Systematic Vol Investing

Equity and Rates | January 2025

Systematic Cross-Asset Strategies
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J.P. Morgan Global Quantitative and Derivative Strategy Research Teams

Top Rankings in Institutional Investor Surveys

United States

Cross-Asset Systematic Strategies:

- Thomas Salopek

Quantitative Equity Research:

- Narendra Singh
- Arun Jain

Equity Derivatives Strategy:

- Bram Kaplan
- Min Moon

ML/Big Data

- Emma Wu

Europe

Cross-Asset Systematic Strategies:

- Dobromir Tzotchev
- Erik Rubingh
- Olivier Daviaud

Quantitative Equity Research:

- Khuram Chaudhry
- Ayub Hanif
- William Summer

Equity Derivatives Strategy:

- Davide Silvestrini
- Yangyang Hou
- Esmail Afsah
- Pankaj Gupta

Asia Pacific

Quantitative Equity Research&ML:

- Robert Smith
- Berowne Hlavaty
- Evan Hu

Equity Derivatives Strategy:

- Tony Lee
- Haoshun Liu
- Masanari Takada

Top Rankings in Institutional Investor Surveys

1. Institutional Investor Global Research Firm **2022**
1. Institutional Investor Global Equity Research Team **2022**
1. Institutional Investor Global Fixed Income Research Team **2022**
2. Institutional Investor All-America Research Team **2023**
3. Institutional Investor All-Europe Equity Research Team **2023**
1. Institutional Investor Emerging EMEA Equity Research Team **2023**
3. Institutional Investor Latin America Equity Research Team **2023**
3. Institutional Investor All-Asia Equity Research Team **2023**
3. Peter Lee Associates Australia Equity Research Firm **2022**

220+ Publishing Analysts

3,900+ Companies Covered

100+ Investor Conferences

Geographies

Americas : **1610+** Companies covered
- North America: **1350+**
- Latin America: **260+**

Asia Pacific: **1500+** Companies covered
- Asia-Ex: **1020+**
- Australia: **170+**
- Japan: **310+**

EMEA: **780+** Companies covered
- CEEMEA: **130+**
- Europe: **450+**
- UK: **200+**

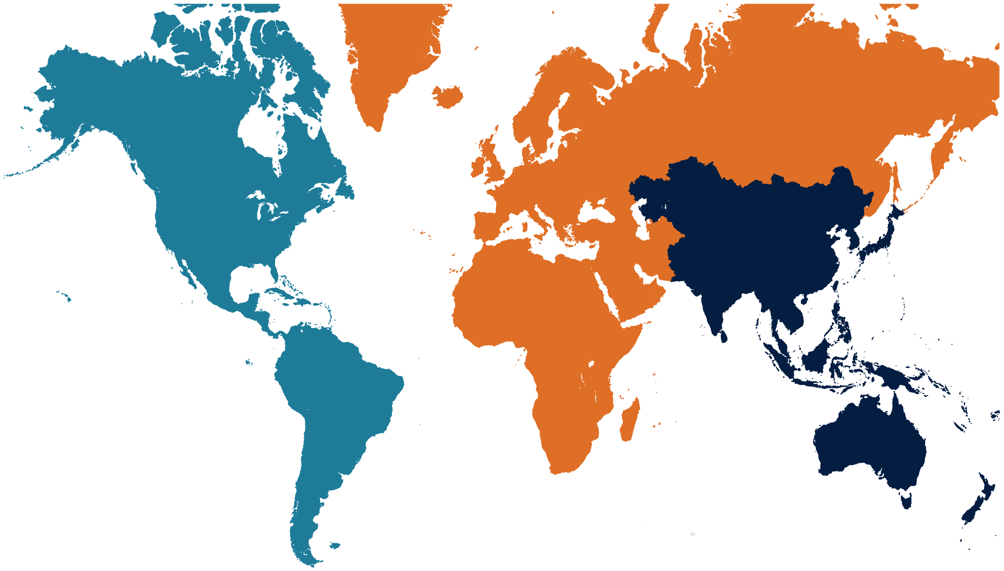
Global Cross Asset Research

Commodities	FX
Credit	Index
Derivatives	Public Finance
Economics	Quant
Emerging Markets	Rates
Equities	Securitised Products
ESG & Sustainability	Strategy

1 — 2023 — **II All-America Quantitative Research**

3 — 2023 — **II Developed Europe Quantitative/Database Analysis**

3 — 2023 — **II Global Fixed-Income – Dev Europe Quantitative Analysis**



2 — 2023 — **II Global Fixed-Income – USA Quantitative Analysis**

5 — 2023 — **II Asia (ex-Japan) Quantitative Research**

5 — 2023 — **II Japan Quantitative Research**

Data as at 1 November 2023

Our team: JP Morgan Systematic Cross-Asset Strategies

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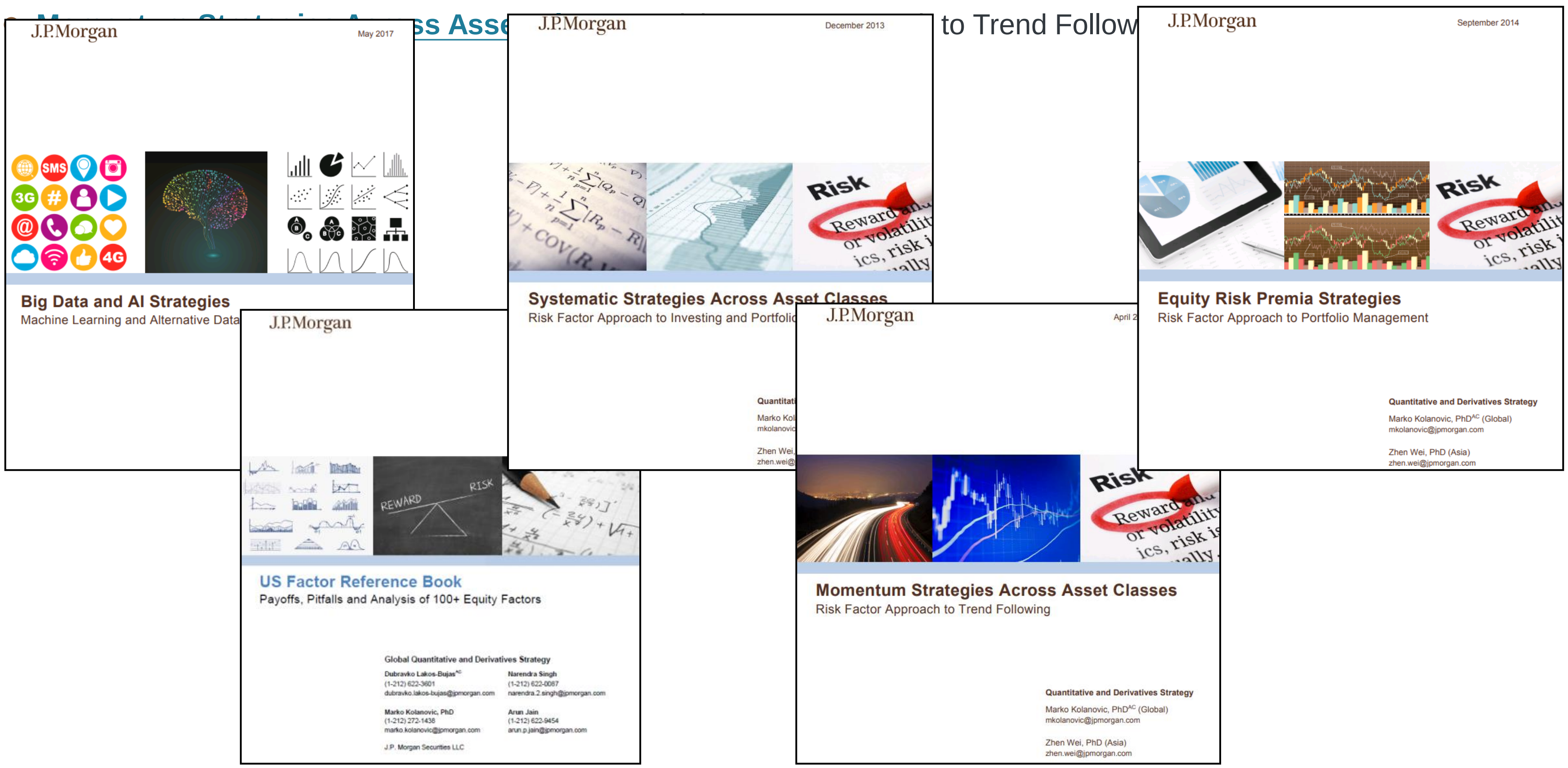
J.P. Morgan Cross Asset Risk Premia

Primers

- Big Data and AI Strategies: Machine Learning and Alternative Data Approach to Investing
- US Factor Reference Book: Payoffs, Pitfalls and Analysis of 100+ Equity Factors
- Systematic Strategies Across Asset Classes: Risk Factor Approach to Investing and Portfolio Management
- Equity Risk Premia Strategies: Risk Factor Approach to Portfolio Management
- … ss Asse … to Trend Follow …



Thematic Reports on Cross Asset Risk Premia Strategies

Systematic Strategies

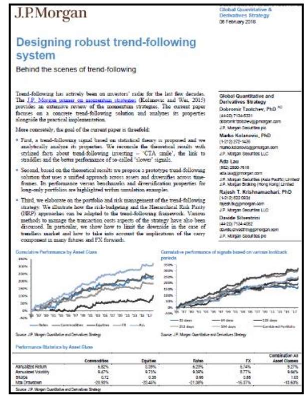
- Designing robust trend-following system
- Market-neutral carry strategies
- Defensive risk premia
- Pure equity factors
- Rates value strategies
- Profiting from positioning dynamics
- Basis Momentum
- The information gist of overnight trading
- Trading vol-of-vol and skew risk premiums
- How close to realized should implied vol trade?

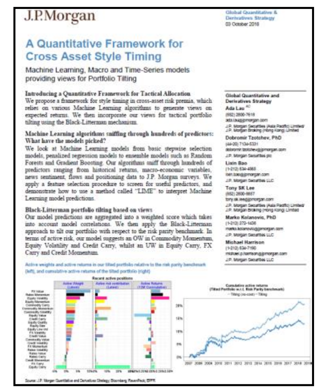
Portfolio Construction / Allocation Strategies

- A Quantitative Framework for Cross Asset Style Timing
- Modelling of 3Y to 5Y expected returns – Bayesian vs Traditional
- Can you time your optimization technique?

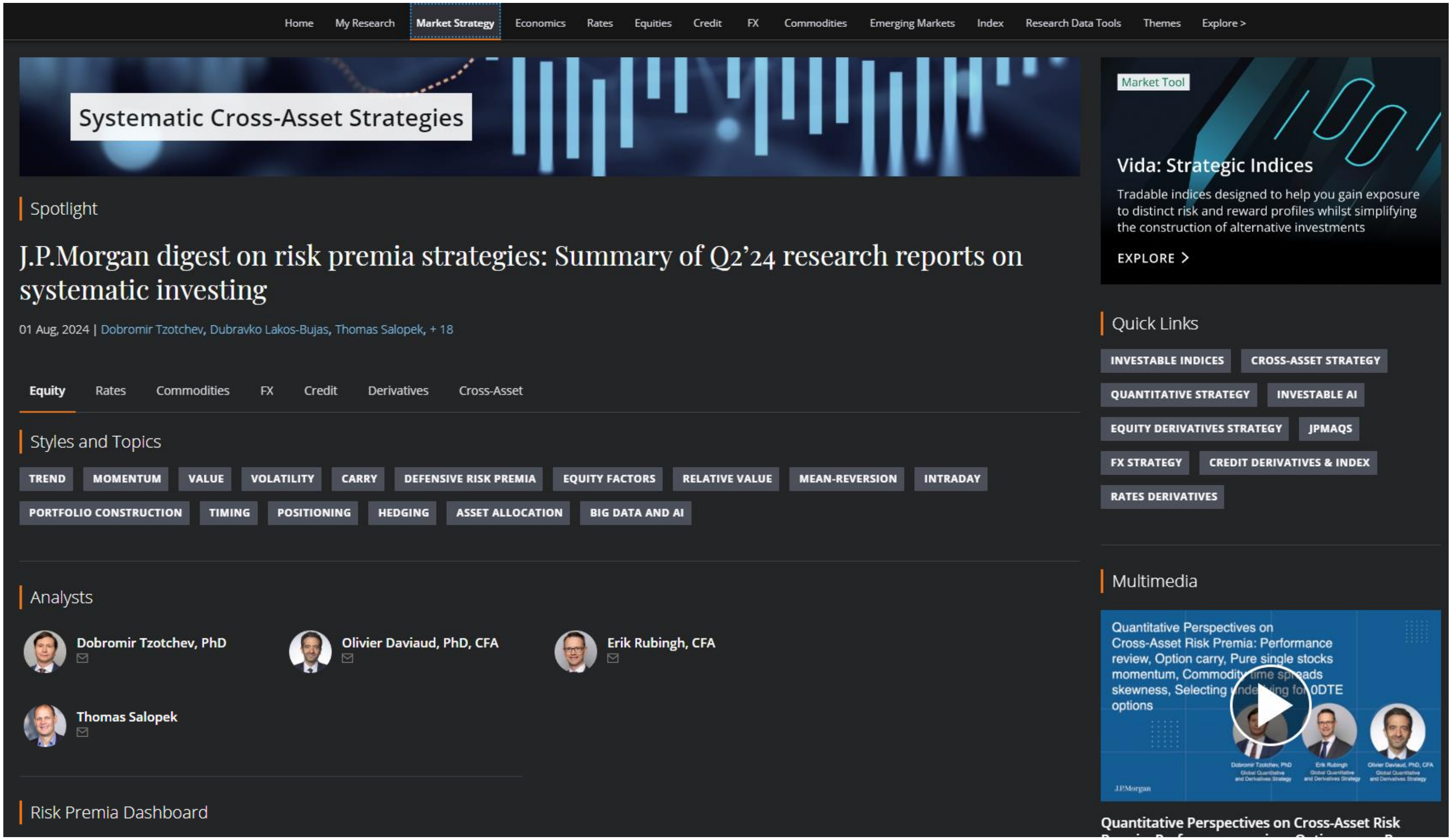
Periodic updates / Monitors

- **Monthly publications**: *Quantitative Perspectives on Cross-Asset Risk Premia, Risk Premia Highlights*
- **Quarterly publication**: *J.P. Morgan digest on risk premia strategies*





https://jpmm.com/#research.strategy.rbi



Agenda

Rethinking P&L attribution for options

P&L attribution: the standard approach (in plain English)

$$
\begin{aligned}
&\text{P\&L of a delta hedged option over } [0,t] = \\
&\qquad \sum \text{Theta P\&L} + \sum \text{Gamma P\&L} + \sum \text{Vega P\&L} \\
&\qquad\qquad + \sum \text{Vanna P\&L} + \sum \text{Volga P\&L}
\end{aligned}
$$

P&L attribution: the standard approach (in formulaic form)

Gamma+Theta term

Vega term

Volga term

$$\mathrm{P\&L}_{[0,t]} = \int_0^t \frac{1}{2} F_s^2 \frac{\partial^2 Q}{\partial F^2} \left(\sigma_s^2 ds - \hat{\sigma}_s^2 ds\right) + \int_0^t \frac{\partial Q}{\partial \hat{\sigma}} d\hat{\sigma}_s + \int_0^t \frac{\partial^2 Q}{\partial F \partial \hat{\sigma}} d\langle F_s, \hat{\sigma}_s \rangle + \int_0^t \frac{\partial^2 Q}{\partial \hat{\sigma}^2} d\langle \hat{\sigma} \rangle_s$$

Instantaneous variance minus (square) live implied vol

Vanna term

Q: Black Scholes price, ***F***: future's price, $\boldsymbol{\sigma}$: instantaneous realized volatility, $\hat{\boldsymbol{\sigma}}$: implied volatility, **‹,›**: quadratic variations

Caveats and limitations

- **Overlap between the components:** the vega term and the gamma + theta term are interconnected.
- **No relationship between P&L and vol premium:** eg if vol realizes 1pt below the implied I sold at inception, how much profit does my delta hedged option make?
- **No insight into impact of implied vol's path on P&L** when you hold to maturity.
- **No insight into option carry** (even approximately)

In a way, this is not a surprise: that formula is primarily a tool to hedge exotic options. It is not meant as a guide to investing.

When delta hedging with inception implied vol, there's a formula:

$$P\&L_{[0,t]} = \int_0^t \Gamma_s^* (\sigma_s^2 - \hat{\sigma_0}^2) ds + e^{-rt} \left(\mathrm{PV}_{\hat{\sigma_t}}(t) - \mathrm{PV}_{\hat{\sigma_0}}(t) \right)$$

where

- $\Gamma^* := e^{-rt} F^2 \partial^2 Q / \partial F^2$ is the discounted dollar gamma
- $\hat{\sigma}$ is the implied vol for strike K, and σ is the instantaneous realised volatility.
- $\mathrm{PV}_{\hat{\sigma}}(t)$ is the Black-Scholes price of the option at time t using implied vol $\hat{\sigma}$

If with delta hedge with market implied vol instead, it becomes:

$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}} \\
& + \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]
\end{aligned}
$$

where

- $\Gamma^* := e^{-rt}F^2\partial^2 Q/\partial F^2$ is the discounted dollar gamma
- $\hat{\sigma}$ is the implied vol for strike K, and σ is the instantaneous realised volatility.
- $\bar{(.)}$ and Cov(.) are respectively the sample average and sample covariance of any function between 0 and t:

$$\bar{f} := \frac{1}{t}\int_0^t f(u)du, \quad \mathrm{Cov}(f,g) := \sqrt{\frac{1}{t}\int_0^t (f(u)-\bar{f})(g(u)-\bar{g})du}.$$

Let’s review these components:

- **Volatility premium component:** a function of how much variance has been realized, vs the implied vol at inception.

$$P\&L_{[0,t]} = \Bigg[\boxed{\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}}$$

$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}$$

$$\overbrace{+ \int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]$$

Let's review these components:

- **Volatility premium component:** a function of how much variance has been realized, vs the implied vol at inception.

If we denote by σ_t^r the realized volatility:

$$\sigma_t^r := \sqrt{\frac{1}{t}\int_0^t \sigma_s^2 ds}$$

Then we can rewrite the vol premium component as:

$$\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Vol premium component}} = \overbrace{\frac{t\overline{\Gamma^*}}{2}(\sigma_t^r + \hat{\sigma}_0)}^{\text{Vol premium scaling factor}} \quad \underbrace{(\sigma_t^r - \hat{\sigma}_0)}_{\text{Vol premium}}$$

Let’s review these components:

- **Vega term:** Vega at the end of the holding period, multiplied by the change in implied vol since inception.
- Key feature: it vanishes at expiry (because vega vanishes at expiry)

$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}} \\
& + \boxed{\overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}}} + \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]
\end{aligned}
$$

Let's review these components:

- **Gamma covariance effect:** a corrective term for the volatility premium component, which accounts for the fact that gamma and instantaneous variance are typically correlated.

$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \boxed{\overbrace{\frac{t}{2}\operatorname{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}}} \\
& + \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2) d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]
\end{aligned}
$$

Let's review these components:

- **dGamma term** and **Residual drift terms:** empirically small

$$P\&L_{[0,t]} = \Bigg[\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}}$$

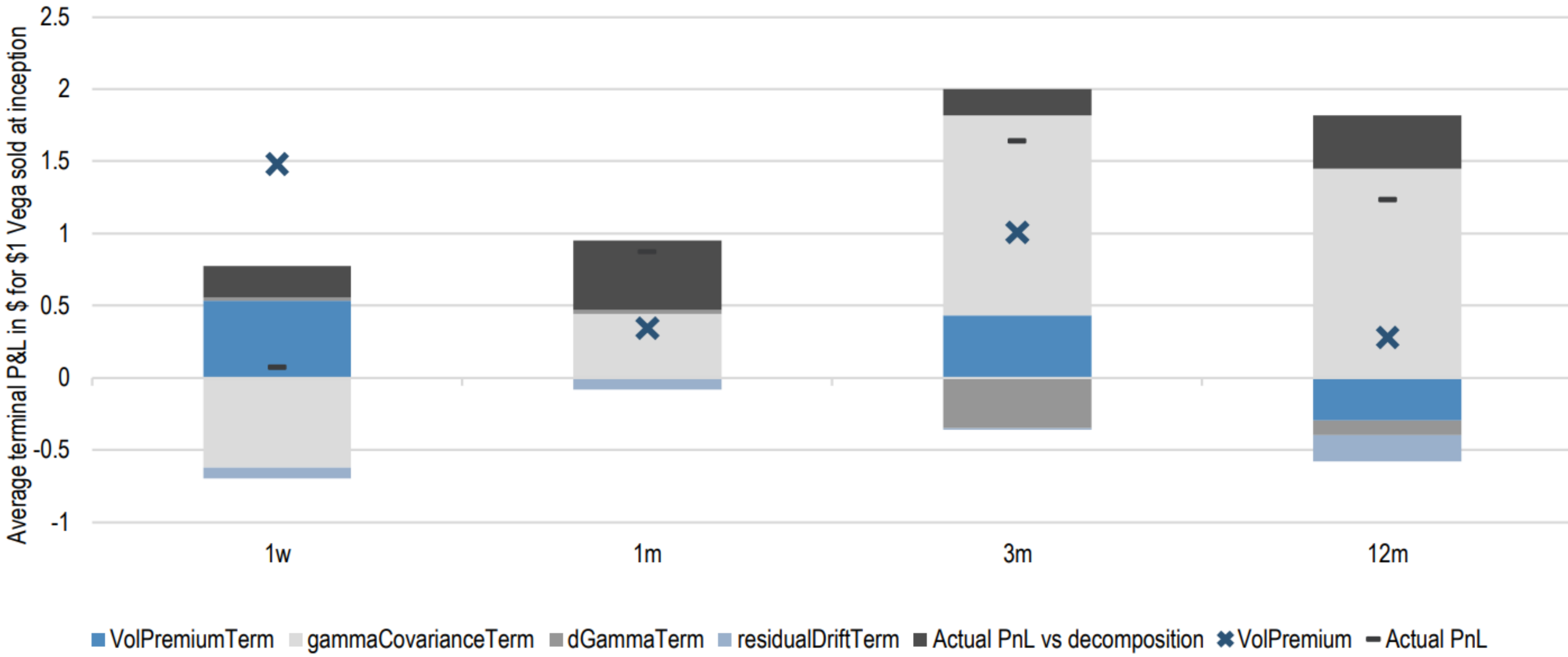
$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \boxed{\overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}} + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]}$$

Two of these terms have a straightforward meaning

- **Volatility premium component:** a function of how much variance has been realized, vs the implied vol at inception.
- **Vega term:** Vega at the end of the holding period, multiplied by the change in implied vol since inception.
- **dGamma term** and **Residual drift terms:** empirically small
- **Gamma covariance effect:** a corrective term for the volatility premium component, which accounts for the fact that gamma and instantaneous variance are typically correlated.

