Leap of faith

Systematic options strategies in U.S. interest rates

US Fixed Income Strategy
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- Over the past few years, the risk-adjusted returns on short gamma programs in U.S. interest rate volatility have rivaled those in risky assets such as equities and credit.
- Though the mortgage bid has faded somewhat, USD swaptions continue to trade structurally rich, in part reflecting greater range volatility risk premium relative to daily volatility.
- Given the highly non-normal (capped upside, non-linear downside) of systematic options strategies, we believe a mixture of non-parametric Sharpe, Sterling, and drawdown ratios is a preferable one-factor risk measure.
- In recent years, the performance of systematic short strangles has improved relative to straddles.
- Occasional delta hedging can improve risk-adjusted returns, but the costs of very frequent rebalancing more than outweigh the benefits. We also do not recommend gamma risk-targeting with straddles.
- A number of *ex-ante* trading signals result in higher risk-adjusted returns, with higher outright levels of vol and higher implied-to-realized vol ratio delivering the greatest benefit.

See page 8 for analyst certification and important disclosures.

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Introduction

As the derivatives market has grown, a consistent theme has been the structural richness of short-dated volatility across various markets. **Over the past five years, for example, systematically selling rates, equity and credit volatility has produced attractive risk-adjusted returns across a range of currencies (Exhibit 1)**. While the specific origins of structural richness in short-dated options vary, they all owe in part to a persistent bid from hedgers that keeps implied volatility elevated relative to what is likely to be realized. The performance of short gamma programs in U.S. rates is particularly notable. Whereas risky assets benefit from a portfolio protection bid, and EUR and JPY rates vol has been driven by consistent dovish central bank intervention, attractive risk-adjusted returns from selling USD swaptions span several policy regimes. **And more generally, the fact that short gamma programs in rates rival those in risky assets is particularly striking in the context of signs of modest structural cheapness in G4 FX options markets**.

Especially in light of a relative lack of macro momentum, these types of trading strategies have garnered greater focus in recent months. **In this piece, we discuss the drivers of volatility risk premium in U.S. interest rates, both in the pre-crisis environment and more recently**. We also argue for using a mixture of non-parametric ratios to benchmark risk given a highly non-normal distribution of returns (truncated with fat tails). **Putting this together, we use historical data to empirically test the best structures and risk management rules (delta and gamma) for short gamma programs**. Finally we consider what *ex-ante* signals can be used to improve risk-adjusted returns.

Origins of volatility risk premium

As a practical matter, in the absence of a bias in the direction of client flows, one would not *a priori* expect high risk-adjusted returns from systematic options-based strategies. Though vols clearly can trade rich or cheap for periods of time, in a truly balanced market, returns from structural one-way positions should tend towards zero over the long run. **In other words, that any programmatic strategy would consistently produce attractive Sharpe ratios is evidence for a less economically sensitive user of volatility product**.

Exhibit 1: By some measures, systematically short volatility strategies in interest rates rival those in equity and credit options markets

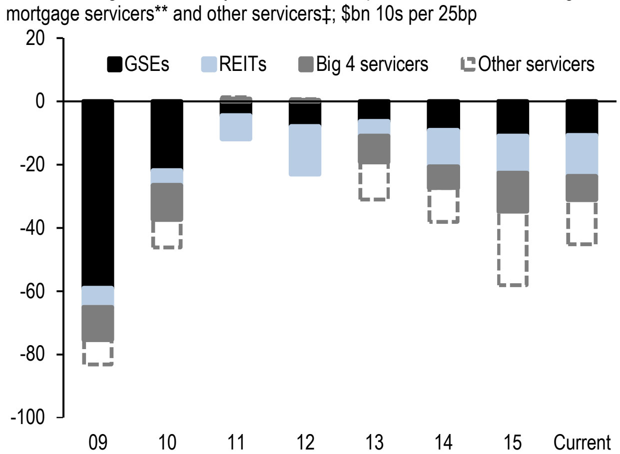
5-year median divided by inter-quartile range of monthly total returns from systematic short gamma strategies in interest rate*, FX†, equity** and credit‡ markets by currency; unitless

	Macro Product		Risky Assets	
Currency	Rates	FX	Equities	Credit
USD	0.39	na	0.33	0.39
EUR	0.44	-0.11	0.05	0.23
JPY	0.39	-0.10	0.23	na
GBP	0.27	-0.10	0.32	na

