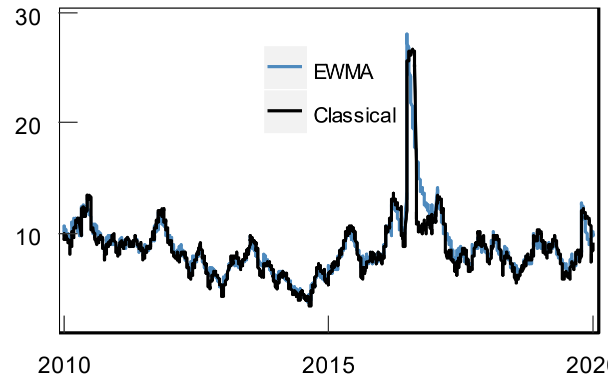
In [2], we can see that the EWMA variance (volatility squared) on day t is the weighted average of the previous day EWMA variance and the squared return on day t (r_t^2). We can choose the parameter λ between 0 and 1 to assign the weight to the most recent return. In [3] the weights given to the observations are explicitly shown. The weights decay every day by a factor of λ, but never go to 0, thereby preserving more distant observations. In the RV model we choose λ to be 0.97, which we find to correspond approximately to the classically defined two-month realized volatility.

Figure 4: The EWMA weighting scheme gives more importance to recent observations and retains more distant data points
Weights of returns used in computation / number of business days ago



Source: J.P. Morgan Equity Derivatives Strategy

Figure 5: The large moves in EWMA volatility fall out of the sample more gradually than traditional realized volatility for cable
Volatility (%)



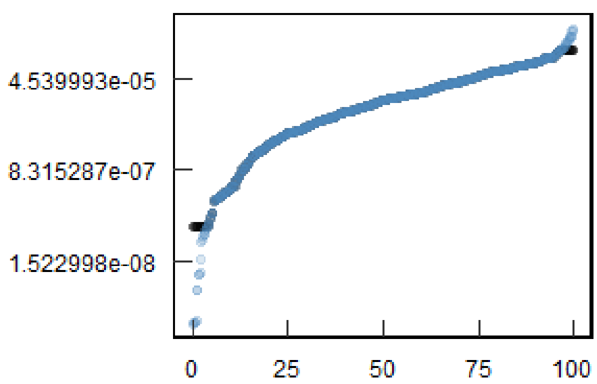
Source: J.P. Morgan

In Figure 4 and Figure 5, we demonstrate the features of the EWMA volatility compared with the traditional definition of realized volatility. For the rest of the report, we use the EWMA definition to compute realized volatility.

Winsorization:

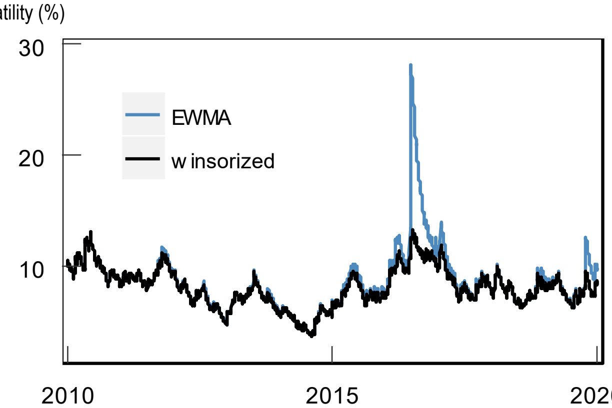
A drawback of the EWMA volatility measure is that excessively large moves are given a very high weight in the days immediately following the move. Therefore, we apply winsorization, which shrinks the excessively large (as well as small) moves towards the median. As Figure 6 demonstrates, we cap the observed values to no more than the 97.5 percentile, and no lower than 2.5 percentile. This produces a more reasonable realized volatility seen in Figure 7 for GBPUSD as an example.