$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}} \\
& + \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]
\end{aligned}
$$

What these components look like for SPX



Source: J.P. Morgan Quantitative and Derivatives Strategy

$$P\&L_{[0,t]} = \Bigg[\overbrace{\frac{t\overline{\Gamma}^*}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}}$$

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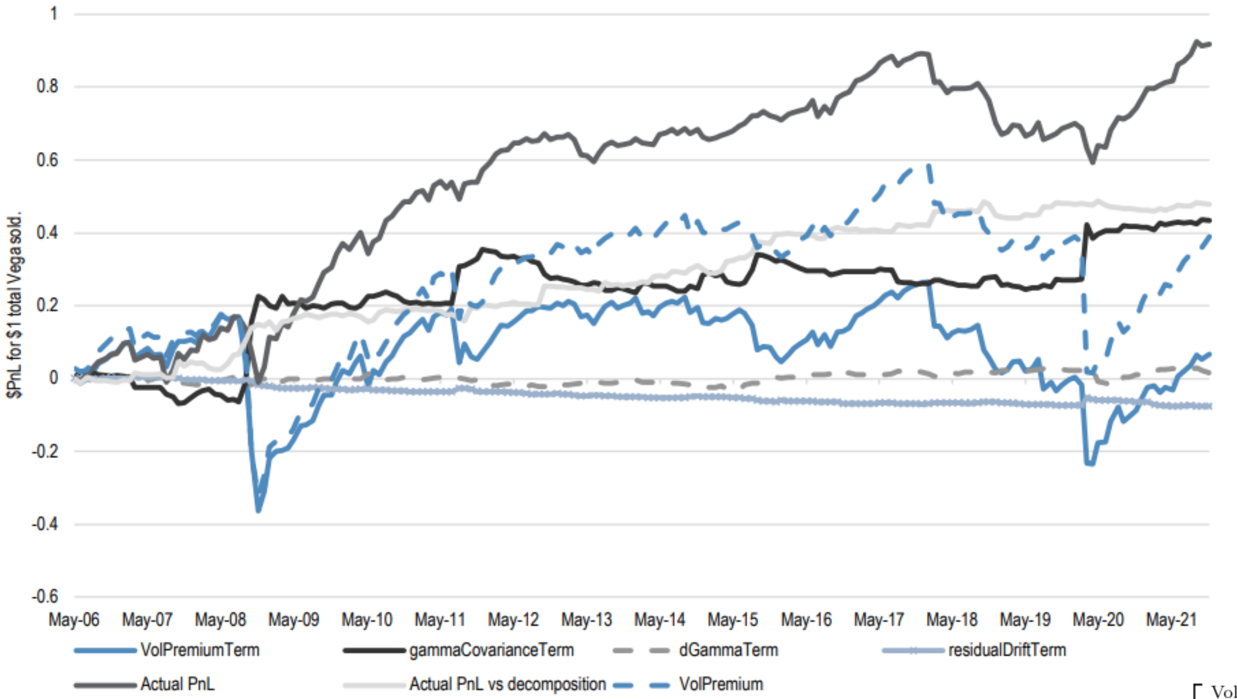
$$+ \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]$$

Looking under the hood, for the 1m tenor

Figure 1: Under the hood: historical contribution of the PnL components for vol sellers



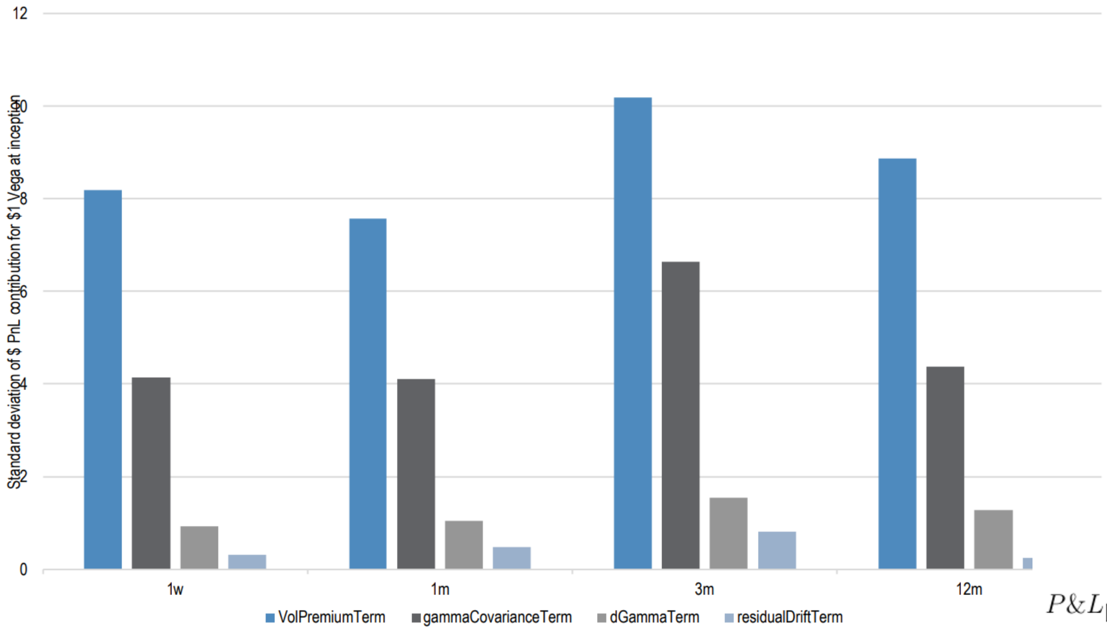
Source: J.P. Morgan Quantitative and Derivatives Strategy

$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}} \\
& + \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2) d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]
\end{aligned}
$$

The vol premium term is the most volatile component

Followed by the gamma covariance effect.

Figure 3: The volatility premium term and the covariance effect are the two most volatile contributors



Source: J.P. Morgan Quantitative and Derivatives Strategy

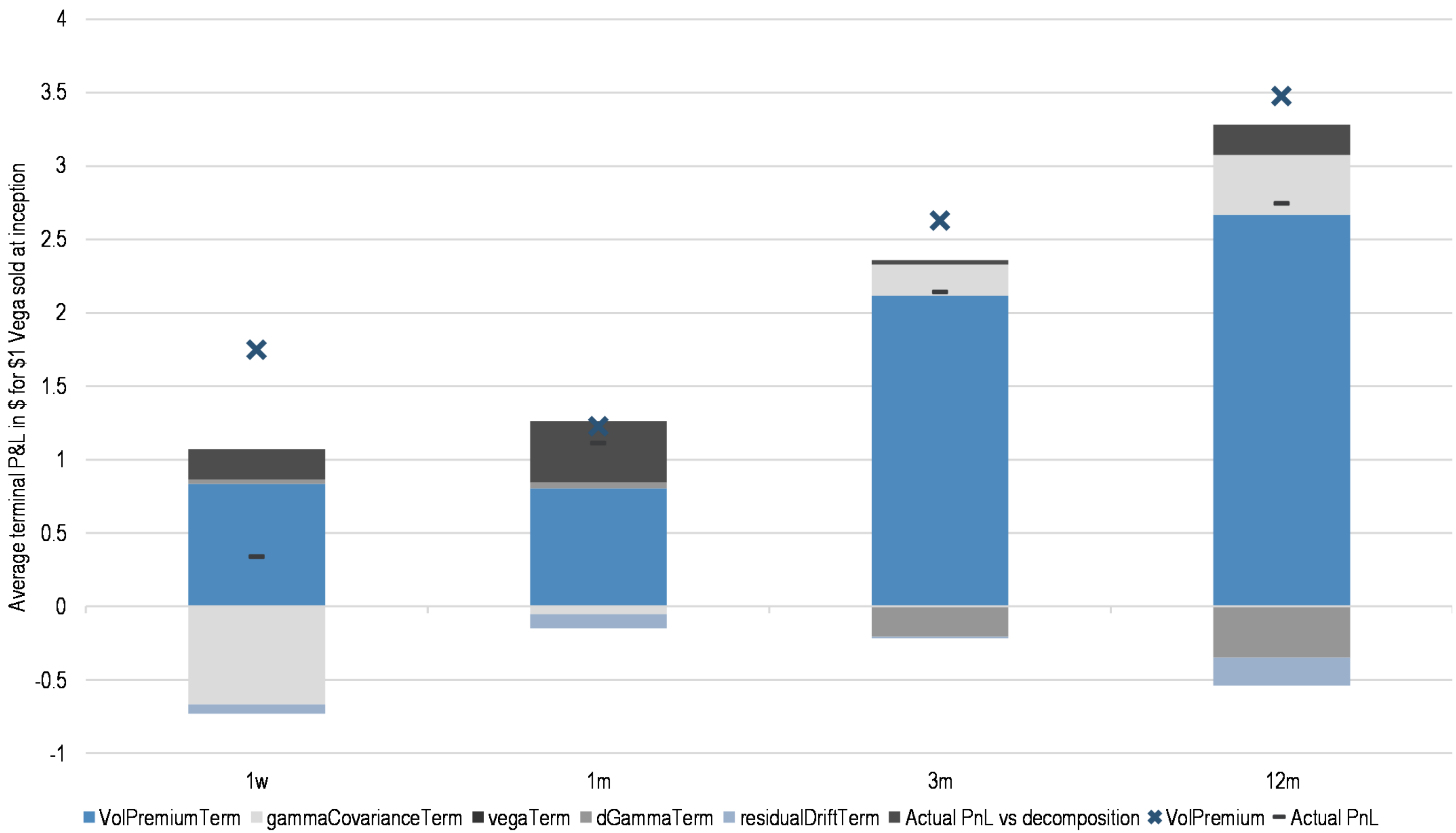
$$P\&L_{[0,t]} = \Bigg[\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)}^{\text{Gamma covariance effect}}$$

$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}$$

$$+ \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]$$

Vol premium term: the main P&L driver for ATM options if we exclude shocks

Average contribution if we exclude Fall '08, Summer '11, Feb '20:



The vol premium term is proportional to the vol premium

If we denote by σ_t^r the realized volatility:

$$\sigma_t^r := \sqrt{\frac{1}{t}\int_0^t \sigma_s^2 ds}$$

Then we can rewrite the vol premium component as:

$$\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Vol premium component}} = \overbrace{\frac{t\overline{\Gamma^*}}{2}(\sigma_t^r + \hat{\sigma}_0)}^{\text{Vol premium scaling factor}} \underbrace{(\sigma_t^r - \hat{\sigma}_0)}_{\text{Vol premium}}$$

How much P&L does 1 point of vol premium generate? (1/2)

Answer: Vega at t=0, on average.

$$\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Vol premium component}} = \overbrace{\frac{t\overline{\Gamma^*}}{2}(\sigma_t^r + \hat{\sigma}_0)}^{\text{Vol premium scaling factor}} \quad \underbrace{(\sigma_t^r - \hat{\sigma}_0)}_{\text{Vol premium}}$$

- **Empirical average around inception Vega:**

Table 1: Average Volatility Premium Scaling Factor (for Vega = $1 at t=0)

	1w	1m	3m	12m
Volatility Premium Scaling Factor ($)	0.94	1.03	1.01	1.01

Source: J.P. Morgan Quantitative and Derivatives Strategy

- **Low correlation with the vol premium (for intermediate tenors at least):**

Table 2: Average correlation between vol premium scaling factor and vol premium

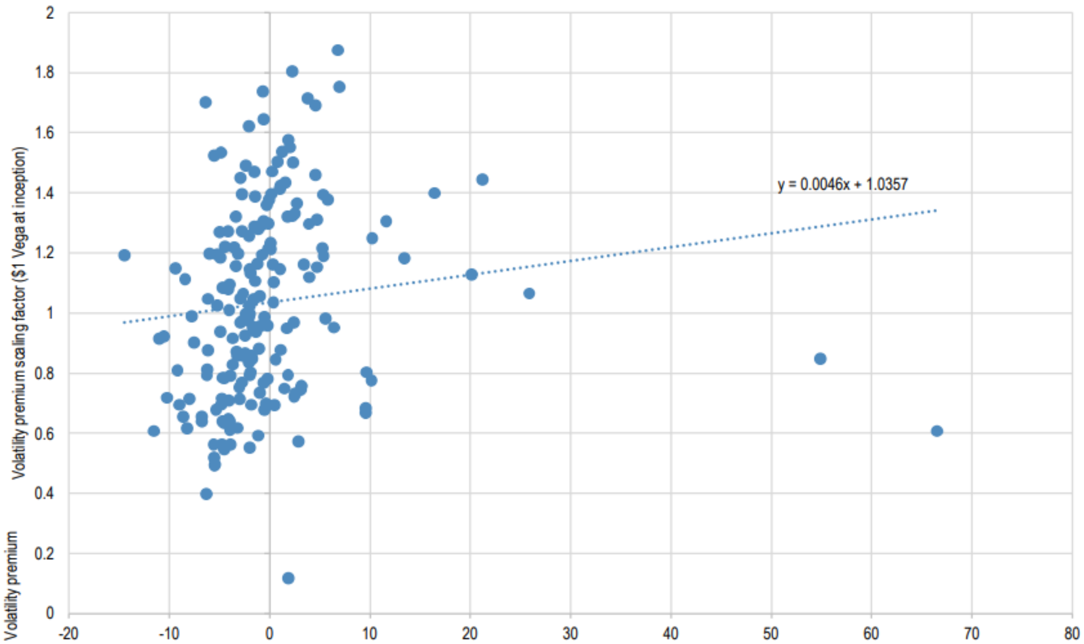
	1w	1m	3m	12m
Correl Vol Prem Scaling Factor/Vol Prem	-34%	-12%	-16%	-31%

Source: J.P. Morgan Quantitative and Derivatives Strategy

How much P&L does 1 point of vol premium generate? (2/2)

ATM options: by and large, low correlation between vol premium and scaling factor.

Figure 4: For the 1m tenor, vol premium and the volatility premium scaling factors aren't very correlated.



Source: J.P. Morgan Quantitative and Derivatives Strategy

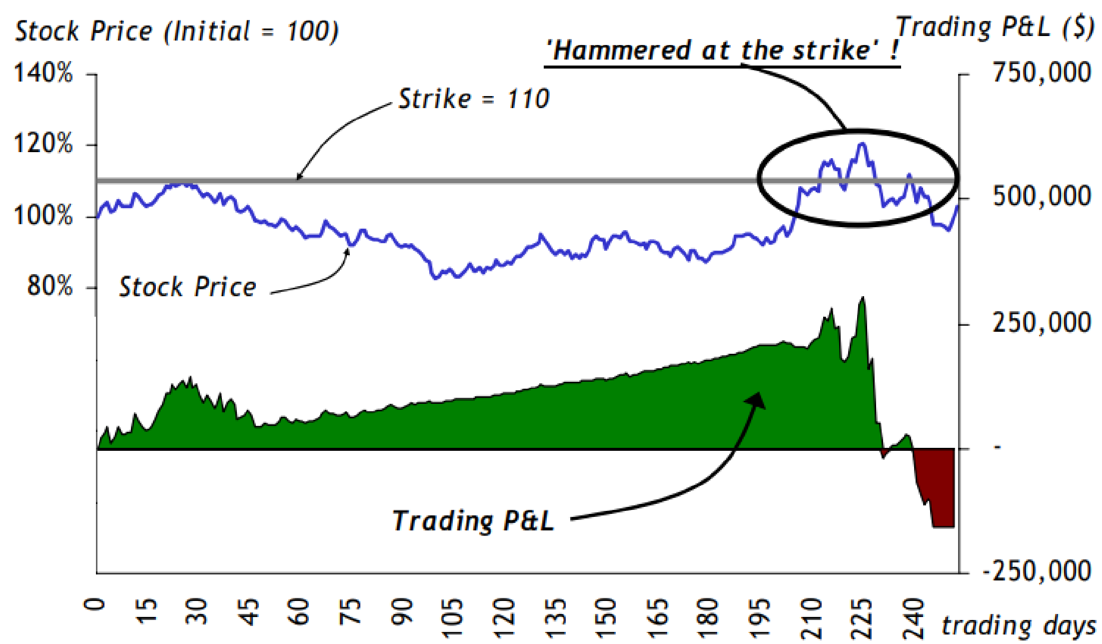
$$\overbrace{\frac{t\Gamma^*}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Vol premium component}} = \overbrace{\frac{t\Gamma^*}{2}(\sigma_t^r + \hat{\sigma}_0)}^{\text{Vol premium scaling factor}} \underbrace{(\sigma_t^r - \hat{\sigma}_0)}_{\text{Vol premium}}$$

The gamma covariance effect: the elephant in the room

Exhibit 2.1.1 — Path-dependency of an option's trading P&L

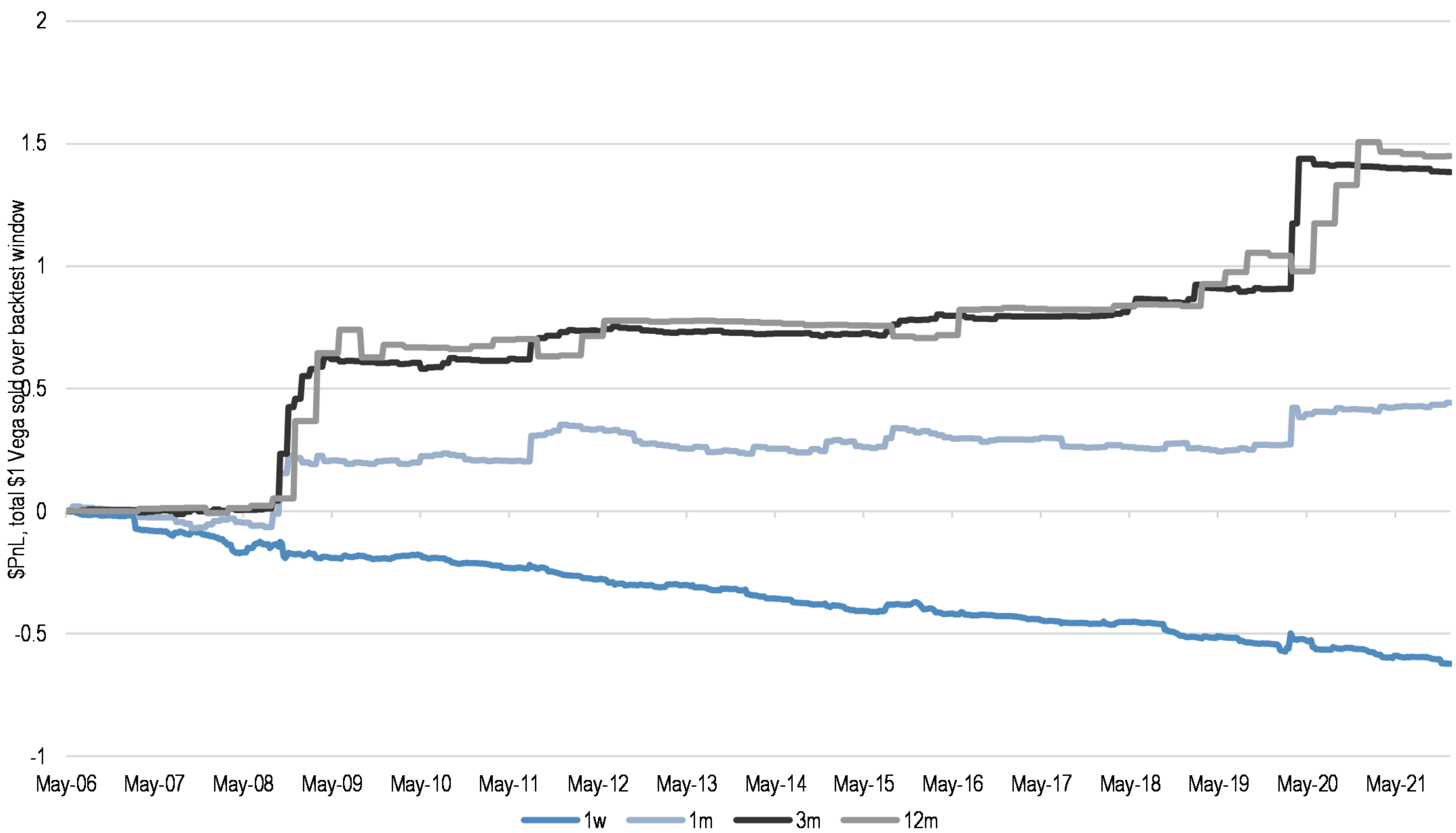
In this example an option trader sold a 1-year call struck at 110% of the initial price on a notional of $10,000,000 for an implied volatility of 30%, and delta-heged his position daily. The realized volatility was 27.50%, yet his final trading P&L is down $150k. Furthermore, we can see (Figure a) that the P&L was up $250k until a month before expiry: how did the profits change into losses? One indication is that the stock price oscillated around the strike in the final months (Figure a), triggering the dollar gamma to soar (Figure b.) This would be good news if the volatility of the underlying remained below 30% but unfortunately this period coincided with a change in the volatility regime from 20% to 40% (Figure b.) Because the daily P&L of an option position is weighted by the gamma and the volatility spread between implied and realized was negative, the final P&L drowned, even though the realized volatility over the year was below 30%!

a)