* Assumes daily sales of 1Mx10Y ATMF straddles with daily delta rebalancing, held to maturity.
† Also assumes daily sales of 1-month opitons with daily delta rebalancing, held to maturity.
** Taken from J.P. Morgan Nexus[SM] investable short volatility risk premia products for S&P500, E-Stoxx 50, FTSE 100 and Nikkei indices. Assumes daily delta rebalancing.
† Taken from J.P. Morgan investible credit indices for CDX.IG (USD) and iTraxx Main (EUR). Assumes daily delta rebalancing.
Source: J.P. Morgan, Bloomberg

Exhibit 2: The wind down of GSE retained portfolios has significantly reduced the bid for gamma, though servicers and REITs have picked up some of the slack

Estimated negative convexity of GSE retained portfolios*, REITs†, the big 4 mortgage servicers** and other servicers‡; $bn 10s per 25bp

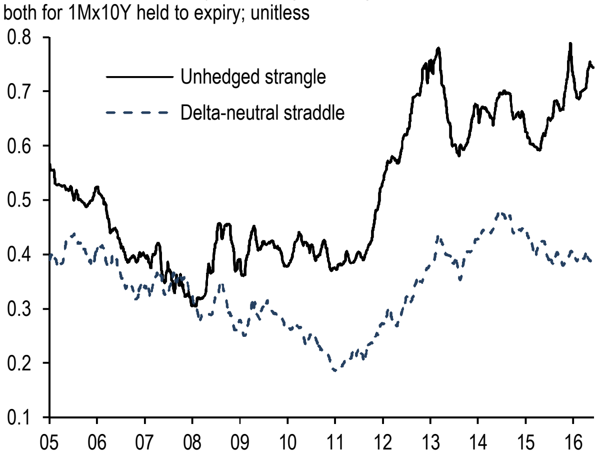


* To model GSE holdings, we assume a representative sample (i.e., the J.P. Morgan Agency MBS index) as of March 2009. We then calculate the change in notional balance assuming no reinvestment and fixed composition by coupon and vintage. If reported holdings are larger than passive paydown expectations in a given period, we assume that excess is invested in the largest production coupon at that time.
†Based on reported holdings, and assuming J.P. Morgan Agency MBS index options-adjusted convexity.
** We model servicing rights as a 30 bp IO strip off the J.P. Morgan Agency MBS Index. We use annual (through year-end 2015) Inside Mortgage Finance data to separate out the big 4 servicers (JPM, C, BAC, WFC) and others‡.
‡ Non-bank and smaller servicers are not usually as active in hedging their holdings as the big 4.
Source: J.P. Morgan, FNMA, FHLMC, REIT company filings, Inside Mortgage Finance

In risky assets, the structural richness of short-dated volatility can generally be attributed to a persistent bid for portfolio protection. Generally speaking, investors tend to be long equities and credit, and buy options to protect their downside. Though this is usually at least partially offset by covered call writing strategies, the bid for portfolio protection is generally the larger flow. One can see this in equity dealer positioning, which tends to be short gamma overall, with an

Exhibit 3: The divergence in risk-adjusted returns from selling unhedged strangles versus delta-neutral straddles suggests a shift in the balance of flows…

Rolling 5-year median divided by inter-quartile range of returns (a non-parametric "Sharpe" ratio*) for unhedged strangle versus delta-neutral straddle†, both for 1Mx10Y held to expiry; unitless



* We use a non-parametric formulation to compensate for the highly non-normal returns generated by systematic options trading strategies, which we discuss in more detail later in this publication.
Note: P/L assumes daily trades, held to expiry. Strangles are struck 25-delta, and straddles are ATMF. Straddle returns also assume daily delta rebalancing with zero transaction costs.
Source: J.P. Morgan