Figure 6: Daily variance observations before/after winsorization
Daily variance (log scale) / Percentile (%)



Source: J.P. Morgan

Figure 7: Winsorization allows a more reasonable estimate of realized volatility after large moves
Volatility (%)



Source: J.P. Morgan

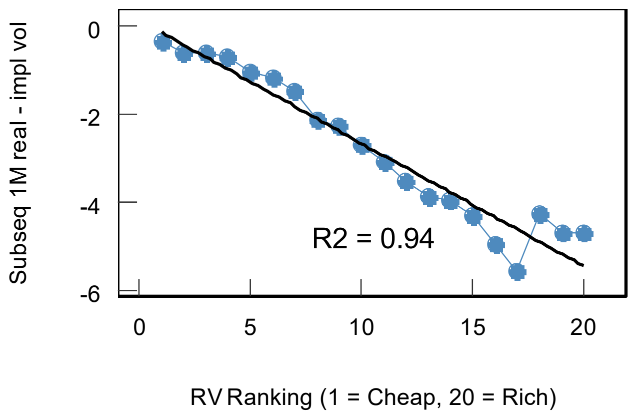
Accounting for the leveraged effects

We observe generally in risky assets that a decline in the asset valuation tends to increase the subsequent realized volatility. In equities this is known as the ‘leverage’ effect. We aim to capture this by including the past 3M return term to the regression. To be consistent across all asset classes, a negative return denotes a weakening in the asset valuation, and vice versa. For instance, moves such as iTraxx Main widening from 50 bps to 55 bps, or JPY going from 100 to 110, would both be expressed as negative 10% returns.

CARV Signals

Based on the data and methodology described above, we obtain daily signals and rankings for each asset over the last 10 years. Figure 8 shows that the ranking is effective in predicting subsequent implied to realized volatility spread. In Figure 9 we see that the CARV signal is only mildly correlated with carry (1M implied – recent 1M realized). The regression R^2 between the two variables is 0.22. Moreover, a carry signal based portfolio will almost always be short biased (implied trades above trailing realized vol 70% of the time in our sample). On the other hand, the CARV signal removes such bias. The split between positive and negative signals are 49.8%/50.2%.

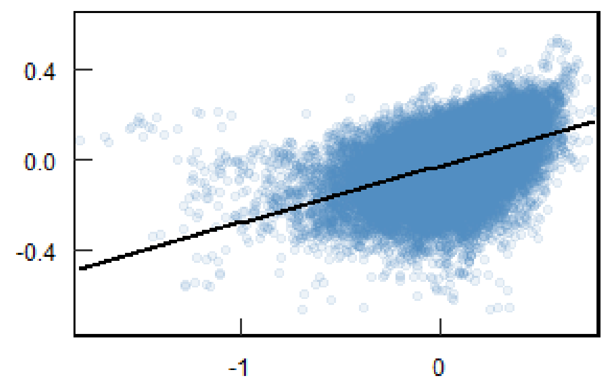
Figure 8: RV ranking is strongly correlated with subsequent implied realized volatility spread



Source: J.P. Morgan

Figure 9: CARV and carry signals are mildly correlated

CARV signal

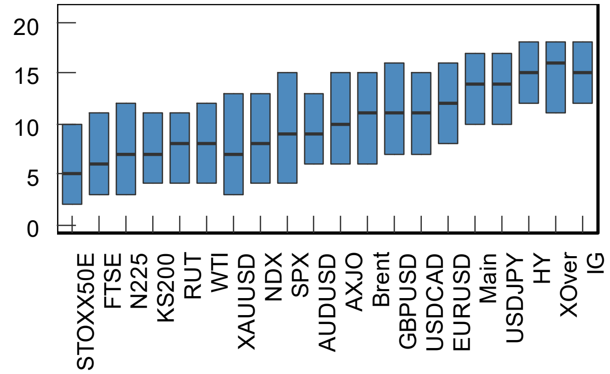


Source: J.P. Morgan

Carry signal = (Implied – Traling Realized)/Implied

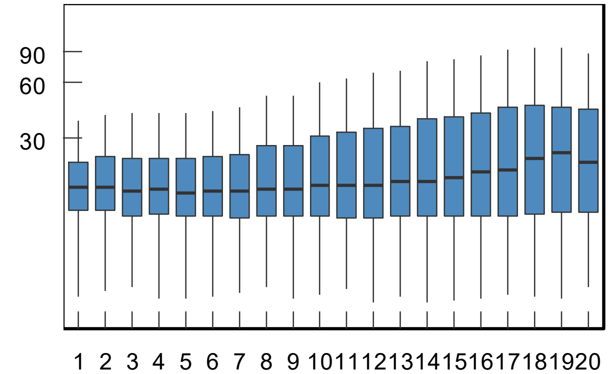
From Figure 10 we can see that credit assets dominate the most expensive vol rankings, whereas European and Asian equities tend to be ranked on the cheaper end. Figure 11 shows the CARV ranking is positively correlated with implied vol levels. This is the result of the credit volatility richness. When we remove credit vol, the ranking shows no correlation with vol levels.