Source: J.P. Morgan Strategy

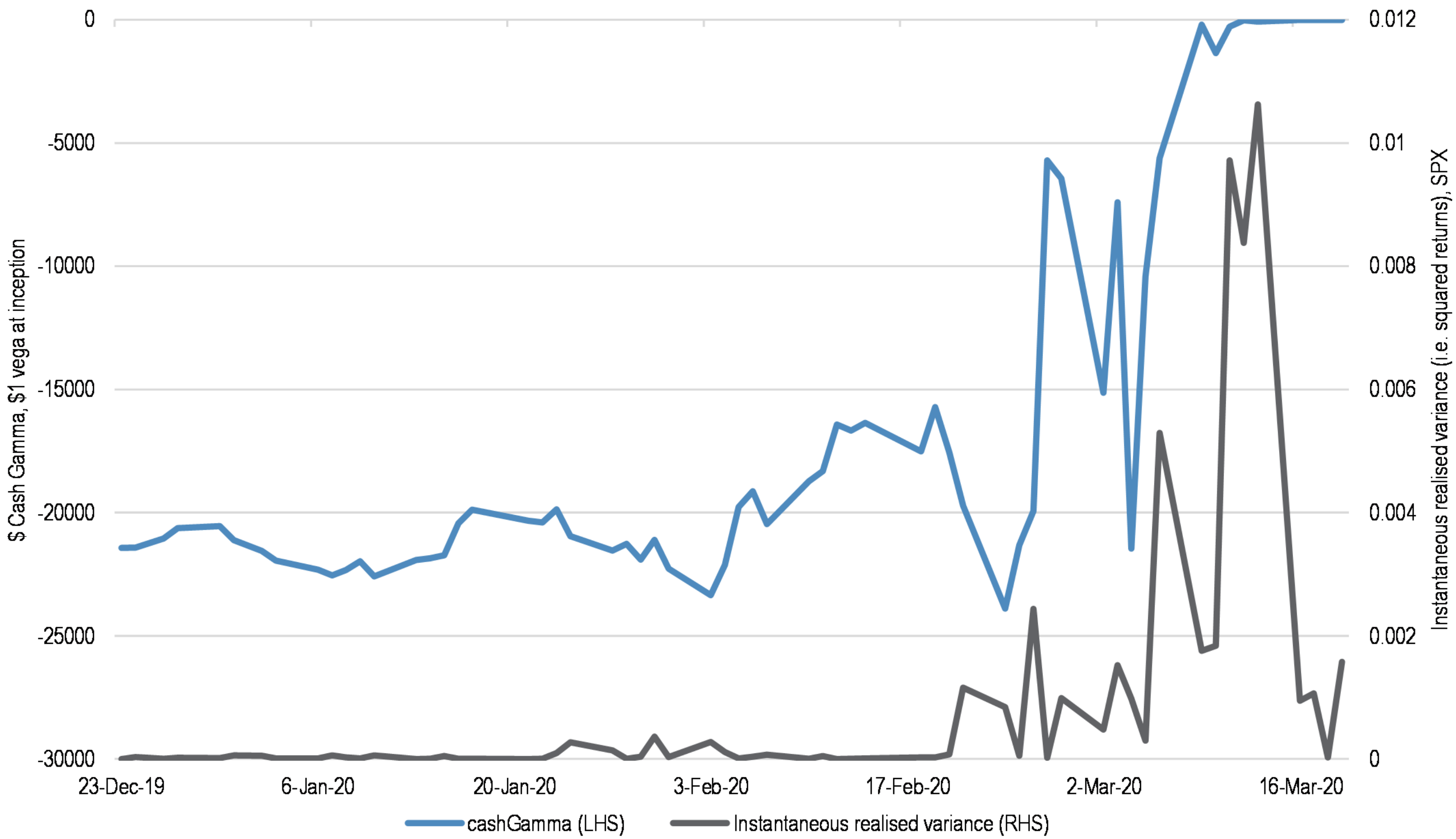
Prone to jumps for long tenors, drift-like for short-dated options



Source: J.P. Morgan Quantitative and Derivatives Strategy

Anatomy of a shock (Feb 2020)

As realized volatility surges, gamma dwindles in absolute terms



Source: J.P. Morgan Quantitative and Derivatives Strategy

Can we calculate the risk neutral expectation of the gamma cov. effect?

$$\begin{aligned}\text{Gamma covariance effect} &:= \frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma\right)\\ &= \frac{t}{2}\frac{1}{t}\int_0^t (\Gamma_s^* - \overline{\Gamma^*})(\sigma_s - \overline{\sigma})ds\end{aligned}$$

Intuition:

- Gamma covariance effect is about the correlation between (instantaneous) realized vol and Γ^*
- Now Γ^* can be linked to the probability of expiring at the strike
- (Think of it as the distance to the strike, adjusted for implied vol and time to maturity)
- So if realized vol increases as we get closer to the strike, the gamma covariance effect will be positive, and vice versa.

Let's introduce $\boldsymbol{\Gamma_M^*}$, the normalized distance to the strike

$$\frac{1}{K^2}\Gamma_M^* := \mathbb{E}(\delta_K(F_T))$$

Γ_M^* is also equal to the second derivative of the (market) option price with respect to the strike.

$$\frac{1}{K^2}\Gamma_M^* = \frac{\partial^2}{\partial K^2} Q(F_t, K, t, T, \hat{\sigma}(K))$$

i.e., to the price of a narrow fly around K.

Γ_M^* is linked to the Black-Scholes gamma Γ^*:

$$\Gamma^* = \Gamma_M^* - 2K^2 \frac{\partial^2 Q}{\partial K \partial \hat{\sigma}} \frac{\partial \hat{\sigma}}{\partial K} - K^2 \frac{\partial^2 Q}{\partial \hat{\sigma}^2} \left(\frac{\partial \hat{\sigma}}{\partial K} \right)^2 - K^2 \frac{\partial Q}{\partial \hat{\sigma}} \frac{\partial^2 \hat{\sigma}}{\partial K^2}$$

Γ_M^* lends itself well to covariance calculations

$$\mathbb{E}[\text{Gamma Covariance Effect}_M] = \frac{\Gamma_M^*(0)}{2}\mathbb{E}\left(\int_0^t \frac{t-u}{t}\left(RV(u,t) - EV(u,t)\right) du \mid S_T = K\right)$$

Subscript because this is not exactly the gamma cov. effect, but one constituent

Realized variance from u to t

Unconditional expected variance from u to t, i.e. the **variance swap** rate.

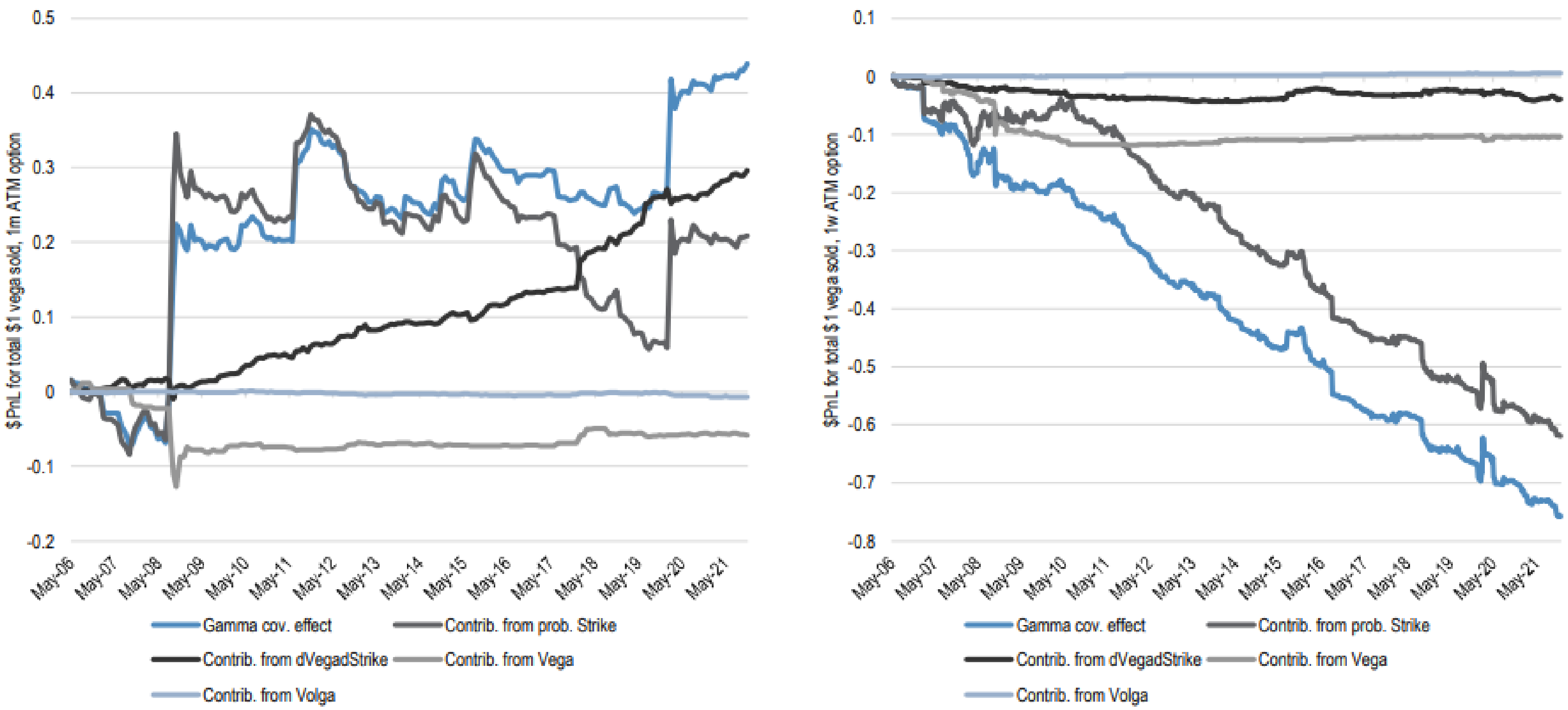
In stylized form,

$$\boxed{\begin{aligned}&\mathbb{E}[\text{Gamma Covariance Effect}_M]\\ &\qquad\approx \frac{\Gamma_M^*(0)}{2}\left(\mathbb{E}[\text{Realised Variance}|S_T = K] - \mathbb{E}[\text{Realised Variance}]\right)\end{aligned}}$$

Γ^*_M seems to dominate the gamma covariance effect

$$\Gamma^* = \Gamma^*_M - 2K^2 \frac{\partial^2 Q}{\partial K \partial \hat{\sigma}} \frac{\partial \hat{\sigma}}{\partial K} - K^2 \frac{\partial^2 Q}{\partial \hat{\sigma}^2} \left(\frac{\partial \hat{\sigma}}{\partial K} \right)^2 - K^2 \frac{\partial Q}{\partial \hat{\sigma}} \frac{\partial^2 \hat{\sigma}}{\partial K^2}$$

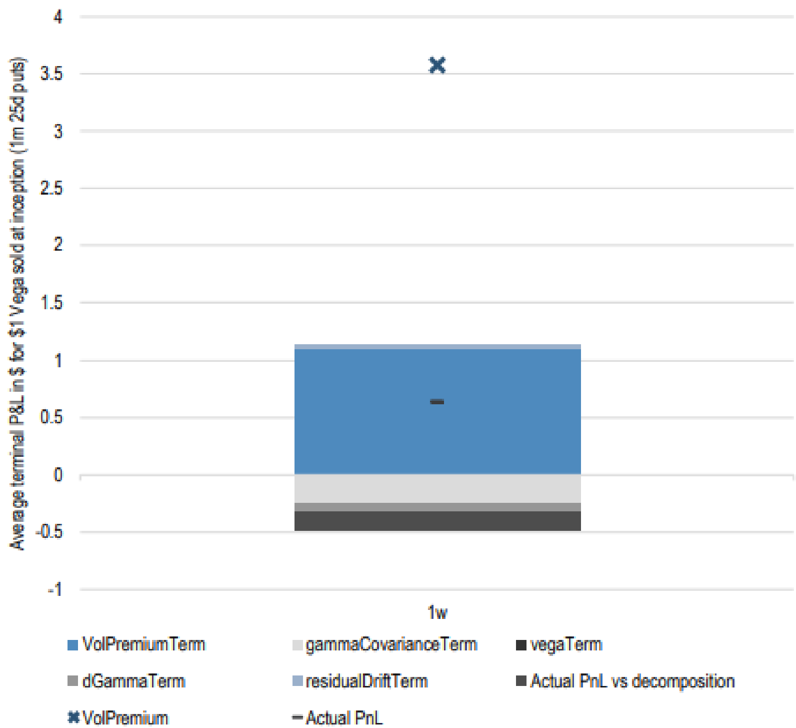
Figure 10: The gamma covariance effect is mostly driven by Gamma's fly component (here with 1m and 1w ATM, seller's perspective)

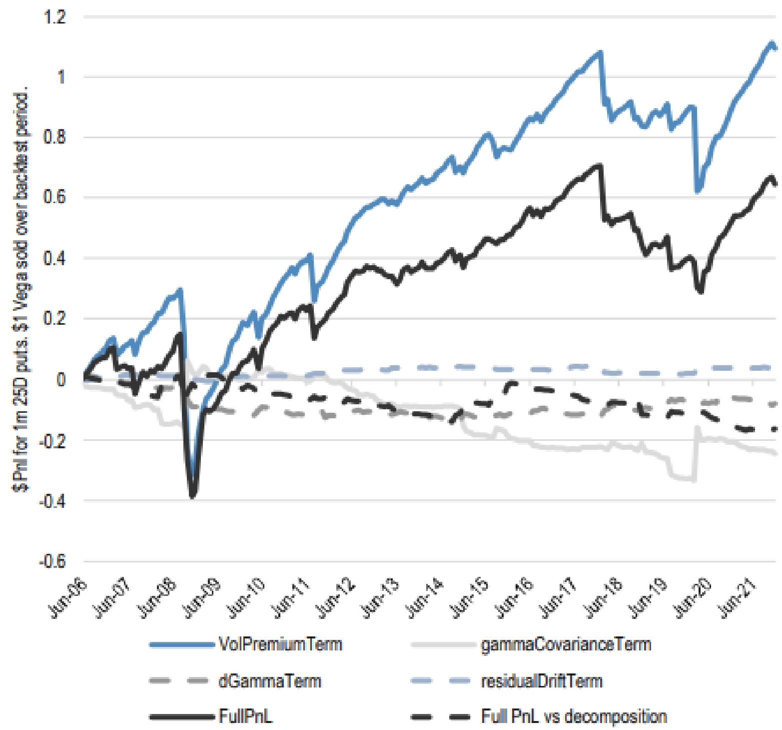


Source: J.P. Morgan Quantitative and Derivatives Strategy

What about out-of-the-money options? (1/3)

Figure 11: Out of the money puts do capture the volatility premium, but only a fraction of it (here with 1m 25 delta puts)

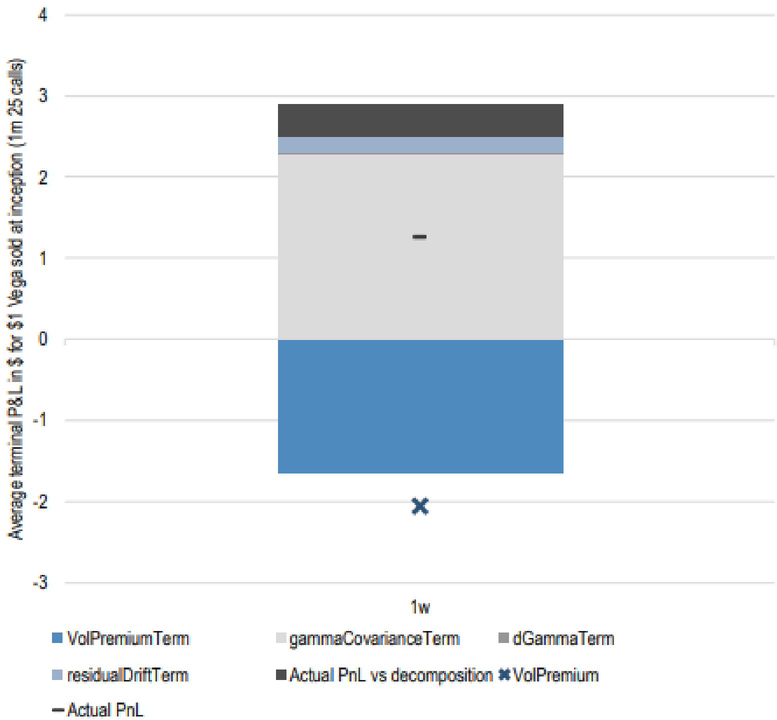


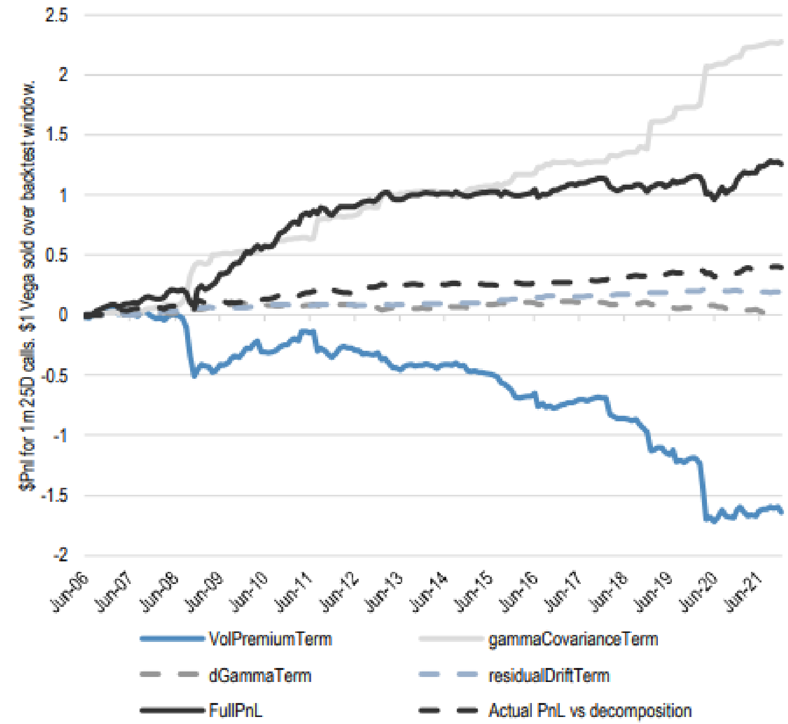


Source: J.P. Morgan Quantitative and Derivatives Strategy

What about out-of-the-money options? (2/3)

Figure 12: Selling 25d calls generates profits too, but in a very different way

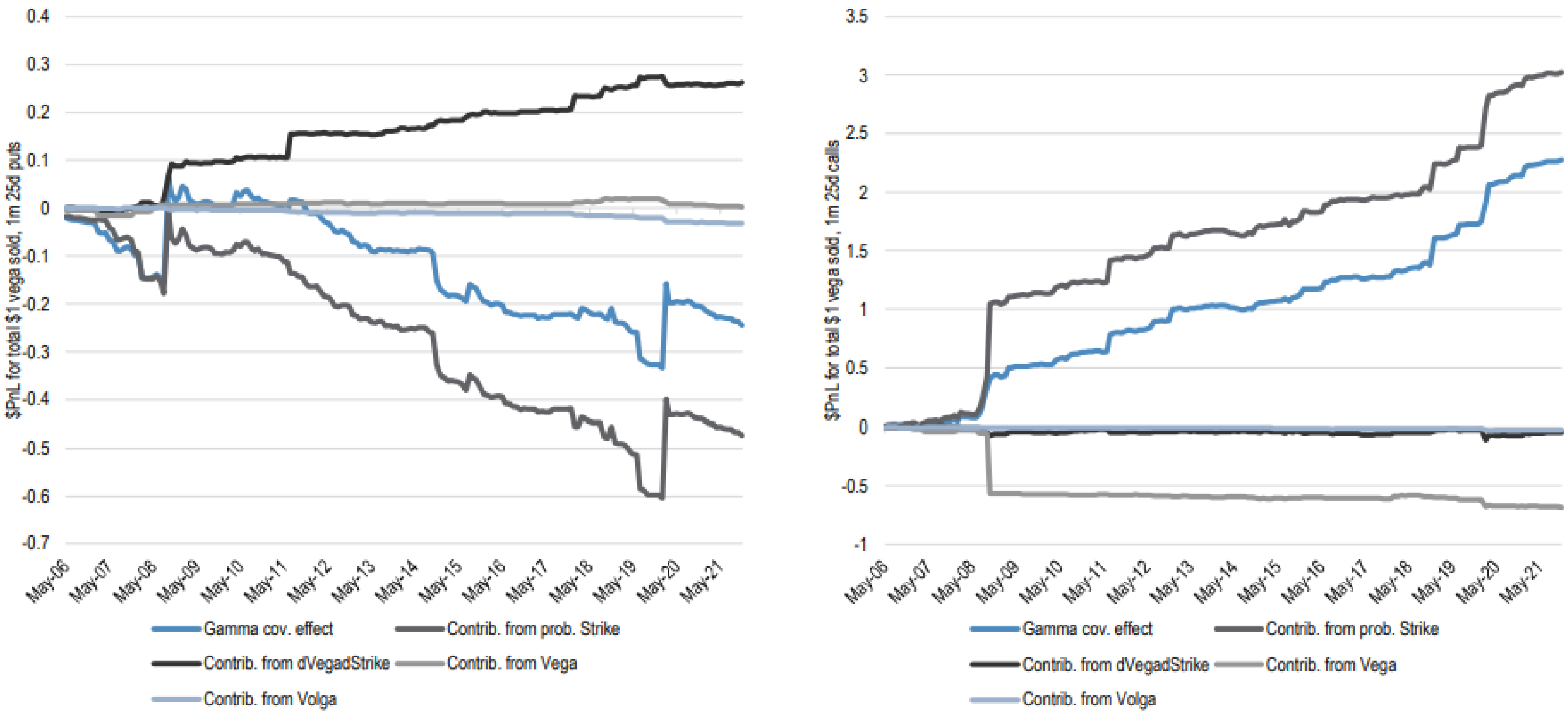




Source: J.P. Morgan Quantitative and Derivatives Strategy

What about out-of-the-money options? (3/3)

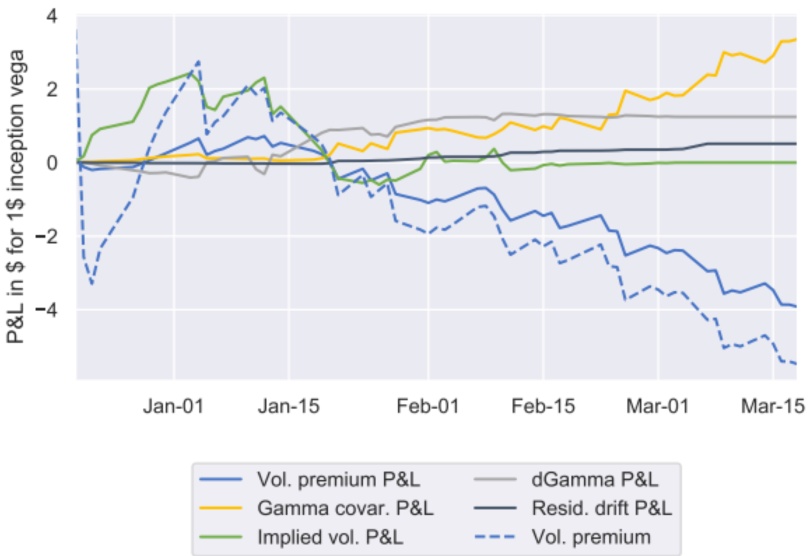
Figure 13: The contribution of Γ^*_M to the Gamma covariance effect is negative for OTM puts, positive for calls (option seller perspective)

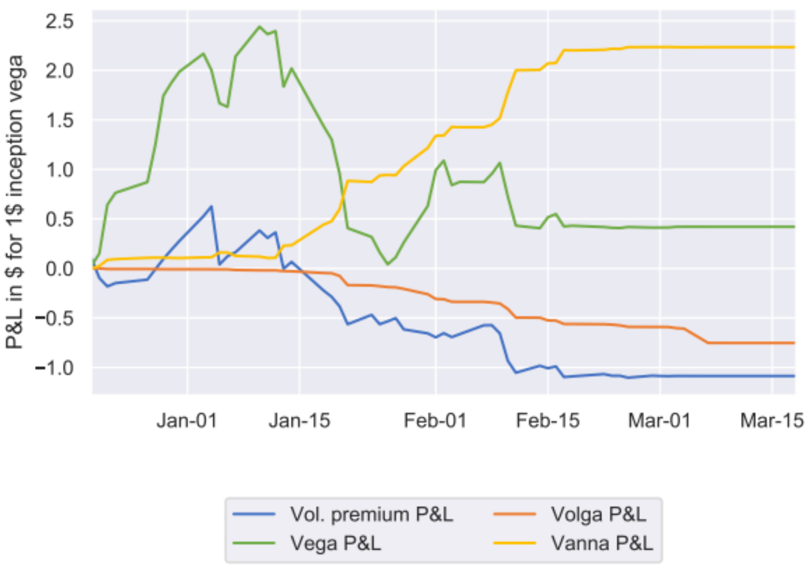


Source: J.P. Morgan Quantitative and Derivatives Strategy

Overall, a more parsimonious description than with classical attribution

Here for a short position on a 3m 25-d SPX call expiring in March 2022.