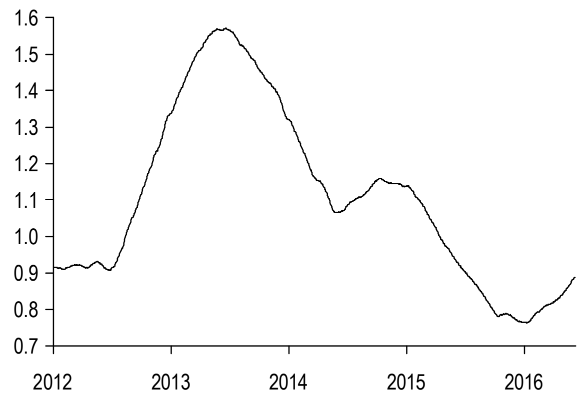
embedded skew position as well (short OTM puts versus calls). Anecdotally, the balance of flows is similar in credit markets in Europe and the U.S. as well. **Because these buyers are willing to pay up for limited downside on their hedges, risky asset vols tend to trade structurally rich**.

In U.S. rates, the story is a bit more complicated and dynamic. **One of the unique features of USD rates versus other currencies is the presence of a large fixed-rate mortgage backed securities (MBS) market**. A long position in MBS can be decomposed into three primary components: long duration from the fixed-rate payment schedule, short interest rate volatility from the prepayment option, and long the mortgage basis which compensates the investor for mortgage-specific risks (secondary and primary/secondary mortgage spreads, turnover prepayments, etc.). In the pre-crisis era, the GSE business model was to isolate the last component, hedging the duration using swaps and volatility using both short- and long-dated swaptions (e.g., 3Mx10Y, 3Yx10Y and 5Yx10Y) and monetize the option-adjusted spread. When their holdings were sufficiently large, these less economic buyers were significant enough to driver pricing in U.S. interest rate options markets—and arguably swaps as well.

More recently, however, the wind down of GSE retained portfolio has significantly reduced their role.

Exhibit 4: …in part reflecting greater jump risk premium in the wake of structural declines in market depth and more frequent discontinuous price action

Ratio of the 1- versus 5-year moving average of market depth* in 10-year Treasuries; unitless



* Market depth is defined as the average of the top 3 bid/ask size in hot-run 10-year Treasuries, averaged between 8:30am and 10:30am daily.
Source: J.P. Morgan, BrokerTec

That has been offset to some extent by mortgage servicers (particularly large banks) and REITs. However, generally speaking we estimate this underlying bid for gamma from mortgage hedgers is currently less than half of what it was in 2009, let alone the pre-crisis era when the GSEs in particular was substantially larger fraction of the mortgage market (**Exhibit 2**).

That said, and as noted above, the risk-adjusted returns on systematic short USD rates gamma strategies have remained attractive in recent years. To some extent, we believe this reflects a decent residual mortgage bid, particularly since the market has delivered negative convexity as rates recovered from the QE era (Exhibit 2). **Interestingly, however, even a cursory look at the performance of different structures suggests a shift in the underlying drivers of richness in short-dated options**. For example, in the pre-crisis period, selling unhedged 1Mx10Y strangles had a comparable Sharpe ratio to straddles with daily delta rebalancing; more recently, the former has improved substantially relative to the latter (**Exhibit 3**).

This can be interpreted as markets pricing in higher range volatility risk premium relative to daily volatility; by focusing on OTM strikes, we are systematically selling this risk premium. Why would markets price in structurally rich tails? **One possible explanation is the structural decline in liquidity that has occurred in recent years owing to changes in market structure (Exhibit 4)**. We can see this empirically, for example in the increasing sensitivity of

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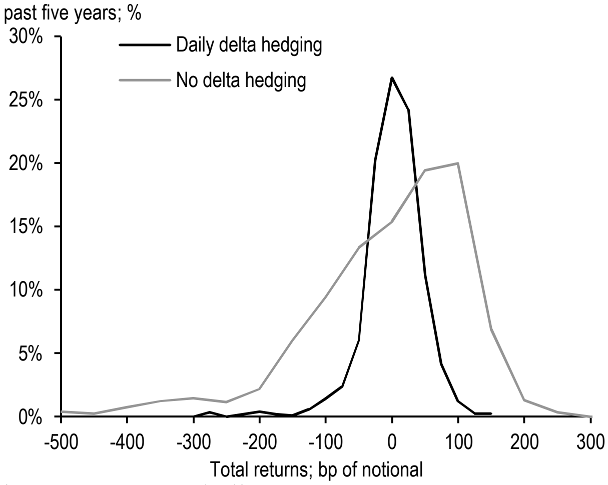
Exhibit 5: Returns from systematic options-based trading strategies are highly non-normal, with limited upside and fat tails from non-linear downside…