Figure 10: Average ranking per asset class
CARV rankings (1 = cheap vol, 20 = rich vol)



Source: J.P. Morgan

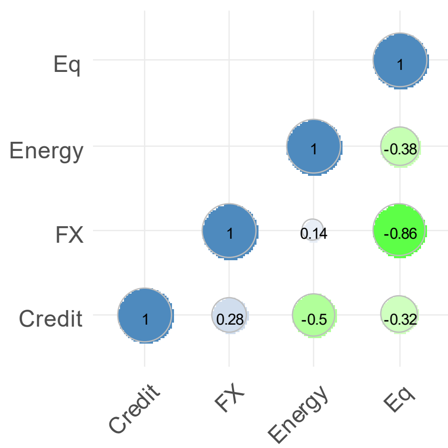
Figure 11: Average implied vol level by CARV rankings
Implied vol (%)



Source: J.P. Morgan

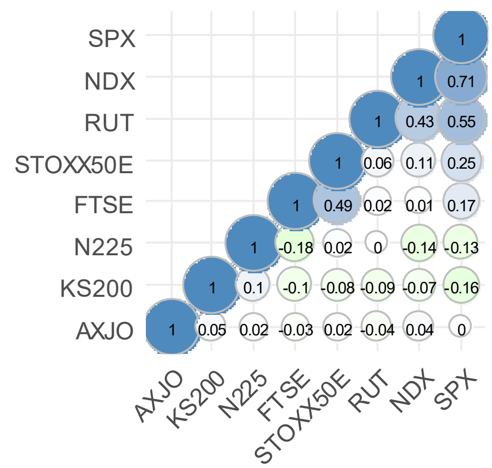
Next we examine the relationship between asset class rankings. Inter-asset class correlation appears to be quite high (Figure 12). In particular, note the negative correlation between equties and all other asset classes. In other words, when equity vol is rich, the other asset classes tend to be cheap, and vice versa.

Figure 12: CARV ranking correlation across asset classes



Source: J.P. Morgan

Figure 13: CARV ranking correlation within equities



Source: J.P. Morgan

Intra-asset class correlation, on the other hand, appear relatively modest across most assets (Figure 13 – Figure 15), with the exception of some minor clustering (such as SPX/NDX/RUT and WTI/Brent).

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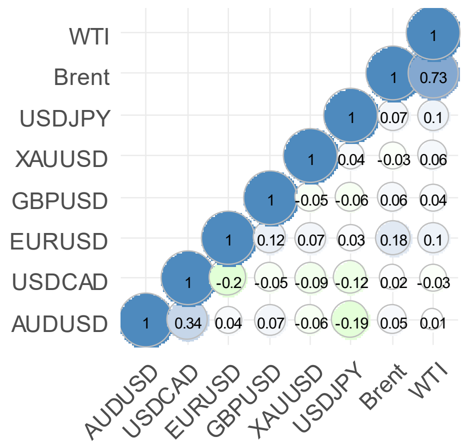
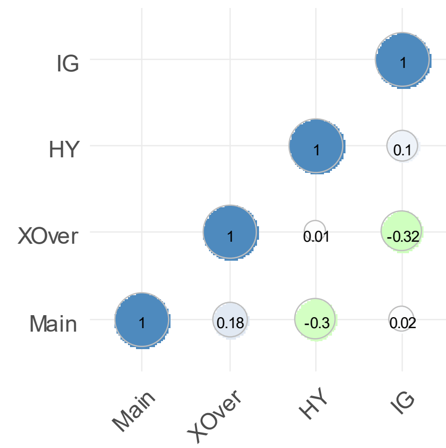
Figure 14: CARV ranking correlation in FX and commodities



Source: J.P. Morgan

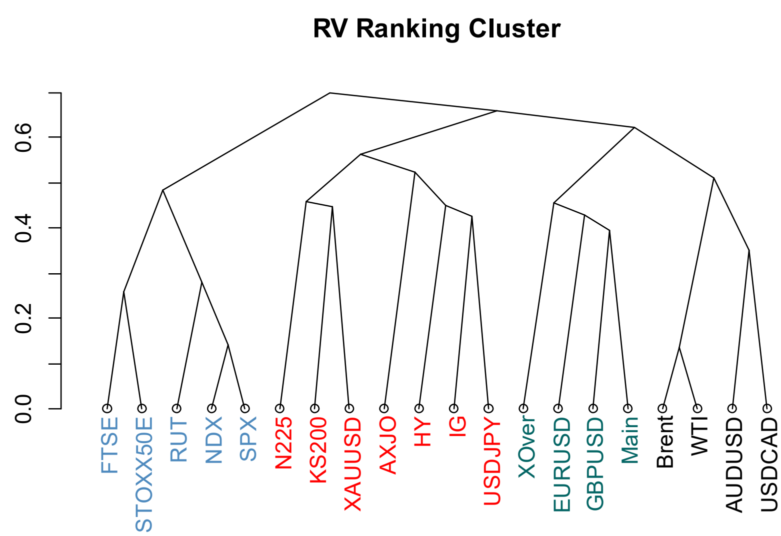
Figure 15: CARV ranking correlation within credit