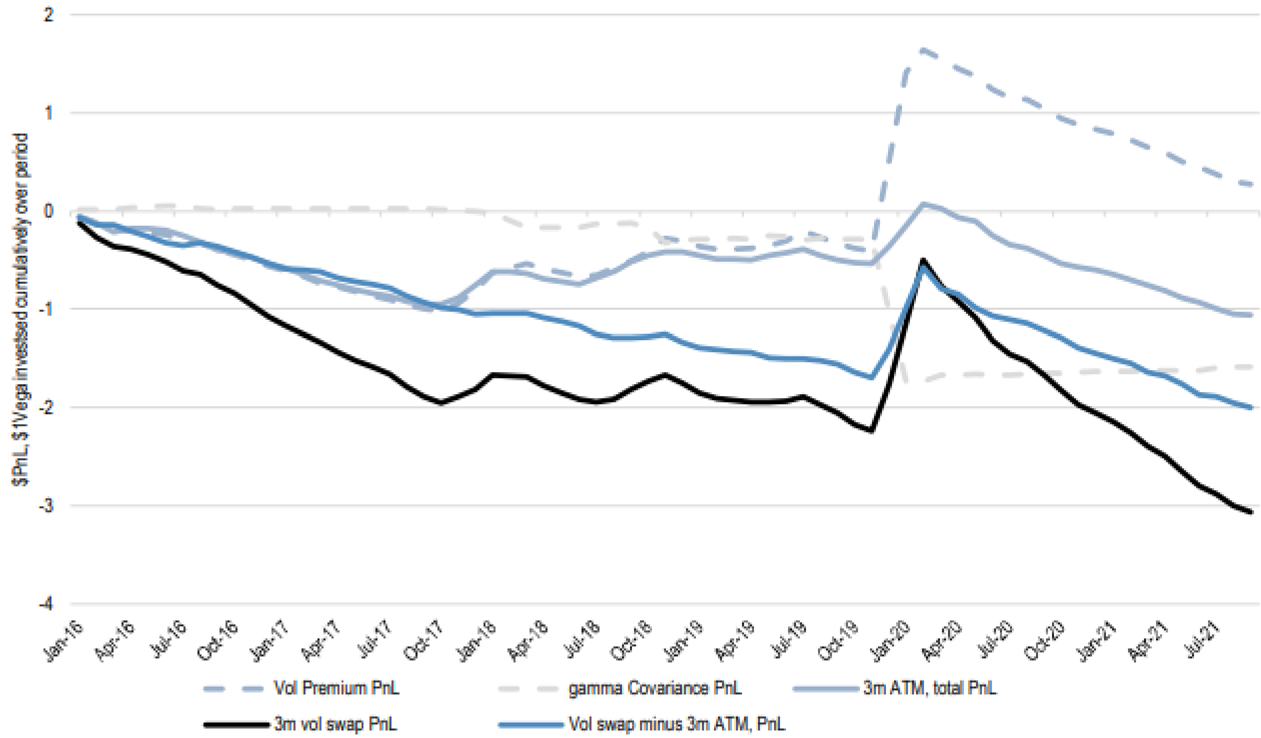


Source: J.P. Morgan Quantitative and Derivatives Strategy

A coupe of first attempts at relative value

#1: Using a vol swap to neutralize the vol premium term of a 3m vanilla

Figure 14: Going long a 3m volatility swap vs short a 3m ATM option: the negative drift of the volatility swap is too punitive.

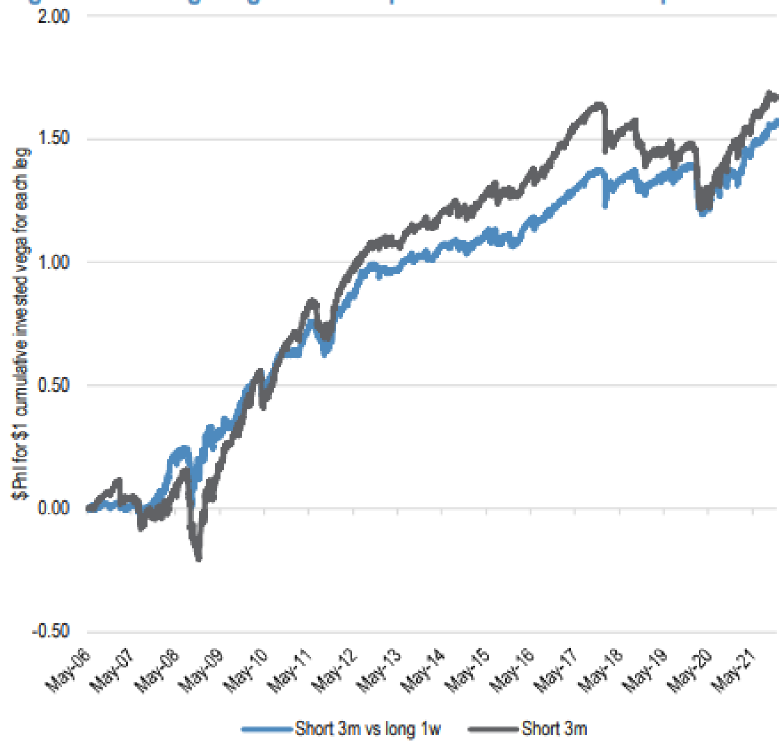


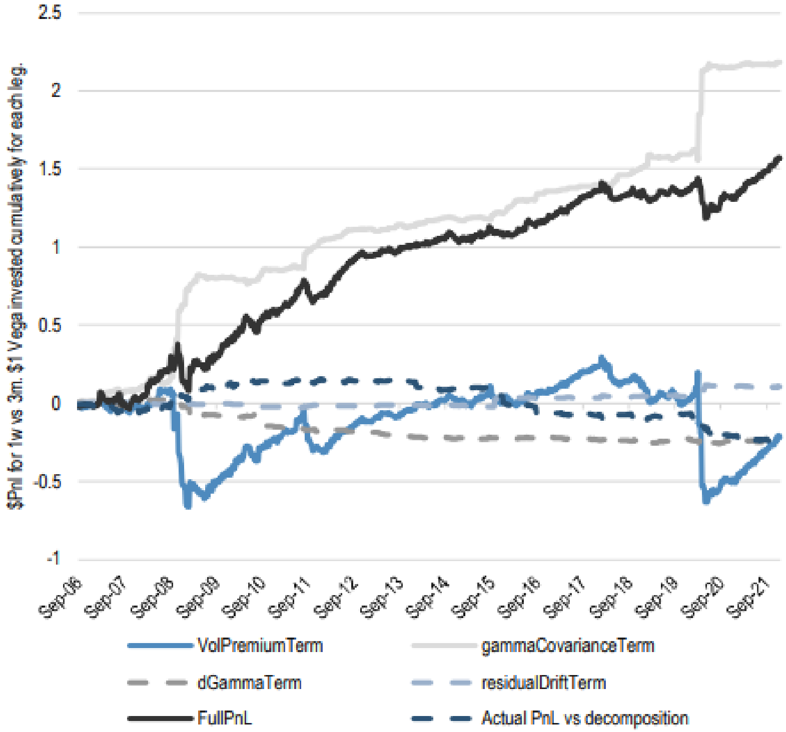
Source: J.P. Morgan Quantitative and Derivatives Strategy

A couple of first attempts at relative value

#2: gamma covariance effect RV, buying 1w ATM vs selling 3m ATM (1/2)

Figure 15: Going long a 1w ATM put vs short a 3m ATM put



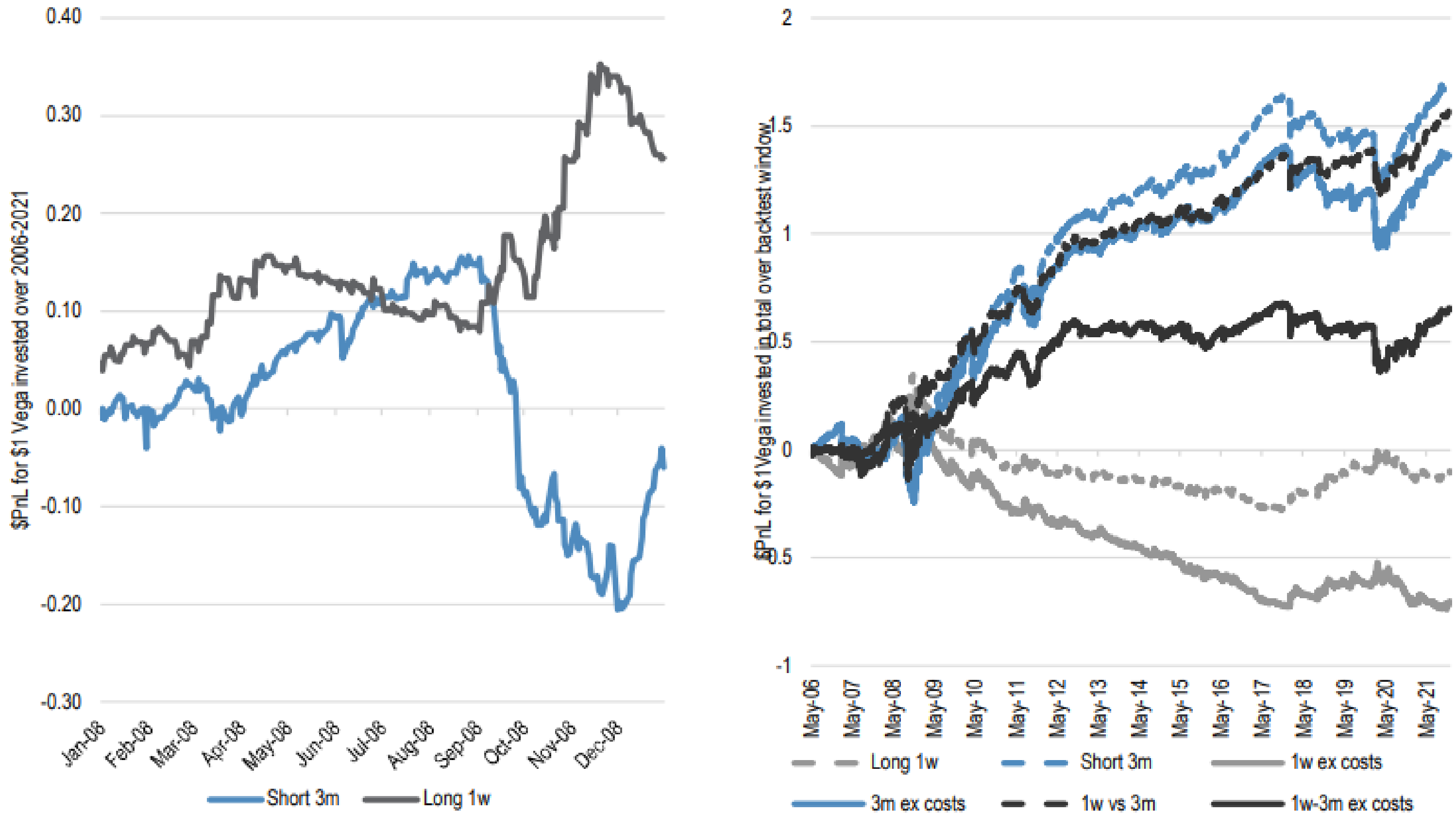


Source: J.P. Morgan Quantitative and Derivatives Strategy

A couple of first attempts at relative value

#2: gamma covariance effect RV, buying 1w ATM vs selling 3m ATM (2/2)

Figure 16: Performance in 2008, and performance after costs.



Source: J.P. Morgan Quantitative and Derivatives Strategy

Digression: implied vol as expected variance (1/3)

What happens if we take the risk neutral expectation of the P&L formula?

$$\mathbb{E}(P\&L_{[0,t]}) = \mathbb{E}\left(\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\operatorname{Cov}(\Gamma^*, \sigma)}^{\text{Gamma covariance effect}}\right.$$

$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2) d\Gamma_s^*}^{\text{dGamma term}}$$

$$\left. + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\langle \hat{\sigma}_s \rangle}^{\text{Residual drift term}}\right)$$

=0 as this is the risk neutral expectation of a trading strategy's P&L

Digression: implied vol as expected variance (2/3)

We hold to maturity and make three approximations

1. E(Residual drift term) = 0
2. E(dGamma term) = 0
3. $\Gamma^* = \Gamma_M^*$

$$0 = \mathbb{E}\left(\overbrace{\frac{t\boxed{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\boxed{\Gamma^*}, \sigma\right)}^{\text{Gamma covariance effect}} \right.$$

$$\cancel{+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}}} - \cancel{\overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}}$$

$$\left. \cancel{+ \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}}} \right)$$

We replace Γ^* by Γ_M^*

Digression: implied vol as expected variance (3/3)

We then use the same technique as with the gamma covariance effect

$$0 \approx \mathbb{E}\left(\frac{t\overline{\Gamma_M^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right) + \frac{t}{2}\,\mathrm{Cov}\left(\Gamma_M^*, \sigma\right)\right)$$

Using the same technique as for the expectation of the gamma covariance effect, this yields:

$$\hat{\sigma}_0^2 \approx \mathbb{E}\left(\frac{1}{t}\int_0^t \sigma_r^2(s)ds | S_T = K\right)$$

Agenda

Long dated USD swaptions

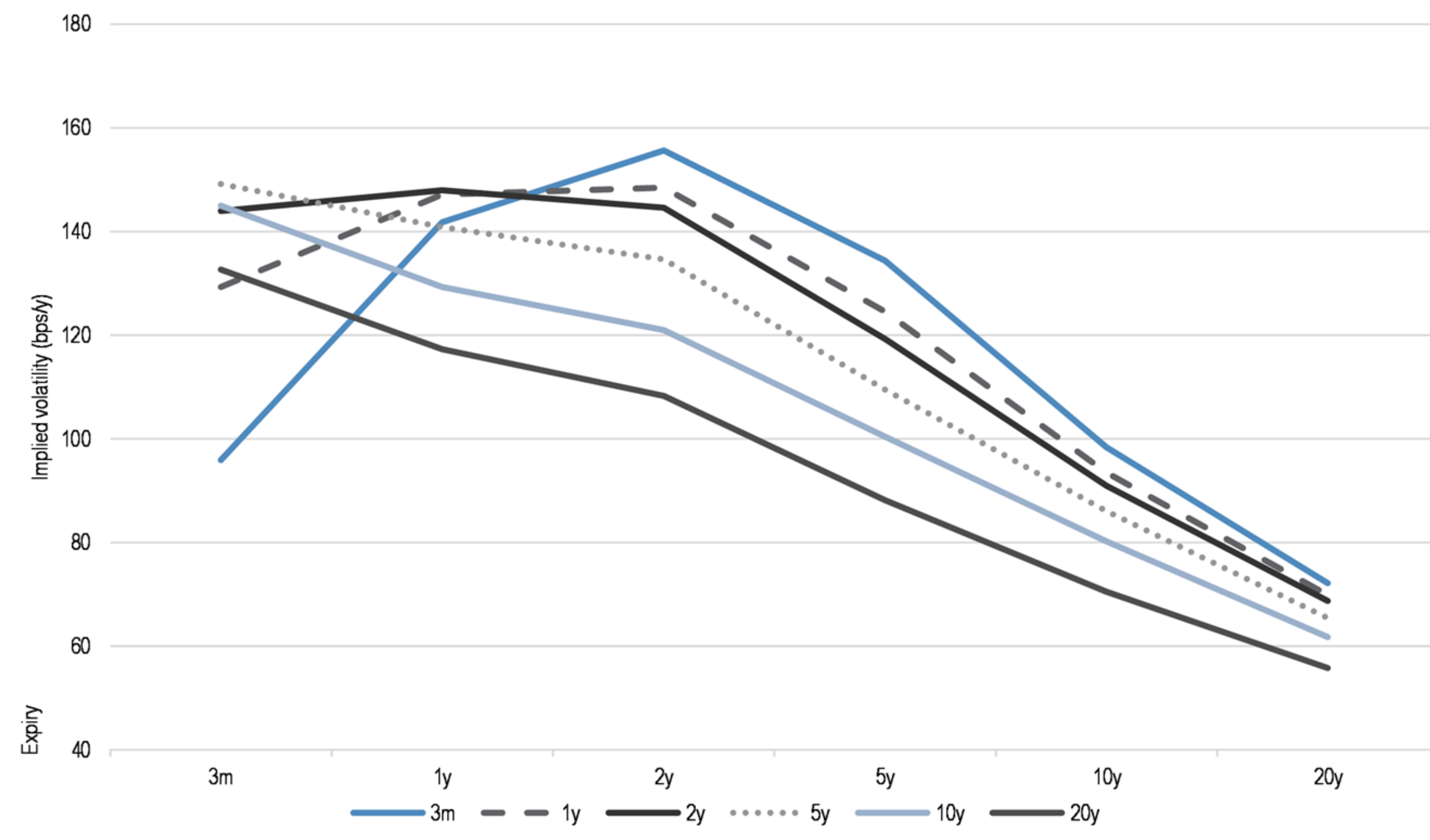
Long vol strategies need to compose with two headwinds

•**Implied typically trades above realized**. So P&L from gamma plus theta typically negative.

•**Term structure of implied vol is upward sloping**, so as swaption ages it incurs negative mark to market.

As we shall see, long dated rates swaptions solve this conundrum.