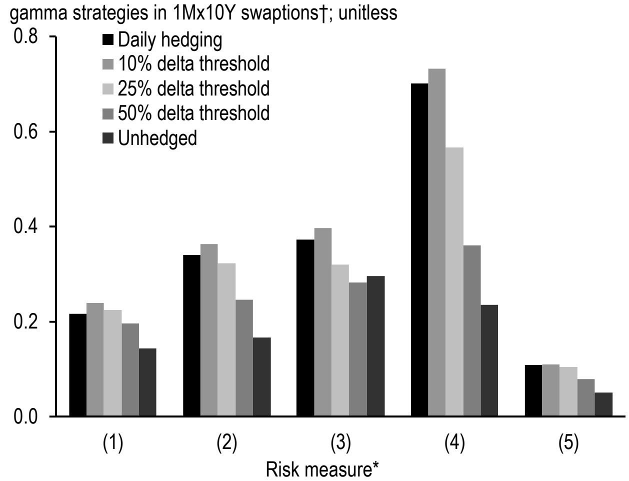
Distribution of total returns for two systematic short gamma strategies* over the past five years; %



* Trades are initiated daily in 1Mx10Y ATMF swaption straddles and held to expiry. Delta hedges are rebalanced daliy and we ignore transaction costs.
Source: J.P. Morgan

Exhibit 6: …and we recommend focusing on non-parametric risk measures, though each has its own advantages and disadvantages

Various risk measures for 5-year total returns from several systematic short gamma strategies in 1Mx10Y swaptions†; unitless



* Sharpe ratio (1) is average divded by standard deviation of returns, and Sortino ratio (2) is averaged returns divded by standard deviation of losses. Median versus inter-quartile range (3) and median returns versus median losses (4) are non-parametricSharp and Sterling ratios, and returns versus 5th percentile (5) as expected returns versus downside risk.
† Assumes daily trades (1Mx10Y straddles), held to expiry with delta rebalancing either daily or based on a threshold rule as indicated.
Source: J.P. Morgan

short-dated volatility to changes in market depth (for details, see Interest Rate Derivatives, *US Fixed Income Markets Weekly*, 5/13/16). There is also clearly the legacy of extreme volatility events of which the most famous example remains October 15, 2014, though the price impact is somewhat more difficult to quantify (for a more in-depth discussion, see *Anatomy of a flash rally*, J. Younger & J. Barry, 2/25/16).

Benchmarking risk-adjusted returns in options markets

In order to evaluate the risk-adjusted returns from different variants of short gamma programs in interest rates, we simulate the P/L for a range of strategies using historical pricing data (including full skew information). Generally speaking, we consider independent daily trades involving the sale of 1-month options[1] each day as of pit close (3:00pm New York time) and held to maturity. Delta hedges, where applicable, are also applied as of the close, and are rebalanced using either a frequency (i.e., daily) or threshold (i.e., when the absolute value of fractional delta of a given position exceeds a given value) rule. For strangles in particular, the payer and receiver deltas are managed separately, and we assume no delta hedge as of trade initiation. Transaction costs are included in the simulated P/L where indicated, and we assume a constant 0.2 bp of yield on each side of the market in all cases.

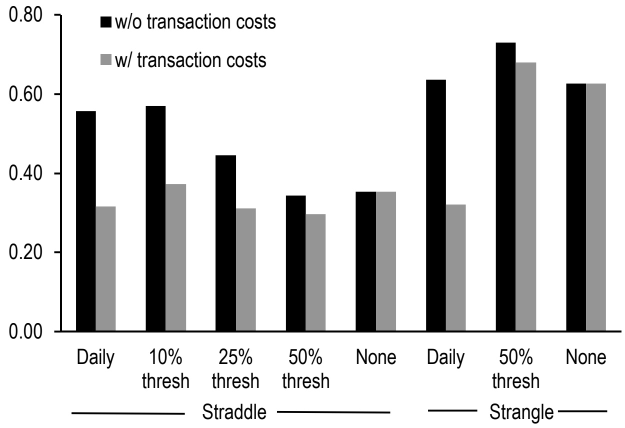
More important is the question of how to properly benchmark risk-adjusted returns. Though in many markets it is appropriate to simply use normal information ratios, the highly non-normal nature of returns from short volatility strategies complicated matters. In other words, returns from systematically selling options are both highly skewed—from limited upside—and have fat tails from non-linear downside, both for outright and actively delta-hedged positions (**Exhibit 5**). **In principle we have many alternatives, including but not limited to:**