Source: J.P. Morgan

To look deeper into the relationship between rankings, we perform a hierarchical clustering analysis on the ranking correlations. The analysis reveals four main clusters (Figure 16). They can be described as the commodity complex, European fixed income, European and US equities, and everything else. Within each cluster, the volatility valuation dynamics tend to behave similarly.

Figure 16: Hierarchical clusters of CARV rankings



Source: J.P. Morgan

Optimal Portfolio Construction

How do we convert trade signals into portfolio weights? Historically we have used relatively simple methods such as equal weighting. In a previous report[3], we demonstrated how a balanced long/short cross asset volatility portfolio can be achieved by combining utility maximization and equal risk contribution portfolios

[3] Cross Asset Volatility: Optimal Portfolio Construction – Beyond Risk Parity, 08 Nov 2019

('hybrid portfolio'). In this report, we apply the hybrid portfolio methodology and incorporate the CARV signals.

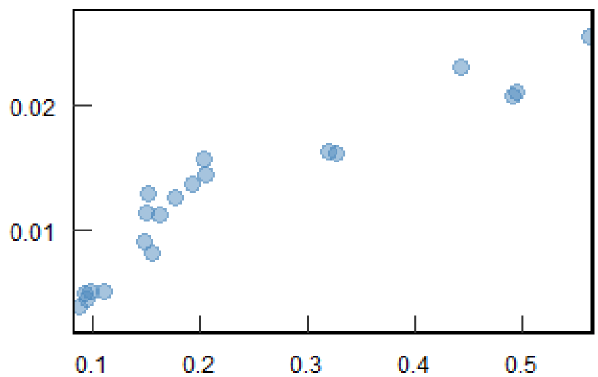
Before delving into the hybrid model itself, we need to define a benchmark portfolio, not only for performance benchmarking, but also as a shrinkage target portfolio.

Defining the benchmark portfolio

We believe that equal vega allocation is not appropriate for cross asset volatility portfolio, since allocating 1 vega to iTraxx Main and to EURUSD implies very different risk exposures. Instead we propose allocating in inverse proportions to implied vol levels. That is, for a 10 vol name, we allocate 1/10 = 0.1 vega, whereas for a 50 vol name, we allocate 1/50 = 0.02 vega. We consider both assets having been allocated roughly 1 unit of risk. This is supported by our observation that the magnitude of implied vol moves is highly correlated with the implied vol levels (Figure 17), and therefore the vol of vol, when measured as a % of vol levels, are in the same order of magnitude across asset classes (Figure 18). It is also consistent with our CARV model since the signals are expressed as a ratio of the implied volatility. Therefore, for the remainder of report, we define equal weight as allocating inversely to implied vol levels. Such a portfolio will have more evenly distributed risks, in our view.

Figure 17: Magnitude of implied vol changes is highly correlated with implied vol levels

Average daily change in implied vol per asset (vega)

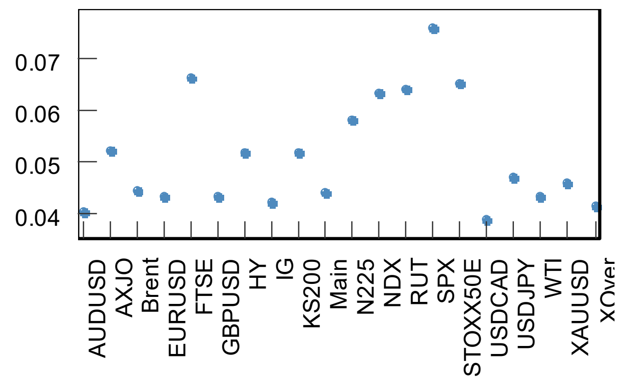


Source: J.P. Morgan

Average implied vol level per asset

Figure 18: Vol of vol across asset classes are around the same order of magnitude

Average daily vol of vol (change as % of implied vol)



Source: J.P. Morgan

In this analysis, we want to evaluate the effective of the CARV model as well as the cross asset optimization methodology. As such, we form two benchmark portfolios.