Term structure of implied vol is typically downward sloping for long expiries and tenors



Source: J.P. Morgan Quantitative and Derivatives Strategy

And on average, vol premium is negative

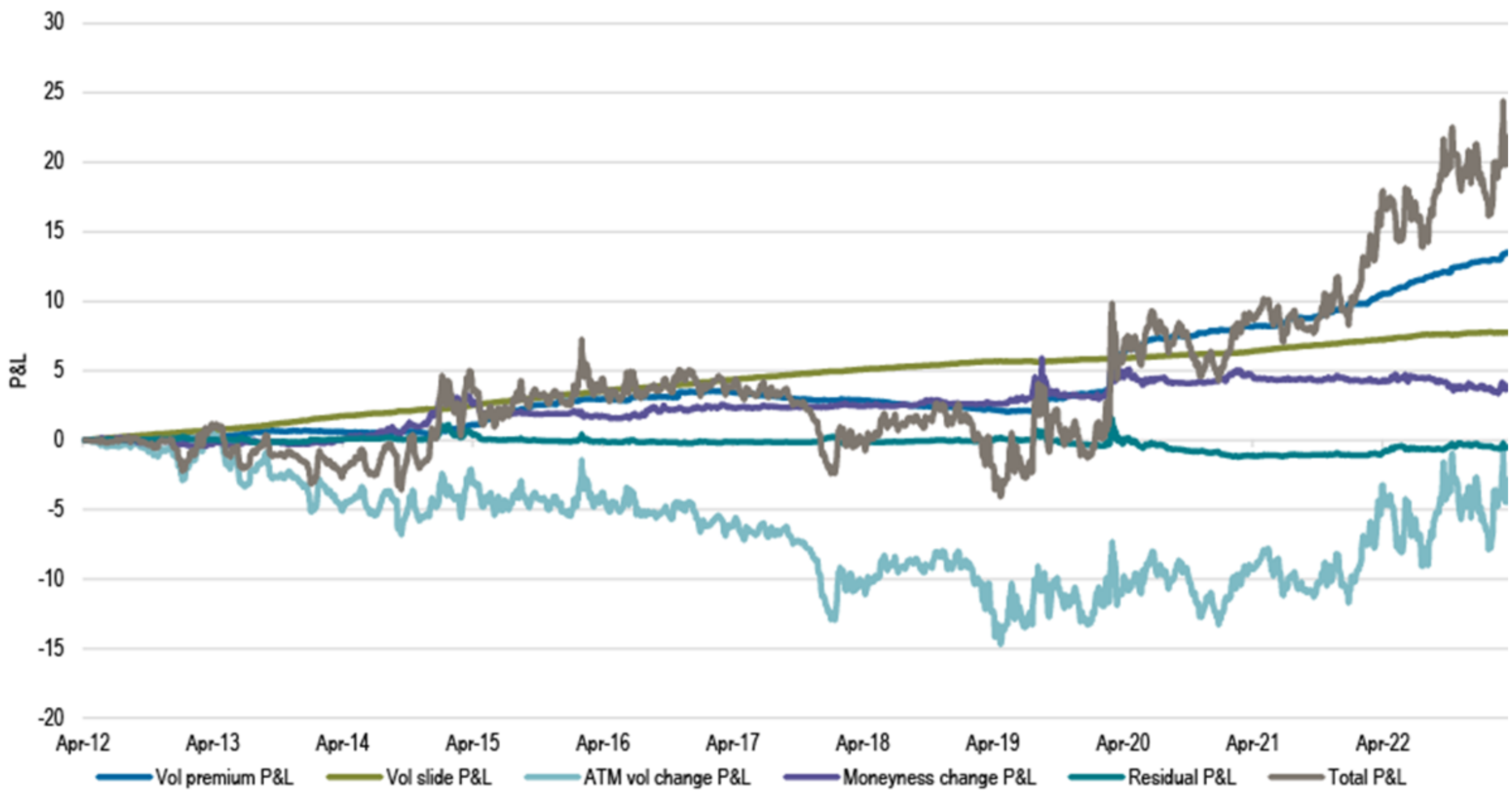
Vol premium = Implied vol at inception – Realized vol through life of option

		Tenor			
		2y	5y	10y	20y
Expiry	3m	6	3	2	2
	1y	15	4	2	-1
	5y	42	16	7	-2
	10y	33	7	-3	-12

Source: J.P. Morgan Quantitative and Derivatives Strategy

An example: long 10y20y USD swaption straddles, delta hedged and held for 1y.

A robust way to gain exposure to implied vol, and to outperform it.



A parenthesis: rewriting the standard P&L decomposition

To understand performance and carry for a vanilla swaption, we need the right tool.

The standard Greeks-based attribution is useful, but has a few limitations.

$$
\begin{aligned}
&\text{P\&L of a delta hedged option over } [0, t] = \\
&\qquad \sum \text{Theta P\&L} + \sum \text{Gamma P\&L} + \sum \text{Vega P\&L} \\
&\qquad\qquad + \sum \text{Vanna P\&L} + \sum \text{Volga P\&L}
\end{aligned}
$$

We use a global decomposition instead

See How close to realized should implied vol trade:

$$P\&L_{[0,t]} = \Bigg[\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\operatorname{Cov}\left(\Gamma^*, \sigma^2\right)}^{\text{Gamma covariance effect}}$$

$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}$$

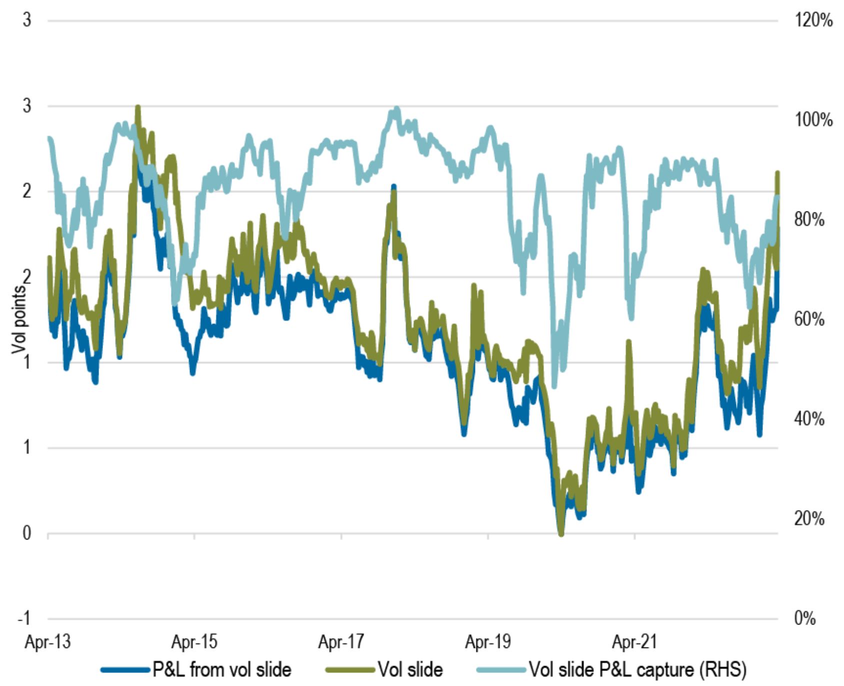
$$+ \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]$$

A straightforward relationship between vol parameters and P&L

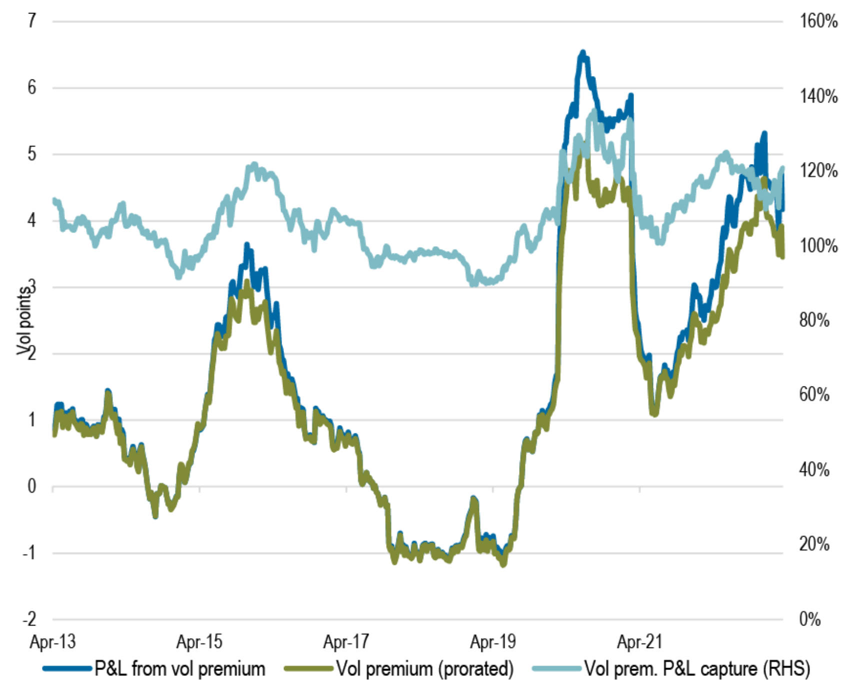
Vol premium = implied at inception for ATM 10y20y – realized through 1y holding period

Vol slide = implied at inception for ATM 10y20y – implied at inception for ATM 9y20y

1 vol pt. of vol slide translates into $0.85 of P&L, on avg.



1bp of vol premium generates $1.07 of P&L on avg.

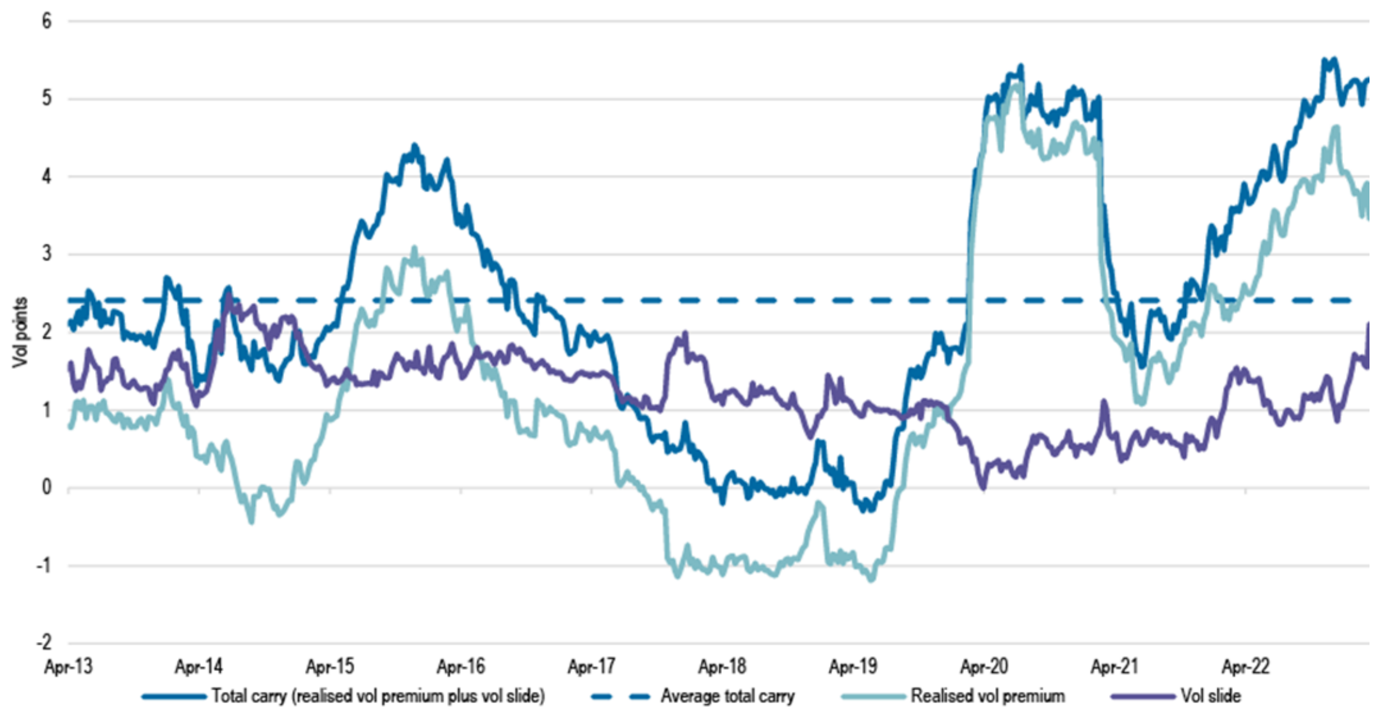


Source: J.P. Morgan Quantitative and Derivatives Strategy

Long dated USD swaptions

Our decomposition allows us to monitor total carry for the trade

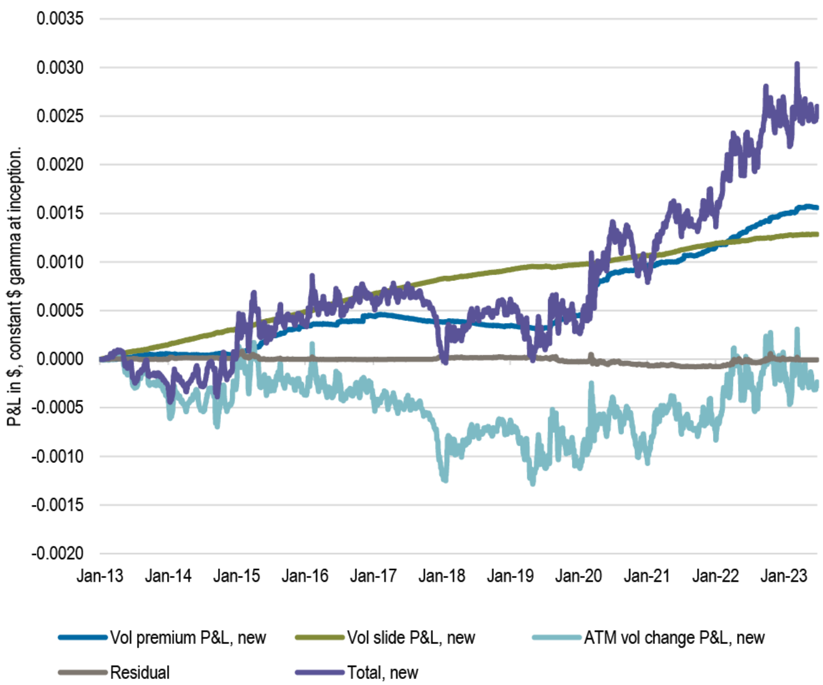
For $1 of inception vega, the strategy would have paid us $2.2 in yearly carry on average



Source: J.P. Morgan Quantitative and Derivatives Strategy

Carry is high, but it can be volatile

The vol premium P&L is volatile



And can be negative for extended periods of time

Source: J.P. Morgan Quantitative and Derivatives Strategy

Can we mitigate that risk?

Idea: sell short dated option to neutralize exposure to realized vol.

Eg if we're long a 11y expiry swaption on 20y swap, sell a 1y expiry swaption on 10y20Y forward.

Caveat:

1. That second swaption is a midcurve trade. It is less liquid than a vanilla swaption.
2. Regardless of sizing scheme at inception, exposure to realized vol will diverge.

There is a work around to caveat #1 though.

Approximating a midcurve with a pair of swaptions

Forward starting swap = basket of swaption trades:

10y20y forward = 30y spot – 10y spot

Hence: midcurve option = option on a basket of swaptions

1y expiry on 10y20y forward swap = 1y expiry on (30y spot swap – 10y spot swap)

Approximation: option on basket ~ basket of options.

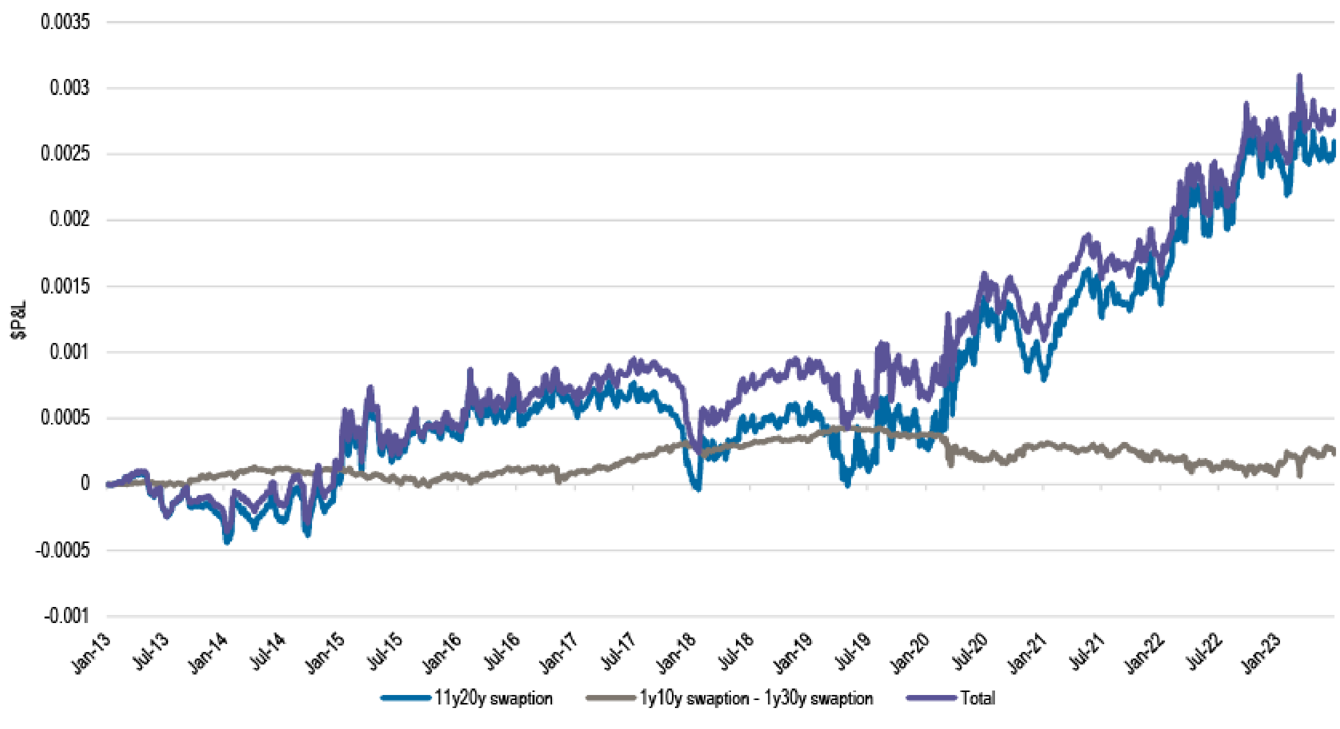
This gives:

1y expiry on 10y20y forward swap = 1y30y swaption – 1y10y swaption

How this strategy fares in practice

Hedging the vol premium P&L does not hurt performance

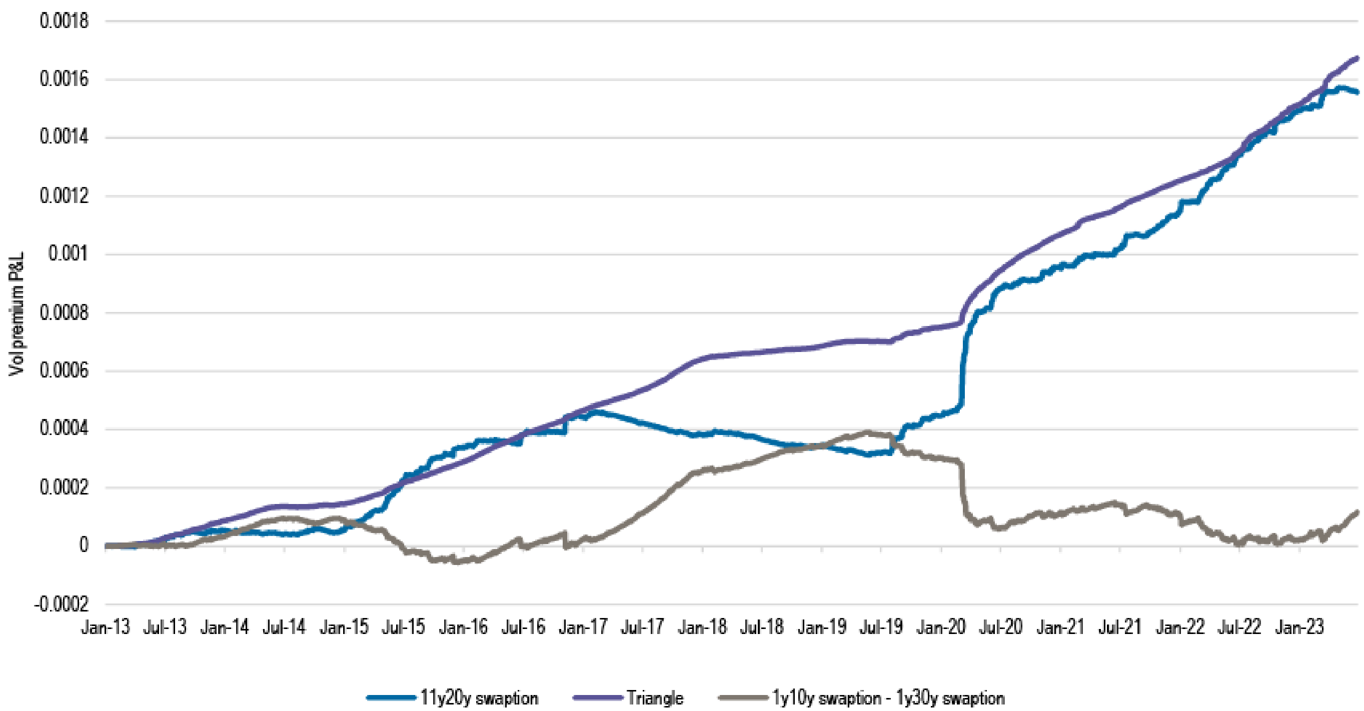
Buy 11y20y swaption vs sell 1y30y swaption vs buy 1y10y swaption



Source: J.P. Morgan Quantitative and Derivatives Strategy

Vol premium P&L is now much smoother

And mostly positive.