1. **Normal Sharpe ratios**: mean returns versus the standard deviation of returns
2. **Normal Sortino ratios**: mean returns versus the standard deviation of losses
3. **A non-parametric "Sharpe" ratio**: median versus inter-quartile range of returns
4. **A non-parametric "Sterling" ratio**: median returns versus median losses
5. **Drawdown ratio**: median returns versus outlier downside (e.g., 5th percentile)

[1] In principle, one could consider 3-month or even longer-dated options. We have chosen 1Mx10Y for simplicity, and also because a 1-month horizon to expiry is more manageable in practice than longer periods.

Exhibit 7: Occasional delta rebalancing can improve risk-adjusted returns, but the benefits of very frequent hedging are more than offset by transaction costs

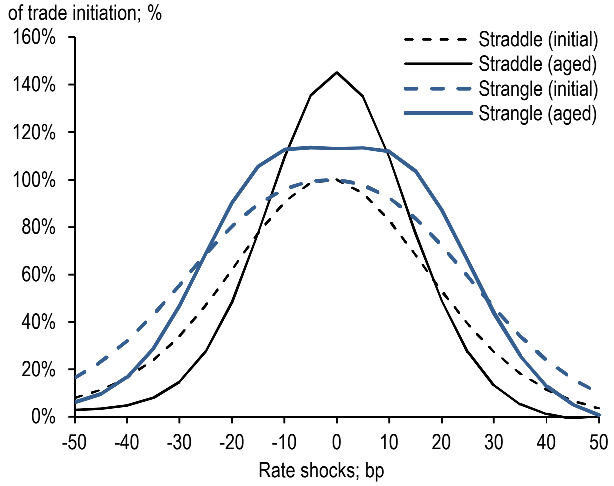
5-year risk-adjusted* returns for various systematic short gamma strategies† and delta management rules, both including and excluding indicative transaction costs; unitless



* The straight average of non-parametric Sharpe, Sterling and drawdown ratios. Details in Exhibit 6.
† Straddles struck ATMF at intiiation, and strangles are 25% fractional delta on the payer and receiver leg. We manage each leg independantly for the strangle strategy, and as a package for straddles. Transaction costs assume 0.2 bp of yield for each rebalancing.
Source: J.P. Morgan

Exhibit 8: Strangles tend to maintain their gamma under rate shocks better than straddles…

Gamma for 1Mx10Y ATMF straddles and a gamma-neutral amount of 25-delta strangles under rate shocks, initial and aged by two weeks, and set to 100% as of trade initiation; %



Source: J.P. Morgan

Using daily delta-hedge straddles as an example, these metrics can be quite different optically, but on the whole high-level trends tend to be consistent across risk measures (**Exhibit 5**). However, for the purposes of this analysis, we use a straight average of (3), (4) and (5) as a benchmark. This both addresses issues of skewness and non-Gaussian behavior in the distribution of returns by avoiding normal statistics, and compares expected returns to the range of likely outcomes, expected losses, and tail risk. **In this way, we believe such a combined metric offers a more holistic view of risk than any individual ratio of moments**.

Optimal structures and risk management

Given a framework for benchmarking risk-adjusted returns, we now turn to the operative question for options traders: what specific strategies are most attractive? As noted earlier, selling unhedged strangles has outperformed delta-neutral straddles in recent years. However, active risk management can potentially result in a significantly different distribution of returns. Therefore, in this section we consider the impact of different rules for active delta and gamma management for both structures.