Pure carry based (carry): Long (+1 unit) vol if current 1M implied is lower than trailing 1M realized, short (-1 unit) vol if current 1M implied is higher than trailing 1M realized.

Equally weighted cross asset vol RV (CARV): Long (+1 unit) vol if current CARV signal is positive, short (-1 unit) vol if current CARV signal is negative.

Optimal portfolio methodology

Relative to simple mean variance or risk parity portfolios, we aim to achieve the following:

- Incorporate not just mean/variance information but also all higher moments (skewness, kurtosis, etc.).
- Control for excess turnover
- Incorporate trading signals, while accounting for the model and data uncertainty

In this report we look at the effect of incorporating the CARV signals into our portfolio optimization algorithm.

We form an optimal cross asset portfolio using the following objective function where w denotes the weights of the optimal portfolio and w_{CARV} the weights of the equal weight CARV portfolio:

$$\max_{w} f(w) = E[U(w)] - \lambda \cdot (w - w_{CARV})^T (w - w_{CARV}) \quad [5]$$

$$w[i]_{CARV} = sign(CARV_i) \quad [6]$$

In [5], $E[U(w)]$ is defined as:

$$E[U(w)] = \frac{1}{1-\gamma} E[(1 + w^T r)^{1-\gamma} \quad [7]$$

In this study we choose the risk-aversion parameter γ to be 10 (a reasonable range of γ is shown in our previous analysis). To introduce the trading signals, we would replace the r vector in [7] with our current CARV forecasts. However, the CARV forecasts only contain first moment information. For all higher moments, we resort to historical data. To that end, we take the 1-month implied – trailing realized vol spread (as a % of implied vol) over the last one year for each asset. The mean of the carry data is then replaced with the CARV signals of the corresponding asset.

Equation [6] indicates that the ith element of our optimal weight vector is shrunk towards +1 if the CARV is cheap, and -1 if the vol is rich. λ determines how much shrinkage we would like to impose. For our study it is chosen so that the shrinkage penalty term and $E[U(w)]$ are weighted equally by the objective function.

For details on the choice of hyperparameters and signal incorporation, please see our report in footnote 3.

An additional restriction we impose is that the long legs and short legs of the optimal portfolio have the same total allocation as equally weighted portfolio, respectively, to ensure comparable results.

We run the optimization daily and obtain a set of new weights everyday. Once the weights are computed, we follow the steps below to compute the P&L.

- The positions are held until the 1-month expiry. In total we have 2,500 business days in the back test period.

- The profit and loss of each position are computed only at expiry, as the weighted average difference between ATMF volatility and subsequent realized vol. Although the results are not directly tradeable we compute the risk and return statistics to give an idea of the performance of a pure volatility strategy based on our RV model.
- By the convention of volatility swaps, we cap maximum gains/losses at 2.5 times the implied vol entry levels.
- Transaction costs are taken out of the P&L according to Table 3. Since the trades are held to maturity, transaction costs are only applied at trade inception.

Table 3: 1M volatility of the following assets are used in this study

Asset	Asset Class	Transaction cost in vega (bid to mid / ask to mid)
AUDUSD	FX	0.25
EURUSD	FX	0.25
GBPUSD	FX	0.25
USDCAD	FX	0.25
USDJPY	FX	0.25
XAUUSD	FX	0.50
SPX	Equity	0.25
STOXX50E	Equity	0.25
NDX	Equity	0.40
RUT	Equity	0.40
FTSE	Equity	0.40
KS200	Equity	0.40
AXJO	Equity	0.40
N225	Equity	0.40
WTI	Energy	0.80
Brent	Energy	1.00
Main	Credit	2.50
XOver	Credit	2.50
IG	Credit	2.20
HY	Credit	2.20

Source: J.P. Morgan

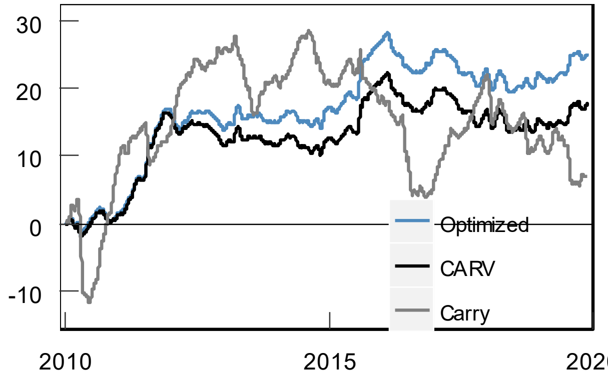
In Figure 19 and Table 4, we compare the three portfolios:

- Long/short portfolio based only on trailing carry signals
- Long/short portfolio based on CARV signals
- Optimized CARV long/short portfolios

We find in both Sharpe ratio and skewness terms, the CARV signals show significant improvement over simple carry measures. In addition, the optimization portfolio improves the Sharpe ratio further withouth any loss of positive skewness.