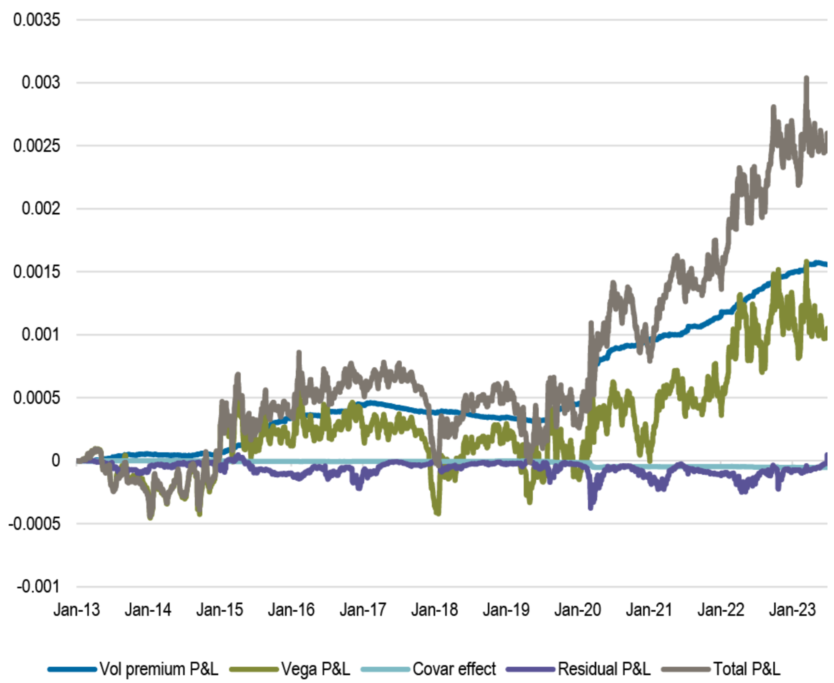


Source: J.P. Morgan Quantitative and Derivatives Strategy

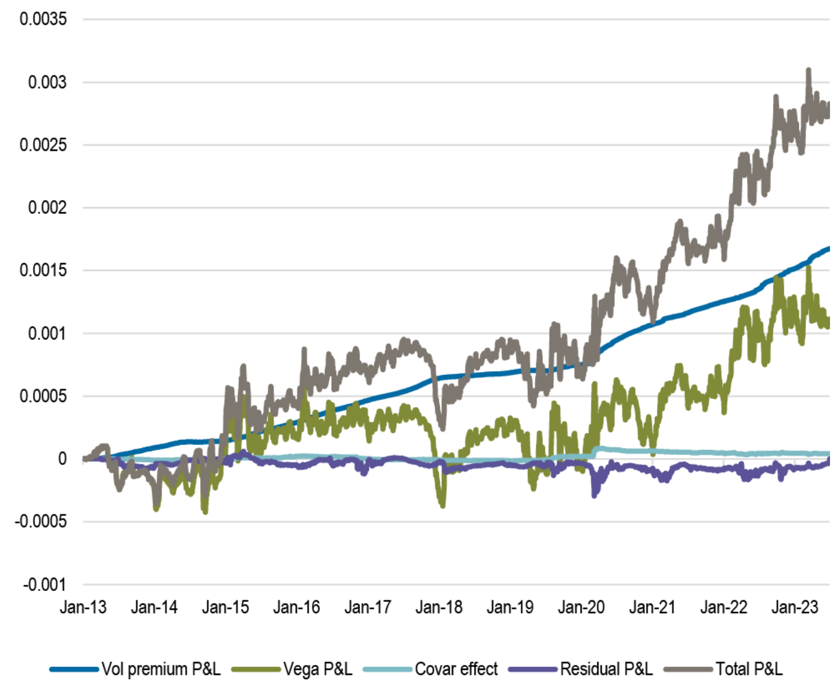
Under the hood: 11y20y and triangle have similar P&L breakdowns

The only P&L component which is different is Vol Premium P&L. Other components are very similar.

Long 11y20y swaption



Long 11y20y swaption vs swaption basket

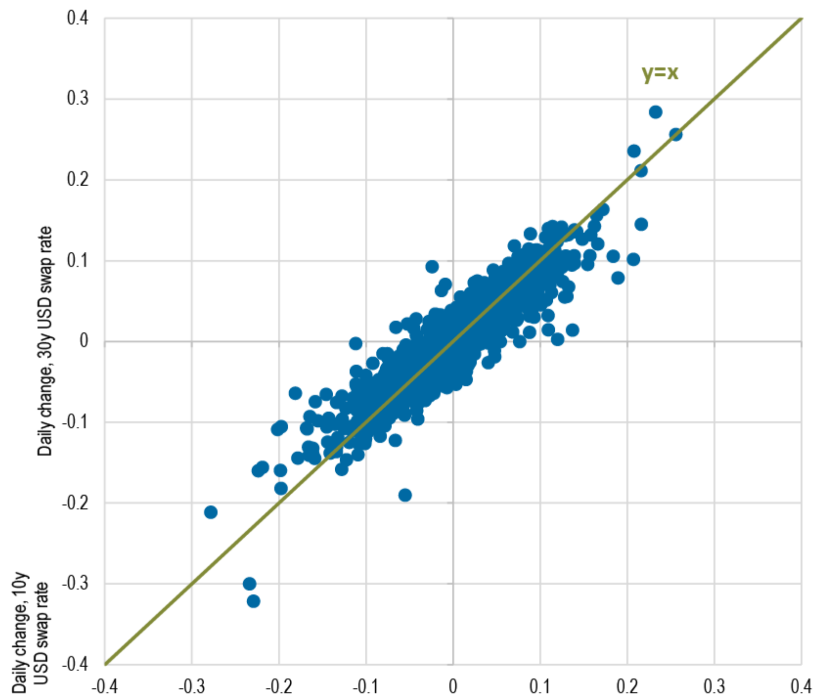


Source: J.P. Morgan Quantitative and Derivatives Strategy

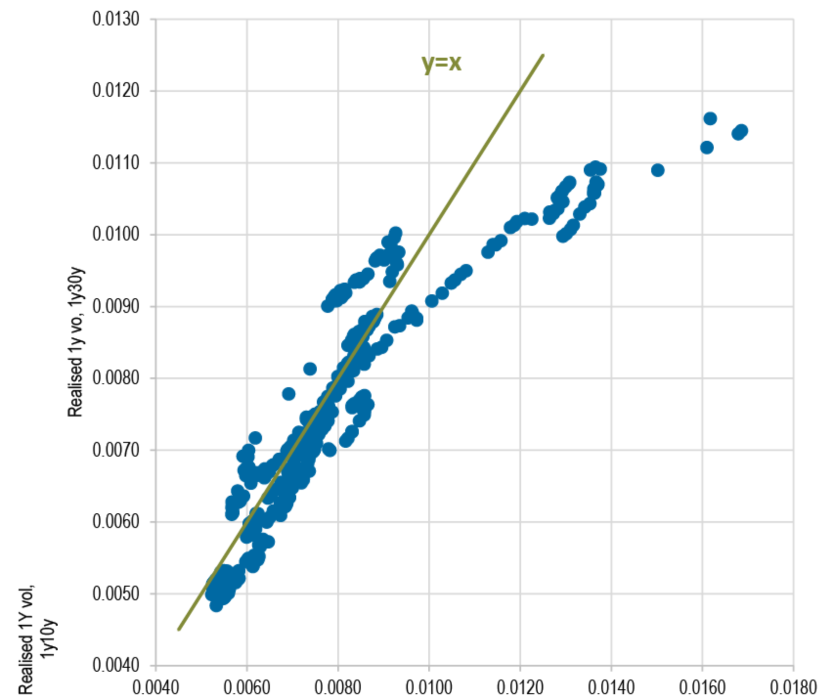
As it turns out, the basket approximation is not an issue

1y option on (30y – 10y swap) ~ 1y30y swaption – 1y10y swaption

The 10y and 30y tenors are very correlated



And 1y realized vols are similar too

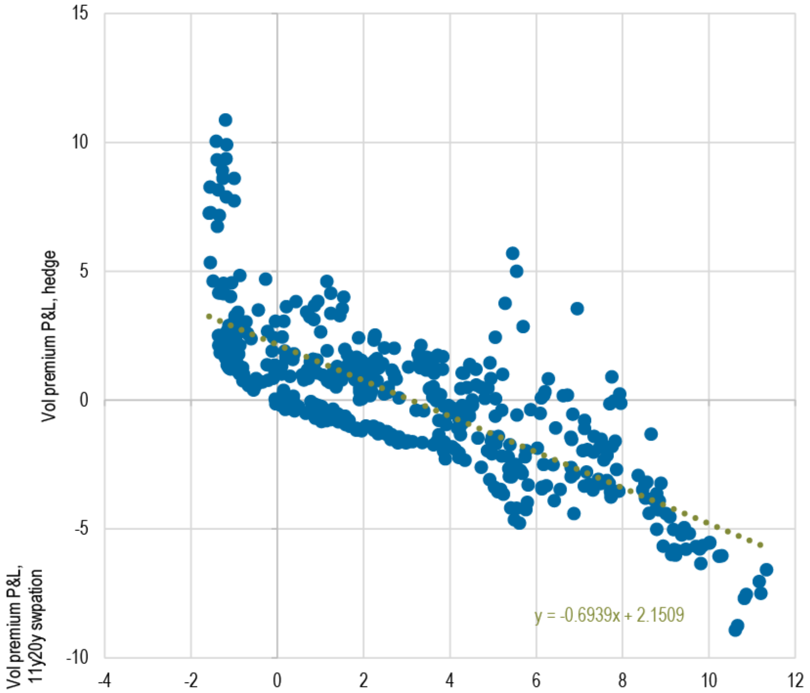


Source: J.P. Morgan Quantitative and Derivatives Strategy

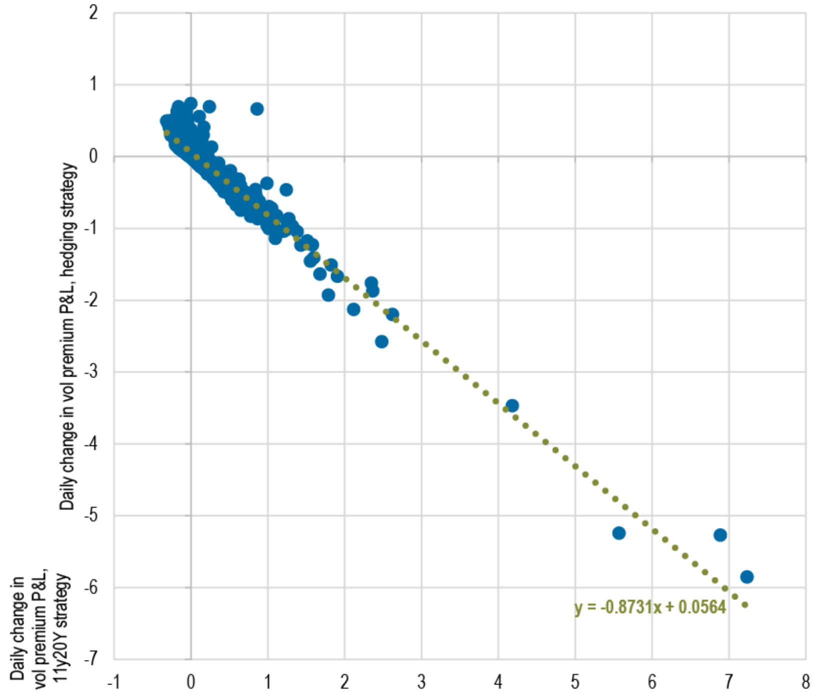
Exposure to vol premium does change, but those variations average out

Because our implementation spreads full notional over weekly start dates.

Hedge is imprecise on a per swaption basis



But works well at the strategy level

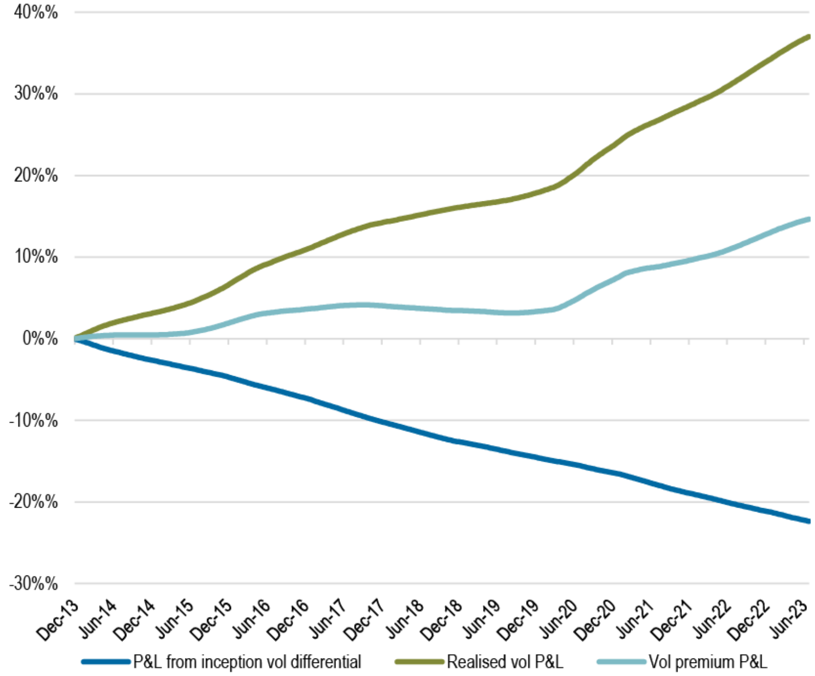


Source: J.P. Morgan Quantitative and Derivatives Strategy

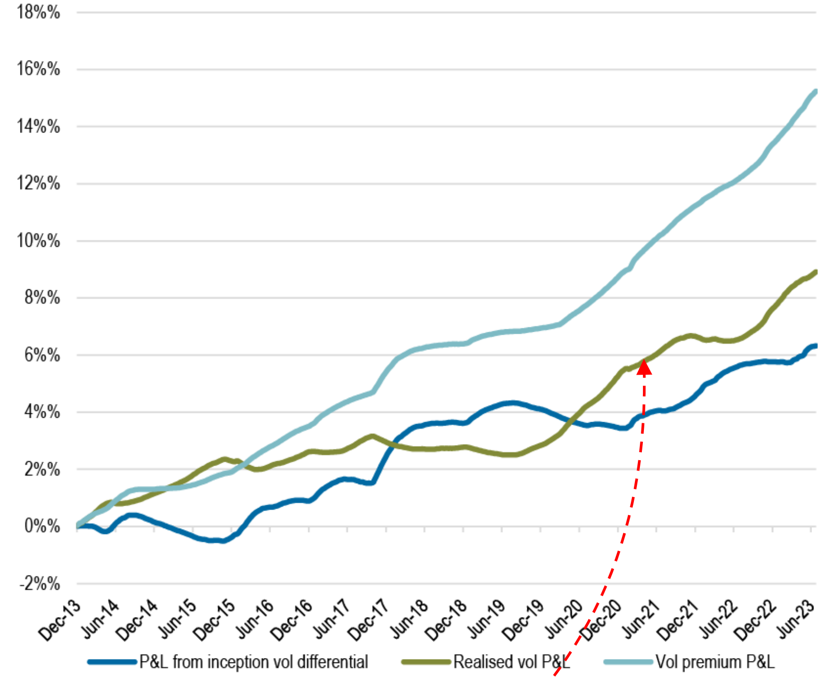
The nature of the vol premium P&L is now different

Note: P&L from inception vol = -(average gamma)/2 Inception vol^2
P&L from realized vol = (average gamma)/2 Realized vol^2

Vol premium P&L is no longer a difference between two components



But the sum of two (mostly) positive quantities

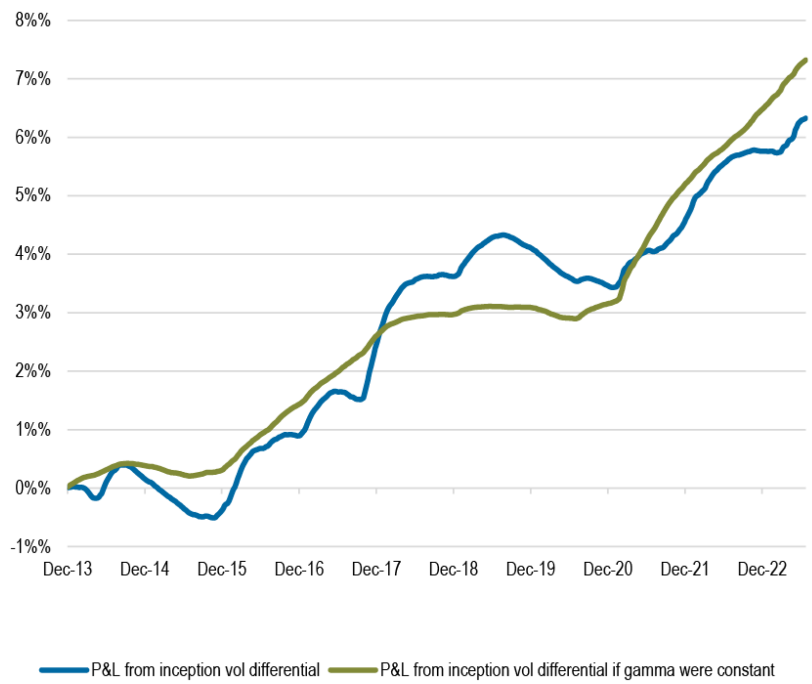


Source: J.P. Morgan Quantitative and Derivatives Strategy

(The reason why realized vol P&L is mostly positive here is because correl between 10y and 10y20y is less than 1)

And it is partly known ex-ante

Assuming that gamma is constant doesn't change the fixed part of the vol premium P&L much



And makes it possible to calculate that P&L ex ante

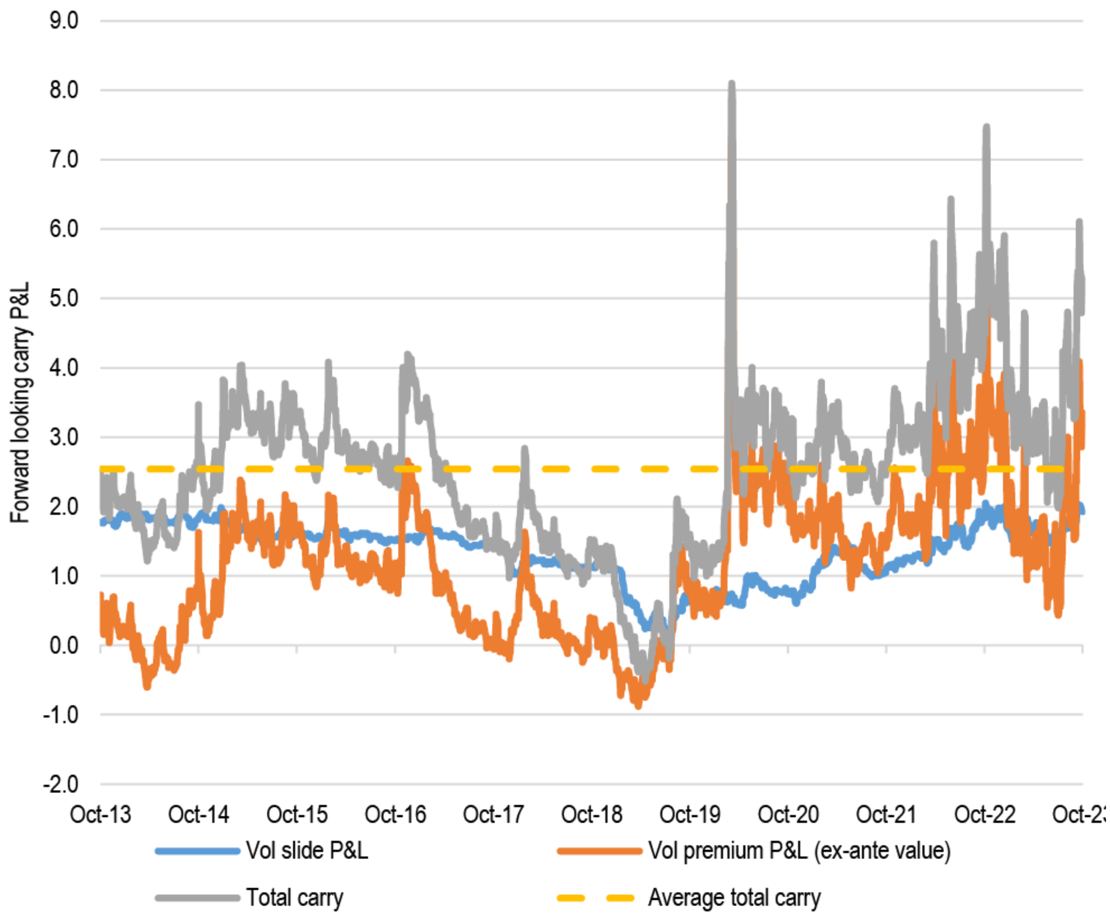
Source: J.P. Morgan Quantitative and Derivatives Strategy

On average, the fixed part of the vol premium P&L has contributed 1.5bps of vol pick up

Which makes it possible to monitor ex-ante carry historically

Note that it skyrocketed in October 2023

Historical carry for long 11y20y vs short 1y30y vs long 1y10y:



Source: J.P. Morgan Quantitative and Derivatives Strategy

Ex-ante carry tends to correlate with the level of implied vol.

Triangle carry vs 11y20y implied vol, scatter plot over past 10y

Source: J.P. Morgan Quantitative and Derivatives Strategy. As of Oct 19th 2023

Conclusions

- Long dated USD rates swaptions provide a way to gain exposure to implied vol with positive carry.
- Carry comes from two sources: the vol premium and the vol slide.
- Carry from vol premium can be volatile. We can hedge that risk by trading a basket of short dated swaptions against it.
- The two approximations which underpin that an idea turn out not to have much of an impact.
- The resulting vol premium is much smoother and more tractable ex ante.
- The main trade off vs the original version is that it generates less upside P&L in crisis, since sensitivity to realized vol is muted.
- So triangle version is a better fit for pure carry seekers.
- Original trade is better fit for investors looking for defensive trade with positive carry.