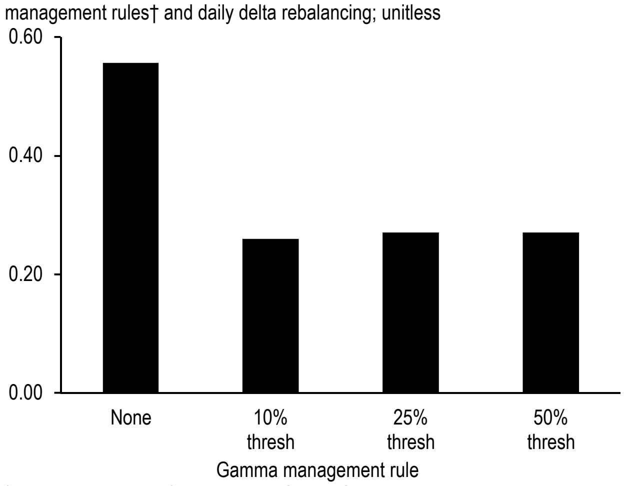
First, we turn to delta. Specifically, we consider several thresholds in addition to daily rebalancing and unhedged positions (10%, 25% and 50%; **Exhibit 7**). As noted above, for strangles these thresholds are tracked for each leg independently and assuming no initial delta hedge. Before considering transaction costs, it appears that risk-adjusted returns with tight delta limits on straddles are comparable (though modestly lower) to strangles. However, incorporating typical bid/offer spreads for delta rebalancing essentially negates this benefit, with risk-adjusted returns net of these costs for daily rebalancing close to or below results from less frequent hedging. **From this we can conclude that while very active delta hedging clearly reduces the variance of returns relative to the mean/median, the benefits are more than offset by the transaction costs required to implement such a strategy**[2].

That said, in principle the difference in risk-adjusted returns between strangles and straddles could be more a function of risk management than fundamental richness. This is because the former tend to retain more of their initial short gamma exposure under a range of rate shocks, particularly as the position ages (**Exhibit 8**). As a result, it is interesting to consider whether using selective re-strikes to target more constant gamma risk over the holding period could be used to improve risk-adjusted returns for straddles relative to

[2] As an important caveat, we assume 0.2 bp from bid to mid or ask to mid. If investors believe they can consistently achieve tighter pricing, then the negative impact of transaction costs will be commensurately lesser.

Exhibit 9: …but gamma risk-targeting via re-striking straddles does not improve risk-adjusted returns

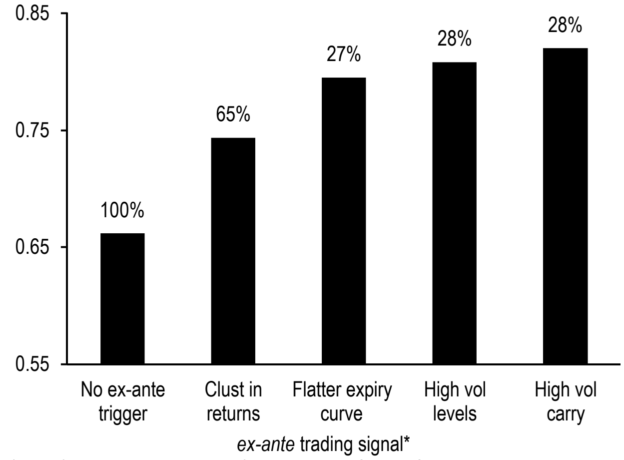
5-year risk-adjusted* returns for ATMF short straddles with different gamma management rules† and daily delta rebalancing; unitless



* The straight average of non-parametric Sharpe, Sterling and returns versus downside ratios. Details in Exhibit 6.
† We assume the straddles are re-struck to the current ATMF if the total gamma falls below a given threshold over the holding period, with the notional also scaled to match the initate gamma of the position.
Source: J.P. Morgan

Exhibit 10: A variety of *ex-ante* trading signals result in higher risk-adjusted returns

5-year risk-adjusted* returns (net of transaction costs) for 25-delta 1Mx10Y strangles with a 50% delta rebalancing threshold using several† *ex-ante* trading signals, % of days with "on" signal as indicated; unitless