Figure 19: Performance of long/short cross asset volatility portfolios (post-transaction cost)

Cumulative P&L (vega)



Source: J.P. Morgan

Table 4: Performance of long/short cross asset volatility portfolios

Excl. t-cost Strategy	Monthly Avg	Monthly Standard Deviation	Annualized Sharpe Ratio	Skewness
Optimized	4.3%	7.3%	2.04	0.82
CARV	4.0%	7.2%	1.93	0.87
Carry	3.5%	14.0%	0.87	(1.46)
Short only	6.6%	19.4%	1.17	(1.49)

Incl. t-cost Strategy	Monthly Avg	Monthly Standard Deviation	Annualized Sharpe Ratio	Skewness
Optimized	1.0%	7.4%	0.48	0.81
CARV	0.7%	7.3%	0.34	0.86
Carry	0.3%	14.1%	0.07	(1.43)
Short only	3.3%	19.6%	0.58	(1.45)

Source: J.P. Morgan

However, when compared with a short vol only portfolio ('short only') where we go short vol on all assets, the CARV pre- and post-optimization portfolio underperforms in Sharpe ratio terms post transaction cost.

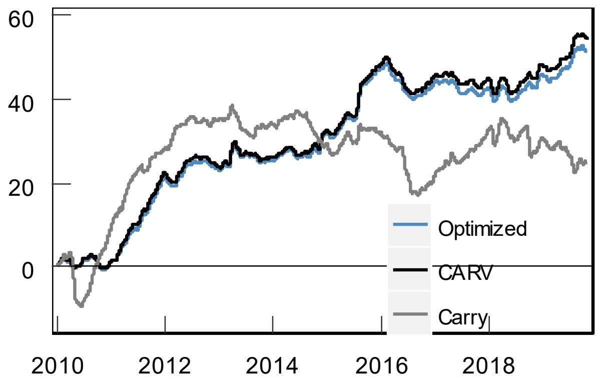
In the analysis above, we take positions in all 20 assets, regardless of the signal strength. In all our prior RV models, we take positions only in the assets with the strongest signals. In Figure 20 and Table 5, we show the performance if we allocate to only the top five assets with the cheapest/richest volatility. Therefore on any given day the CARV portfolio only invests in 10 assets, with the remaining 10 having zero weights. While the optimized portfolio will be shrunk towards the CARV portfolio, it is still allowed to take positions in all assets.

We observe similar performance pickup by the CARV signals. When overlaid with the optimization algorithm, the improvement in Sharpe ratio is relatively muted, but we observe meaningful improvement to skewnewss. The portfolios also outperforms the short only portfolio, post-transaction cost.

It is worth noting that, pre-transaction cost, there is little performance difference between trading all assets and picking only the top 5. Post-transaction cost, the performance difference is material. This indicates that lowly ranked assets tend to have weaker signals that are completely eroded by transaction costs.

Figure 20: Performance of long/short cross asset volatility portfolios – only take positions in strong signals (post transaction cost)

Cumulative P&L (vega)



Source: J.P. Morgan

Table 5: Performance of long/short cross asset volatility portfolios – only take positions in top/bottom 5 signals