Agenda

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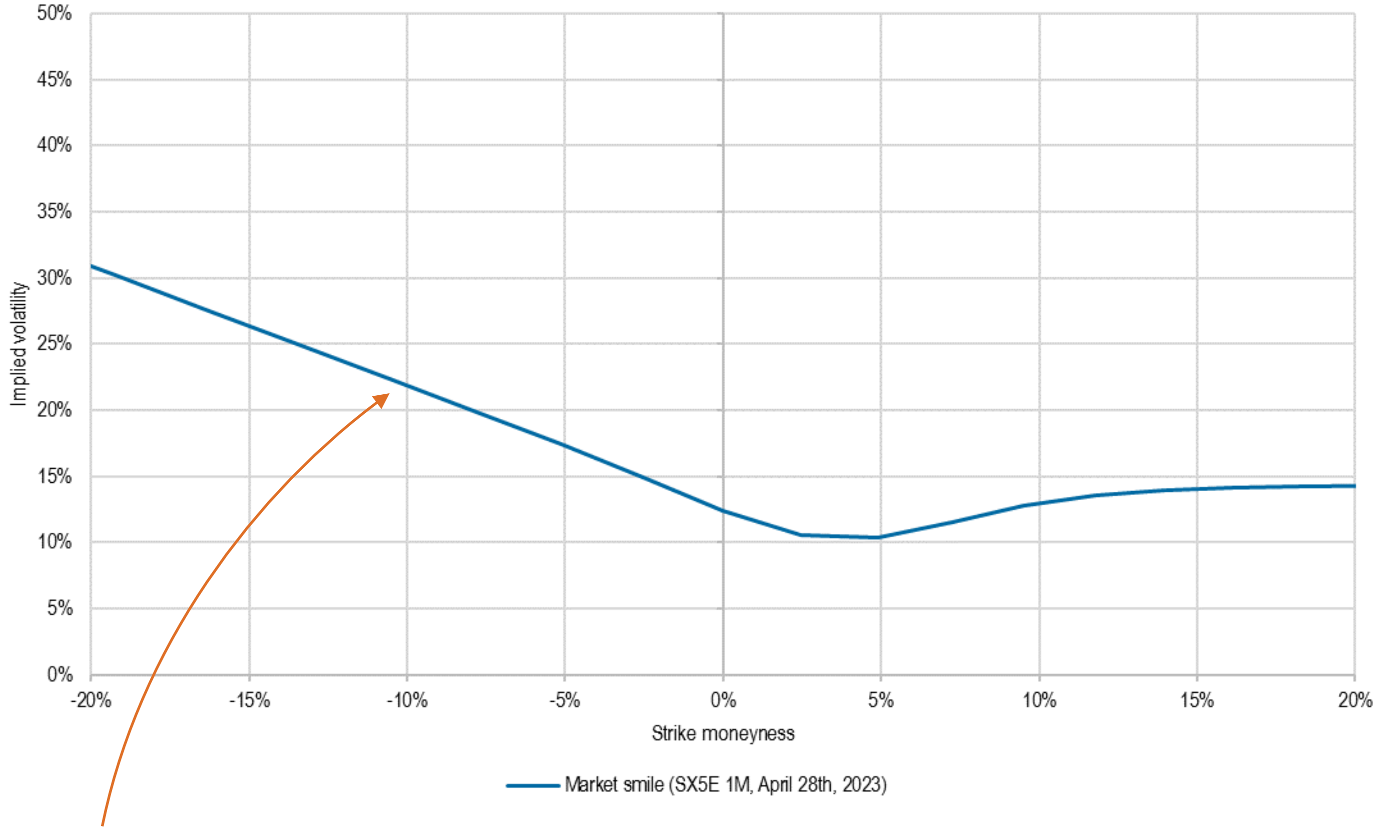
Calculating a fair smile

How can we assess if a point on the vol smile is rich or cheap?



Let's take this -10% 1M Eurostoxx strike for example: is 22% vol rich, cheap or fair?

Source: J.P. Morgan Quantitative and Derivatives Strategy

The existing toolkit

Typically, participants rely on the notions of realized vol and realized skew/convexity

- **Realized vol**: to assess ATM implied vol
- **Realized skew and convexity**: to assess OTM implied vol.
  - Eg for short dated maturities, Realized skew = (Beta of vol to spot)/2
  - For convexity and/or longer dated maturities, things are more involved (see Bergomi 2015 for example).

Calibrating a model to the historical dynamics of the underlying is also a possibility, but

- Exact shape of smile may be a feature of the model, rather than a feature of data
- Monetization channels aren't clear

Rewriting the smile P&L

Formulas for realized skew and convexity are based on standard Greeks-based P&L decomposition for delta-hedged vanilla option:

$$\begin{aligned}\text{P\&L of a delta hedged option over } [0,t] = \\ \sum \text{Theta P\&L} + \sum \text{Gamma P\&L} + \sum \text{Vega P\&L} \\ + \sum \text{Vanna P\&L} + \sum \text{Volga P\&L}\end{aligned}$$

We use a global decomposition instead

See [How close to realized should implied vol trade]**:**

$$P\&L_{[0,t]} = \Bigg[\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma^2\right)}^{\text{Gamma covariance effect}}$$

$$+ \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}$$

$$+ \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} \Bigg]$$

On average, the P&L of a delta-hedged option should be zero

1. E(Residual drift term) = 0
2. E(dGamma term) = 0
3. $\Gamma^* = \Gamma^*_M$, the price of a small butterfly centered around K.

$$0 = \mathbb{E}\left(\overbrace{\frac{t\boxed{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma}_0{}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\boxed{\Gamma^*}, \sigma^2\right)}^{\text{Gamma covariance effect}} \right.$$

$$+ \bcancel{\overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}}} - \bcancel{\overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)d\Gamma_s^*}^{\text{dGamma term}}}$$

$$\left. + \bcancel{\overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}}} \right)$$

We replace Γ^* by Γ^*_M

This yields the following approximation for fair implied vol

$$\hat{\sigma}^2(K) \approx \mathbb{E}\left(\frac{1}{T}\int_0^T \sigma^2(s)ds|S_T = K\right)$$

where

- $\hat{\sigma}(K)$ is the implied vol for strike K
- $\sigma(s)$ is the instantaneous realised vol at time s (in a discrete setting that's the square root of the squared log return).
- $S_.$ is the price of the underlying asset.

This formula should lend itself well to empirical estimation

$$\hat{\sigma}^2(K) \approx \mathbb{E}\left(\frac{1}{T}\int_0^T \sigma^2(s)ds | S_T = K\right)$$

Say K = 90% (i.e. option is a 10% OTM put).

Then we need to estimate expected variance conditional on asset price dropping 10% over life of option.

Historically, this is what this realized variance looks like

Eurostoxx: 1m historical realized variance as a function of log return over 1m and variance swap at inception.

Variance swap vol at beginning of 1M window (columns); Log return of the underlying over 1M window (rows)

	11%	15%	18%	22%	26%	30%	33%	37%	41%	45%	48%	52%	56%	60%	63%	67%	71%	75%	78%	82%
-48%	67%																			
-45%	68%																			
-41%	61%																			
-38%																				
-35%		76%																		
-31%																				
-28%	42%		76%	77%	76%															
-24%					76%	76%	76%													
-21%						78%			75%											
-18%	29%	34%	34%	34%																
-14%	26%	31%	34%	25%	32%				77%											
-11%	18%	24%	31%	29%	24%	27%														
-8%	17%	20%	20%	26%	26%	26%	25%		34%											
-4%	12%	15%	19%	21%	24%	26%	32%		31%	33%	71%									
-1%	11%	13%	16%	18%	21%	27%	29%	30%	33%	32%		56%								
2%	9%	12%	14%	18%	21%	23%	28%	32%	31%	32%	37%	36%								
6%		11%	15%	20%	22%	22%	25%	40%	33%	34%	36%	34%		35%						
9%			15%	21%	22%	24%	24%				34%					48%	52%	55%		
12%					21%	27%	33%	30%						48%			55%			53%
16%							28%											48%		49%

Source: J.P. Morgan Quantitative and Derivatives Strategy

How to read this empirical chart

An example:

- Historically, when
    - 1M Estoxx varswap traded at 22%
    - And Estoxx dropped 11% over the month that followed
- Then vol realized around 29% on average, over that period.

Variance swap vol at beginning of 1M window (columns); **Log return of the underlying over 1M window** (rows)

	11%	15%	18%	22%	26%	30%	33%	37%	41%	45%	48%	52%	56%	60%	63%	67%	71%	75%	78%	82%
-48%	67%																			
-45%	68%																			
-41%	61%																			
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-18%	29%	34%	34%	34%																
-14%	26%	31%	34%	25%	32%				77%											
-11%	18%	24%	31%	29%	24%	27%														
-8%	17%	20%	20%	26%	26%	26%	25%		34%											
-4%	12%	15%	19%	21%	24%	26%	32%		31%	33%	71%									
-1%	11%	13%	16%	18%	21%	27%	29%	30%	33%	32%		56%								
2%	9%	12%	14%	18%	21%	23%	28%	32%	31%	32%	37%	36%								
6%		11%	15%	20%	22%	22%	25%	40%	33%	34%	36%	34%		35%						
9%			15%	21%	22%	24%	24%				34%					48%	52%	55%		
12%					21%	27%	33%	30%						48%			55%			53%
16%							28%											48%		49%

Source: J.P. Morgan Quantitative and Derivatives Strategy

To estimate today's smile we pick the relevant slice of data

If today's variance swap is 15%, then we pick this column:

Variance swap vol at beginning of 1M window

Log return of the underlying over 1M window	11%	15%	18%	22%	26%	30%	33%	37%	41%	45%	48%	52%	56%	60%	63%	67%	71%	75%	78%	82%
-48%	67%																			
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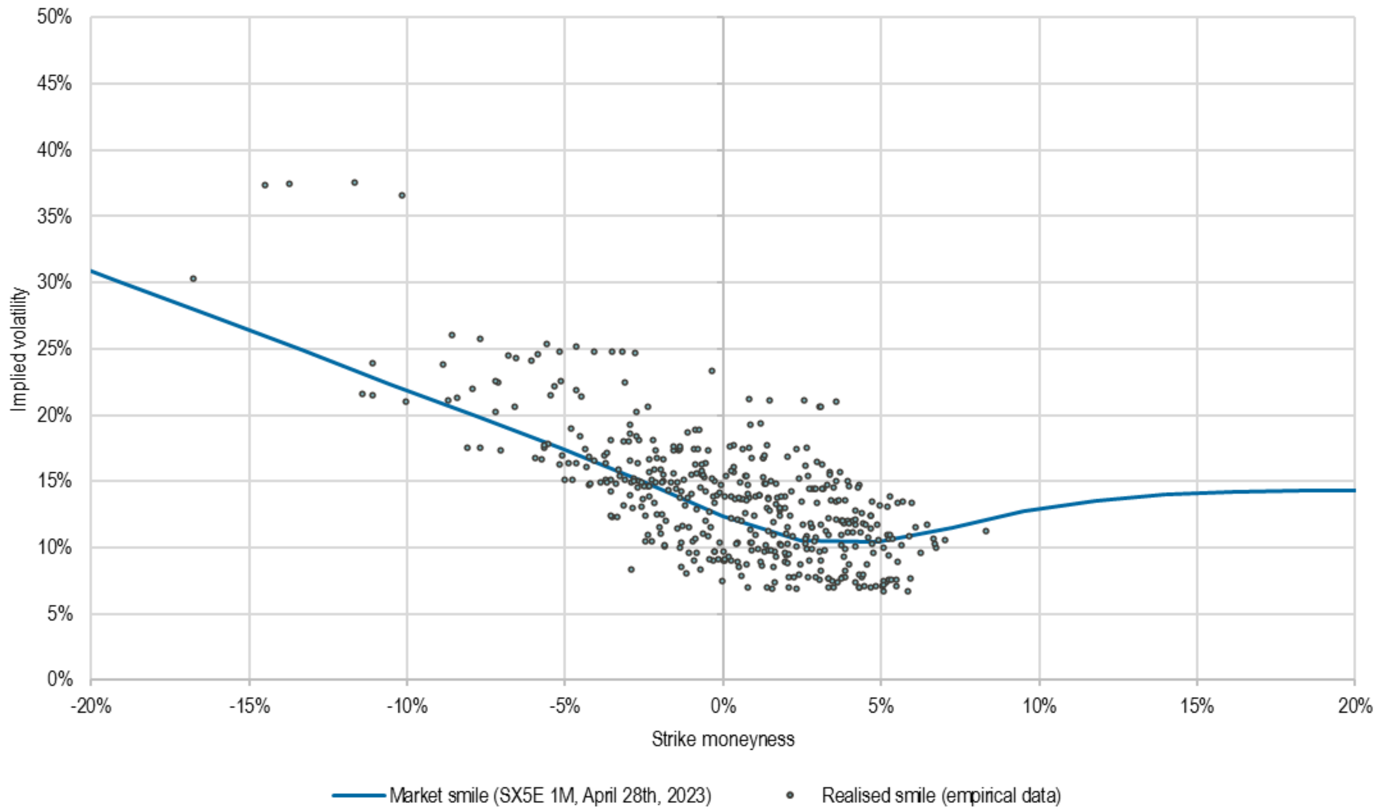
-11%	18%	24%	31%	29%	24%	27%														
-8%	17%	20%	20%	26%	26%	26%	25%		34%											
-4%	12%	15%	19%	21%	24%	26%	32%		31%	33%	71%									
-1%	11%	13%	16%	18%	21%	27%	29%	30%	33%	32%		56%								
2%	9%	12%	14%	18%	21%	23%	28%	32%	31%	32%	37%	36%								
6%		11%	15%	20%	22%	22%	25%	40%	33%	34%	36%	34%		35%						
9%			15%	21%	22%	24%	24%				34%					48%	52%	55%		
12%					21%	27%	33%	30%						48%			55%			53%
16%							28%											48%		49%

Source: J.P. Morgan Quantitative and Derivatives Strategy

Plotting it in scatterplot format and overlaying the market smile



Source: J.P. Morgan Quantitative and Derivatives Strategy

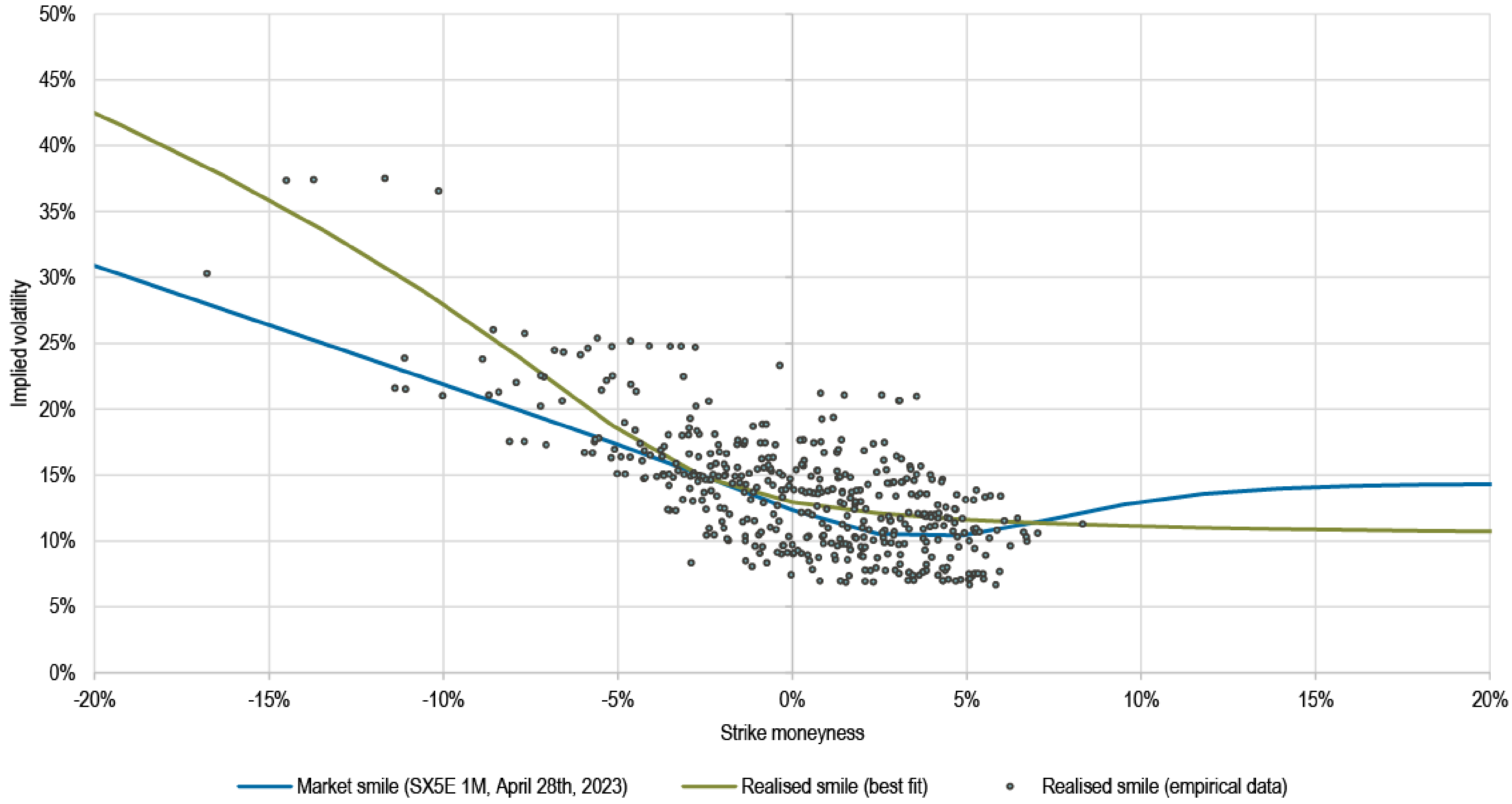
Final step: fitting a smile through the scatterplot

Non-arbitrage conditions → We can't just fit any curve.

We chose the so-called SVI family (SVI = "Stochastic Volatility Inspired"), introduced in 2014 by Gatheral and Jacquier.

$$t\hat{\sigma}(K)^2 = a + b\left\{\rho(K - m) + \sqrt{(K - m)^2 + c^2}\right\}$$

Our fitted smile

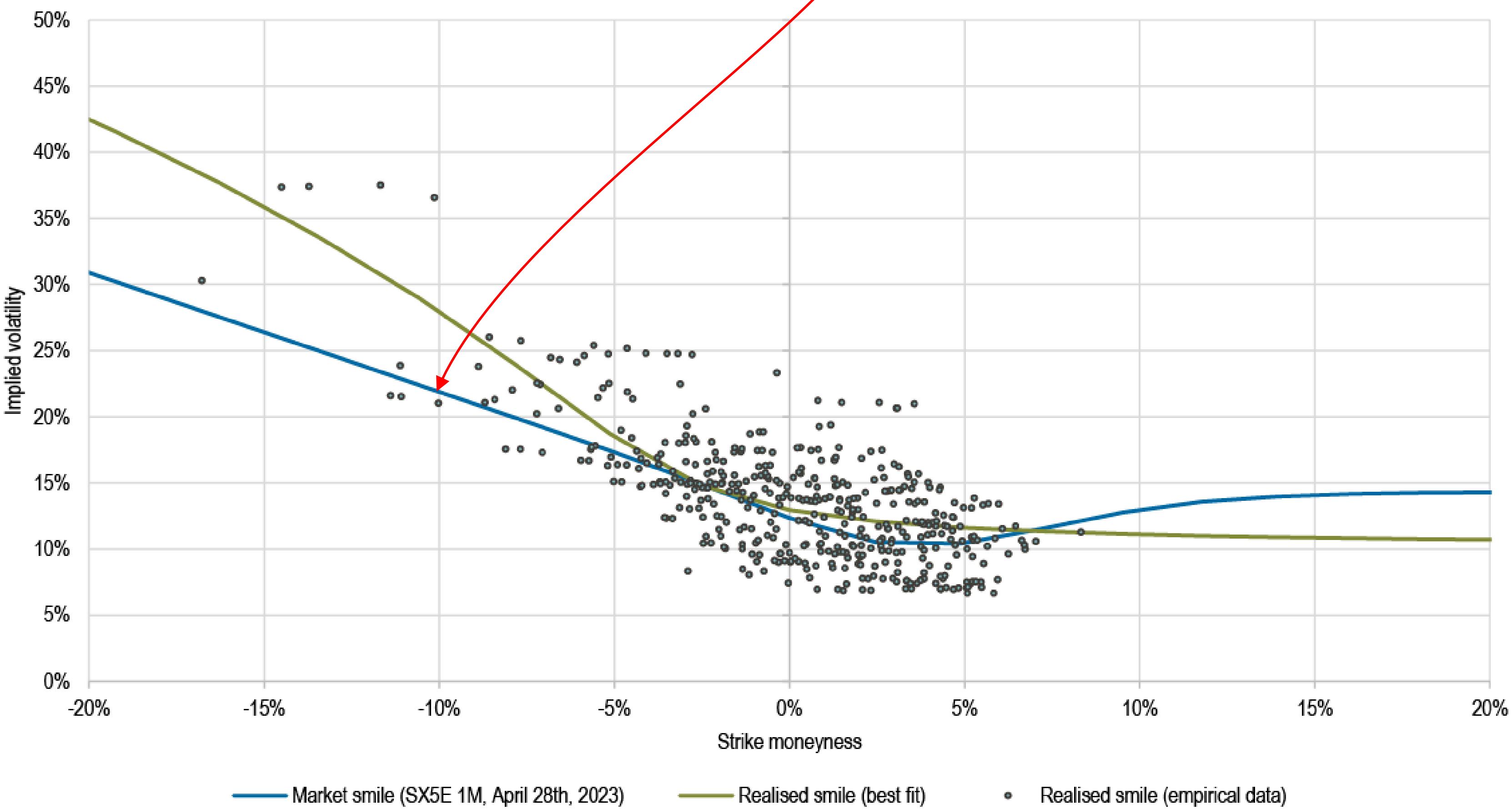


Source: J.P. Morgan Quantitative and Derivatives Strategy

Our fitted smile

We can now contextualize the implied vol level for the -10% strike:

Overall, puts look a little cheap, calls a little expensive.