* As before, we use the average of non-parametric Sharpe, Sterling, and drawdown ratios. Details in Exhibit 6. We assume 0.2 bp bid to mid for delta rebalancing.
† We consider a range of possible signals, each of which is used as an "on/off" trigger, meaning we only sell strangles when a single factor exceeds a particular threshold. The *ex-ante* trading signals are as follows: (1) for volatility returns clustering, we only sell if a comparable trade initiated one month prior (i.e., most recent that has since expired) was profitable; (2) for expiry curve, we require the *ex-ante* 1Mx10Y minus 3Mx10Y ATMF implied volatility spread be greater than zero; (3) for vol level, we require the *ex-ante* 1-year trailing Z-score be greater than 0.5; and (4) for vol carry, we require *ex-ante* 1Mx10Y ATMF implied divded by 1-month trailing realized volatillity be greater than 1.2x.
Note: We also indicate the frequency with which one trades using each rule.
Source: J.P. Morgan

strangles. To do so, we perform an additional set of historical simulations assuming the options are re-struck, keeping the expiry and maturity constant, if the gamma falls below a given threshold relative to the initial exposure (e.g., 10% or 20%). The notional balance of the new position is also re-sized such that the new structure has the same gamma as the initial position.

The results, combined with daily delta hedging and excluding transaction costs are summarized in **Exhibit 9**. **We find that gamma risk targeting actually reduces risk-adjusted returns, even excluding transaction costs**. This makes sense, in that this rebalancing tends to happen when delivered moves are large; under those circumstances, a rebalancing rule could result in straddles getting shorter gamma at very inopportune times.

Using *ex-ante* trading signals to boost returns

In addition to testing for the best structure and risk management strategy, we can also ask whether *ex-ante* information can be incorporated into short gamma programs to increase risk-adjusted returns. Clearly, this is an expansive question, with a massive space of possible combinations to explore. Rather that conducting such an exhaustive search, we concentrate on a few intuitive "on/off" trading signals, focusing on the most promising structure from purely systematic testing; i.e., we choose whether or not to sell 25-delta strangles (50% delta threshold) based on a handful of simple criteria. Specifically, we consider:

1. **Clustering in volatility returns**: sell if the most recent completed short vol trade was profitable
2. **Vol carry**: sell if *ex-ante* implied versus 1-month trailing realized volatility is > 1.2x
3. **Vol level**: sell if the *ex-ante* Z-score of 1Mx10Y implied volatility is > 0.5 standard deviations
4. **Expiry curve**: sell if the *ex-ante* slope of the 1M/3M expiry curve is > 0 bp/day

The results are presented in **Exhibit 10**. **While we find each of these trading signals increases the risk-adjusted returns, with high implied-to-realized vol ratio delivering the greatest benefit**.

Conclusions and future work

In this piece, we consider the potential for short gamma programs in U.S. interest rate options to generate market-neutral P/L. Over the past five years,

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systematically selling 1Mx10Y USD swaptions has produced risk-adjusted returns comparable to options on risk assets. **Though the mortgage bid that initially supported USD swaption vols is now substantially smaller than it was in the pre-crisis era, vols remain structurally rich in part owing to higher jump risk and fatter tails amidst a liquidity-challenged environment**.

Specifically, we backtest several structures and rules-based risk management strategies over the past five years. In terms of benchmarking returns, we argue for a non-parametric approach to capture the non-normal aspects of the distribution, and specifically advocate an average of percentile-based Sharpe, Sterling, and drawdown ratios. **Using this metric, we find that selling strangles is generally more attractive than straddles**. Further, while delta rebalancing generally improves risk-adjusted returns, the costs of doing so very actively are prohibitive; implementing a simple 50% threshold is optimal based on our simulation. Gamma risk targeting, on the other hand, generally results in lower risk-adjusted returns. **Finally, we find that a range of *ex-ante* trading signals improve the P/L distribution—including clustering, level, expiry curve slope and vol carry**.

Clearly, the story is far from over. This work is intended as a proof of concept to investigate the high level drivers of systematic short gamma returns. In particular, there is much work yet to be done on trading signals, including fair value modeling, potential spillover effects from other markets (e.g., vol spikes in equities transferred to rates with a lag, or vice versa), more precise mean reversion and other technical indicators, long vol signals, and so on. One could also consider a number of other wrinkles, including other risk targeting rules, expiry curve or tail switches, more high-frequency delta hedging using intraday data, and so on. **In the interests of brevity, we leave this for future work, and conclude that short gamma programs in the U.S. still show promise. In particular, we recommend focusing on strangles and otherwise OTM strikes and incorporating some delta management and information from trailing implied/realized ratios with a sufficiently high threshold**.

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