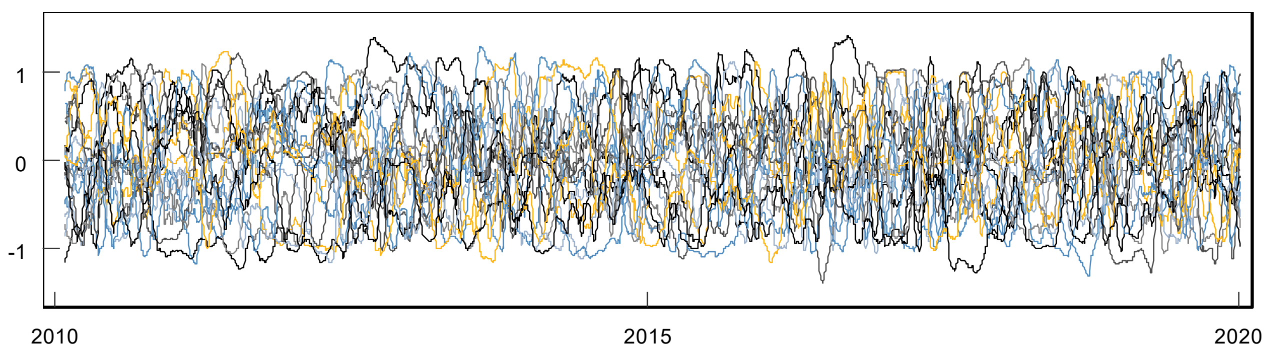
Excl. t-cost Strategy	Avg	Monthly Standard Deviation	Annualized Sharpe Ratio	Skewness
Optimized	5.4%	8.9%	2.10	0.66
CARV	5.5%	9.5%	1.99	0.52
Carry	4.4%	13.3%	1.13	(0.99)

Incl. t-cost Strategy	Avg	Monthly Standard Deviation	Annualized Sharpe Ratio	Skewness
Optimized	2.1%	8.9%	0.81	0.64
CARV	2.2%	9.6%	0.79	0.50
Carry	1.0%	13.4%	0.26	(0.97)

Source: J.P. Morgan

Taking the optimized portfolio in Figure 20 and Table 5, we try to further understand the behavior of the optimizer. Figure 21 shows the time series of the optimal weights for all assets, which appears to be quite volatile. However, since we initiate 1-month positions daily and carry to maturity, the transaction cost is only incurred at every trade inception. It is also worth noting that even though no hard upper and lower bounds were specified during the optimization, the optimal weights are relatively well behaved and largely bounded above and below, thanks to the shrinkage penalty.

Figure 21: 21-day moving average of the optimal weights



Source: J.P. Morgan

In Figure 22 we show the CARV portfolio weights before and after the optimization. the optimization portfolio weights deviate actively from the discrete positions of +1/0/-1. The distances between the optimized weights and the shrinkage targets depend on the strengths of the signals (Figure 23).

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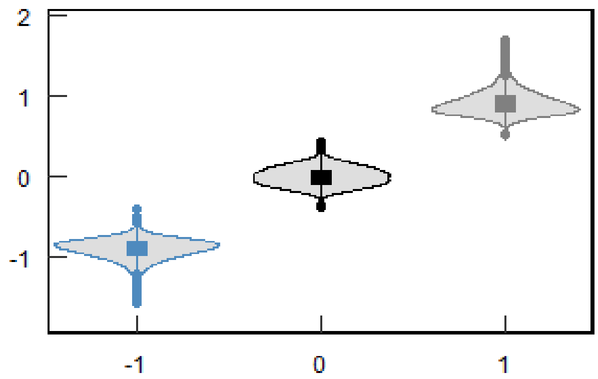
Figure 22: Optimized vs. raw CARV portfolio weights

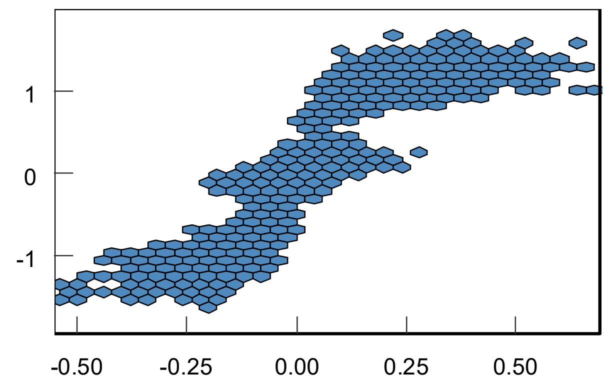
Optimized weights



Source: J.P. Morgan

Figure 23: Optimized portfolio weights vs. CARV signals

Optimized weights

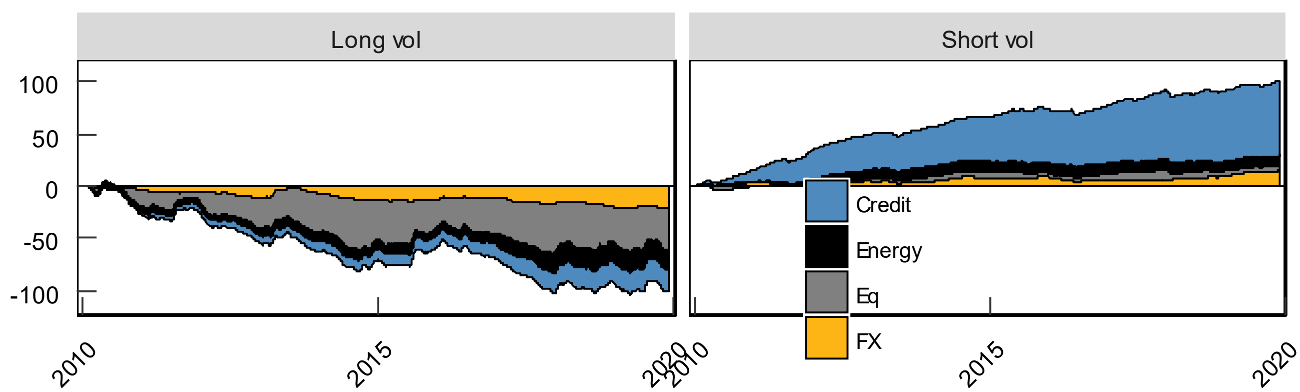


Source: J.P. Morgan

Figure 24 shows the P&L contribution of various asset classes in both the long and short vol legs of the optimal portfolio. The most notable feature is that credit vol P&L dominates the short vol leg, whereas equity P&L contributes a large portion to the long vol leg.

Figure 24: P&L contribution by asset class and direction

Asset class P&L as % of total cumulative P&L



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Put Sale. Investors who sell put options will own the underlying asset if the asset's price falls below the strike price of the put option. Investors, therefore, will be exposed to any decline in the underlying asset's price below the strike potentially to zero, and they will not participate in any price appreciation in the underlying asset if the option expires unexercised.

Call Sale. Investors who sell uncovered call options have exposure on the upside that is theoretically unlimited.

Call Overwrite or Buywrite. Investors who sell call options against a long position in the underlying asset give up any appreciation in the underlying asset's price above the strike price of the call option, and they remain exposed to the downside of the underlying asset in the return for the receipt of the option premium.

Booster. In a sell-off, the maximum realized downside potential of a double-up booster is the net premium paid. In a rally, option losses are potentially unlimited as the investor is net short a call. When overlaid onto a long position in the underlying asset, upside losses are capped (as for a covered call), but downside losses are not.

Collar. Locks in the amount that can be realized at maturity to a range defined by the put and call strike. If the collar is not costless, investors risk losing 100% of the premium paid. Since investors are selling a call option, they give up any price appreciation in the underlying asset above the strike price of the call option.

Call Purchase. Options are a decaying asset, and investors risk losing 100% of the premium paid if the underlying asset's price is below the strike price of the call option.

Put Purchase. Options are a decaying asset, and investors risk losing 100% of the premium paid if the underlying asset's price is above the strike price of the put option.

Straddle or Strangle. The seller of a straddle or strangle is exposed to increases in the underlying asset's price above the call strike and declines in the underlying asset's price below the put strike. Since exposure on the upside is theoretically unlimited, investors who also own the underlying asset would have limited losses should the underlying asset rally. Covered writers are exposed to declines in the underlying asset position as well as any additional exposure should the underlying asset decline below the strike price of the put option. Having sold a covered call option, the investor gives up all appreciation in the underlying asset above the strike price of the call option.

Put Spread. The buyer of a put spread risks losing 100% of the premium paid. The buyer of higher-ratio put spread has unlimited downside below the lower strike (down to zero), dependent on the number of lower-struck puts sold. The maximum gain is limited to the spread between the two put strikes, when the underlying is at the lower strike. Investors who own the underlying asset will have downside protection between the higher-strike put and the lower-strike put. However, should the underlying asset's price fall below the strike price of the lower-strike put, investors regain exposure to the underlying asset, and this exposure is multiplied by the number of puts sold.

Call Spread. The buyer risks losing 100% of the premium paid. The gain is limited to the spread between the two strike prices. The seller of a call spread risks losing an amount equal to the spread between the two call strikes less the net premium received. By selling a covered call spread, the investor remains exposed to the downside of the underlying asset and gives up the spread between the two call strikes should the underlying asset rally.

Butterfly Spread. A butterfly spread consists of two spreads established simultaneously – one a bull spread and the other a bear spread. The resulting position is neutral, that is, the investor will profit if the underlying is stable. Butterfly spreads are established at a net debit. The maximum profit will occur at the middle strike price; the maximum loss is the net debit.

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