Source: J.P. Morgan Quantitative and Derivatives Strategy

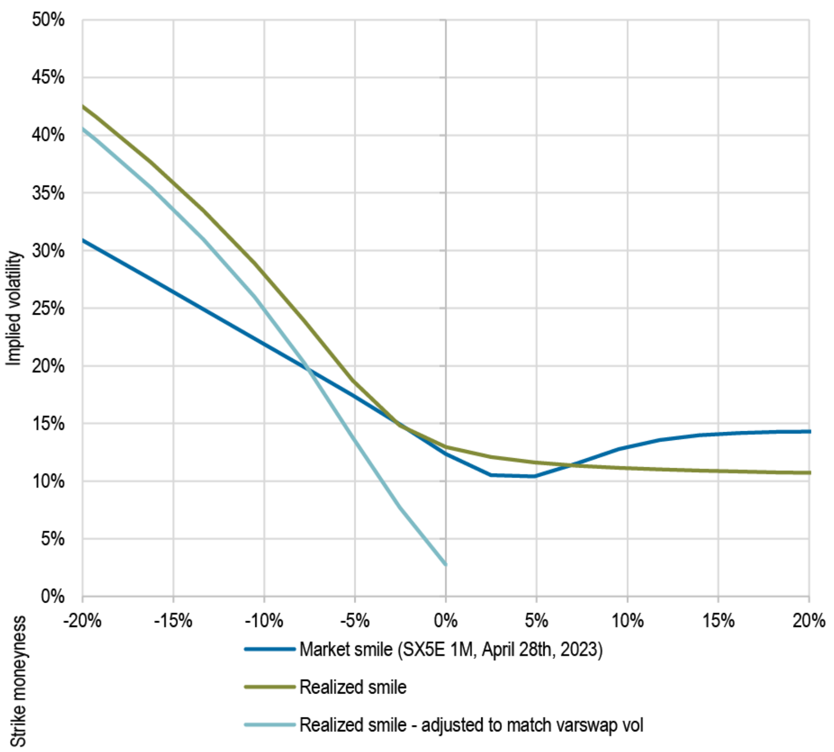
Bringing the risk premium in

Risk neutral measure vs physical measure:

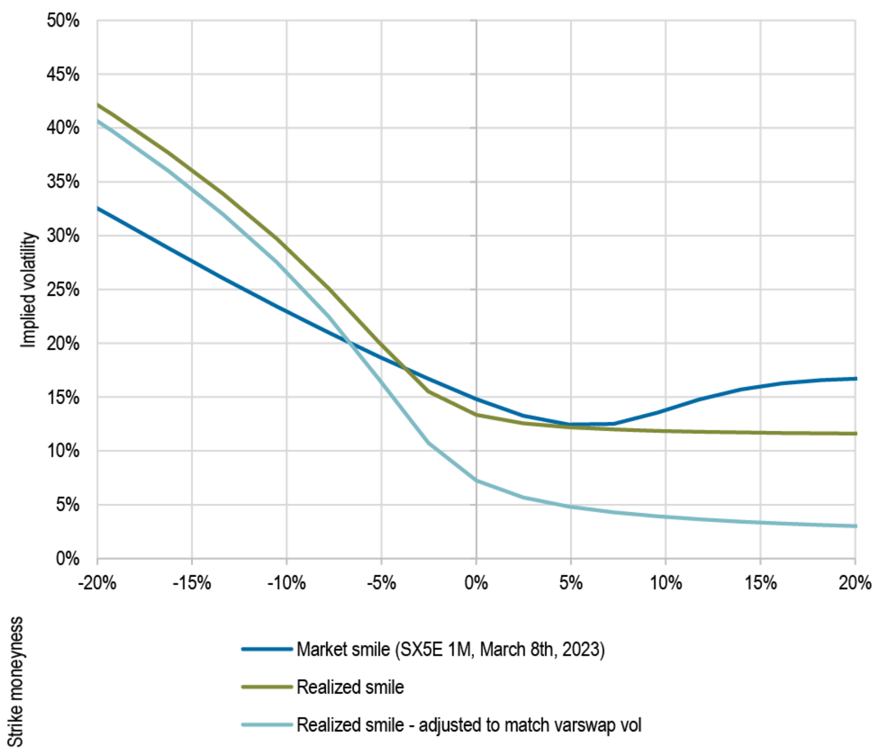
- Equation we saw earlier is true in a risk-neutral world, but we use it in a physical world.
- In particular, a var swap level consistent with our fitted smile need not match the market variance swap level.

Enforcing that consistency with a parallel shift distorts the smile significantly → probably not the right approach.

April 28th: parallel shifting squared smile sends calls into negative territory.



Better luck with March 8th, but smile is greatly distorted.



Source: J.P. Morgan Quantitative and Derivatives Strategy

Conclusion

Our method has caveats:

1. The smile that we produce does not embed information about the future
2. The equation that it builds on involves approximations
3. Choice of SVI family to fit smile was arbitrary. That choice probably matters the most for far OTM call strikes, given the scarcity of data there.

Yet:

1. There aren't very many tools available to assess the value of the smile, especially for long-dated maturities.
2. Some of the caveats above are also present in standard techniques for forecasting ATM-implied vol.
3. Our methodology is relatively straightforward to implement

Agenda

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Strike selection

Which vanilla option is the best sell?

Which SPX option to sell?

The vol premium is a natural candidate

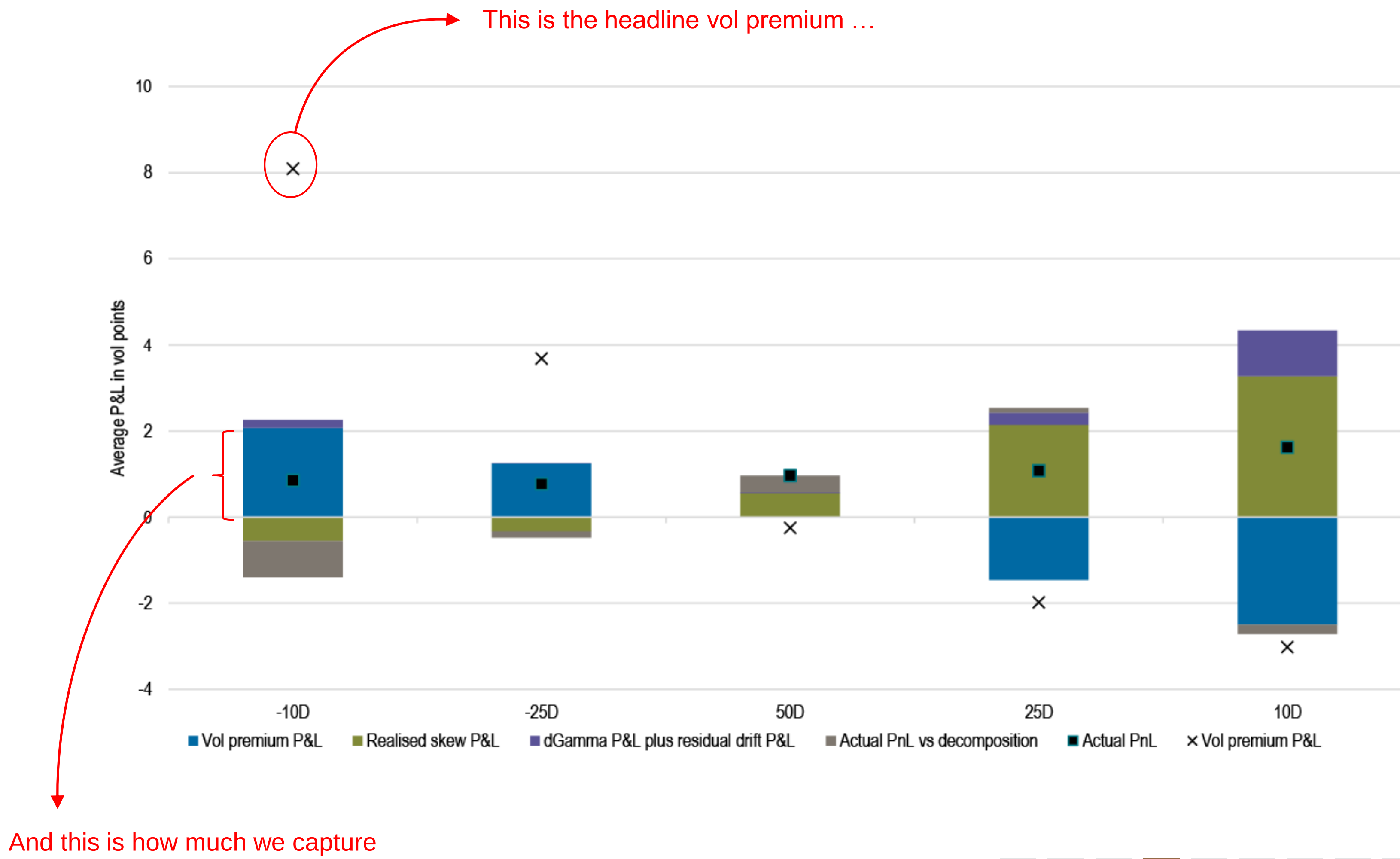
Average vol premium since 2006, in vol points. Positive means implied above realized.

	10% Delta Put	25% Delta Put	ATMF	25% Delta Call	10% Delta Call
1w expiry	6.0	3.6	1.6	-0.7	-1.1
1m expiry	8.1	3.7	-0.2	-2.0	-3.0
3m expiry	9.6	4.7	0.3	-2.0	-3.3
12m expiry	2.4	1.4	-0.2	-1.7	-3.5

Source: J.P. Morgan Quantitative and Derivatives Strategy

But we only capture a fraction of it

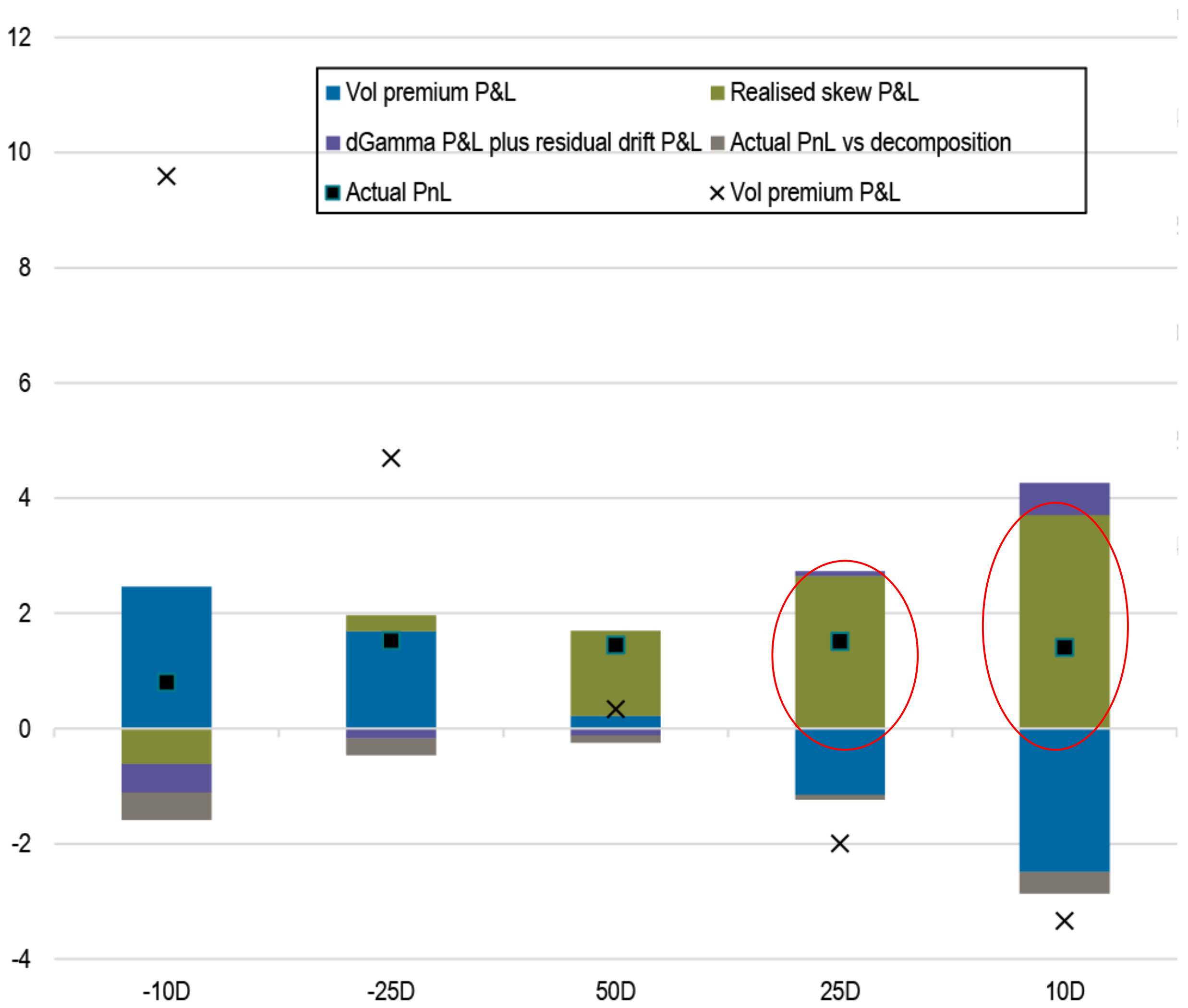
And that fraction depends on the moneyness



Strike selection: which vanilla option is the best sell?

Moreover, there is another major P&L driver beyond the vol premium

It is the skew effect, i.e. the directionality of realized vol



Source: J.P. Morgan Quantitative and Derivatives Strategy

Two P&L drivers, two regions of the expiry/tenor matrix

Short dated OTM puts: high vol premium P&L

	-10D	-25D	50D	25D	10D	Average
1w	1.12	0.46	0.03	0.01	0.48	0.42
1m	0.30	0.36	0.60	0.66	0.98	0.58
3m	0.22	0.61	0.67	0.74	0.68	0.58
12m	0.02	0.15	0.24	0.31	0.32	0.21
Average	0.41	0.39	0.38	0.43	0.62	0.45

Intermediate maturity OTM calls: high realized skew P&L

Source: J.P. Morgan Quantitative and Derivatives Strategy

In conclusion

When selling delta hedged options, two main P&L drivers: the vol premium and the realized skew

So two approaches when selecting a strike to sell:

- Look for a strike with a high vol premium (eg short dated OTM puts)
- Look for a strike benefitting from a high realized skew (eg intermediate maturities OTM calls)

An alternative : look for a strike where P&L comes mostly from one driver (eg intermediate maturities OTM puts).

Agenda

A foray into intraday realized vol forecasts

With 0DTEs in mind

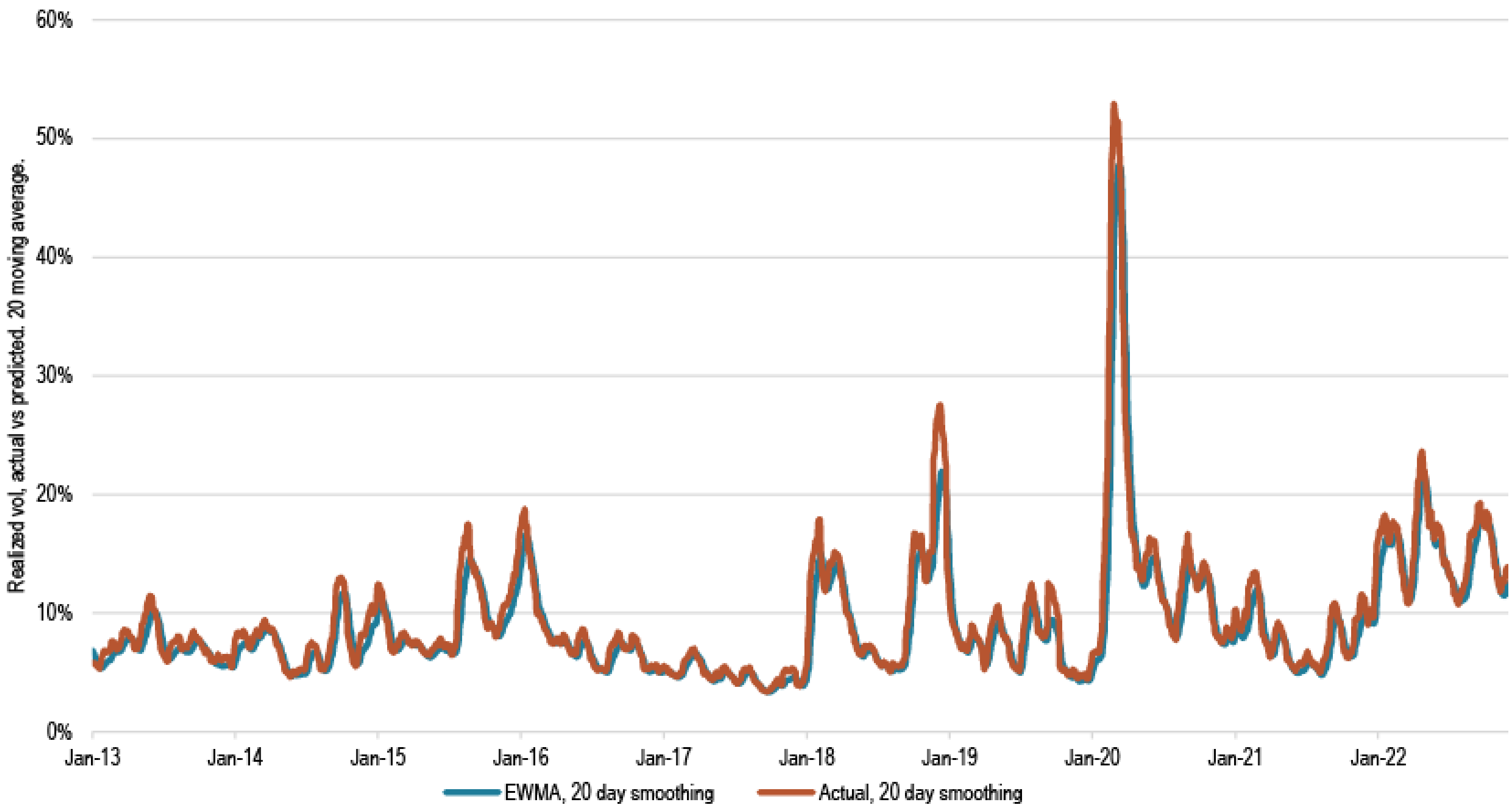
Forecasting realized vol over one day

A new area of market focus

- 2022: advent of same day SPX options
- Brought renewed focus on same day realized vol forecast, since this is what drives P&L
- A timely topic given recent advances in Machine Learning
- Short dated realized vol more amenable to forecasts than long dated realized vol

Our starting point: a simple moving average

EWMA already does a fairly decent job at forecasting same day realized vol (for SPX)



Source: J.P. Morgan Quantitative and Derivatives Strategy

Same day realized vol = Realized vol of one-minute returns from SPX open to SPX close.

Can we improve on that?

We can, by introducing more features (realized vol over intraday time samples) and machine learning algos

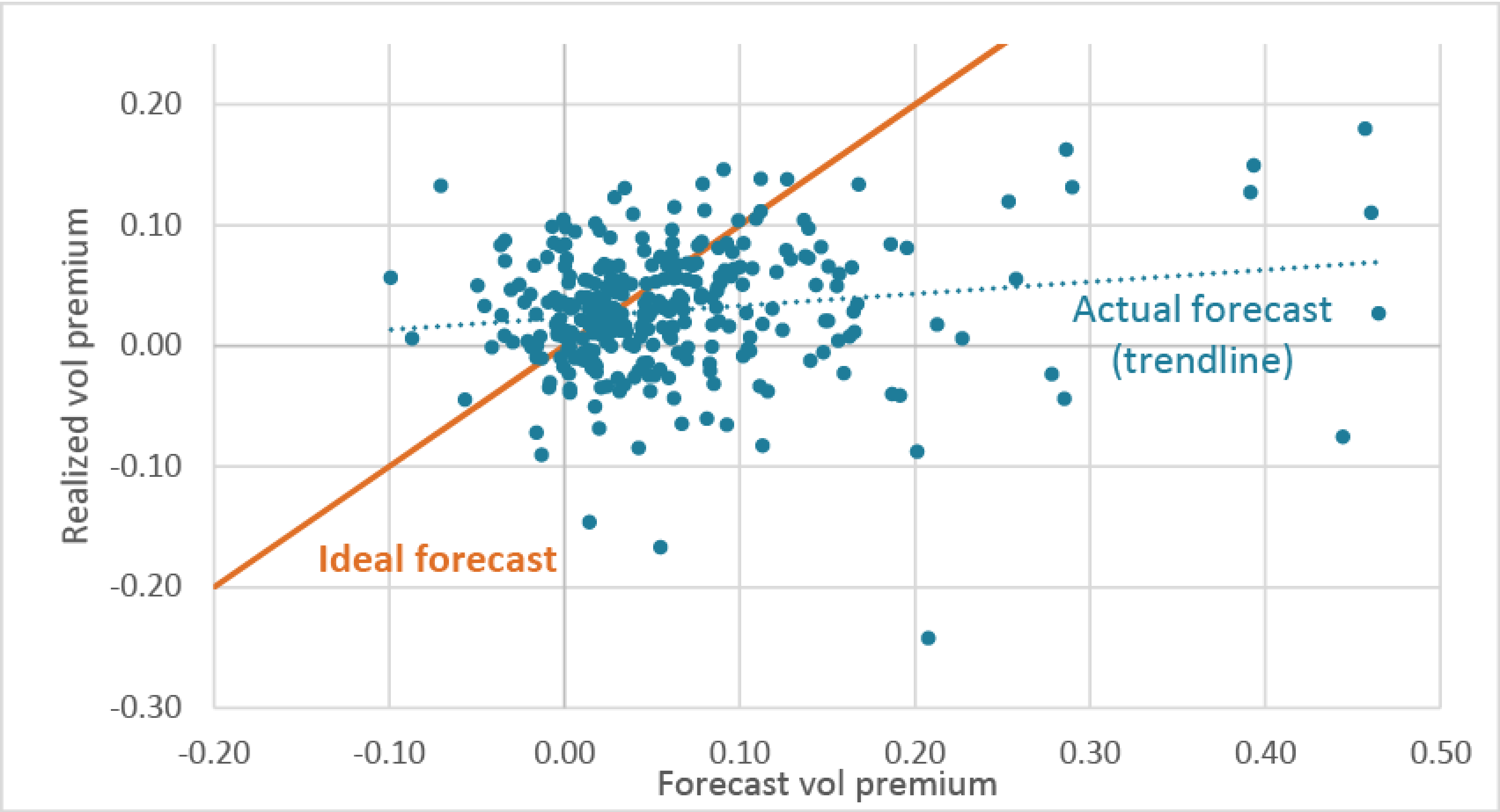
Mean squared error using EWMA with 20 days of daily realized vol is 65%. With intraday features and ML, it's 37%.

t-1 RV samples length (min)	MLP	OLS	XGB	LASSO	HAR	EWMA	Avg
60 mins	0.37	0.40	0.41	0.39	0.40	0.41	0.40
30 mins	0.55	0.54	0.60	0.53	0.53	0.56	0.55
10 mins	0.64	0.54	0.62	0.54	0.55	0.54	0.57

Source : J.P. Morgan Quantitative and Derivatives Strategy.

Trading implication: can we forecast the vol premium?

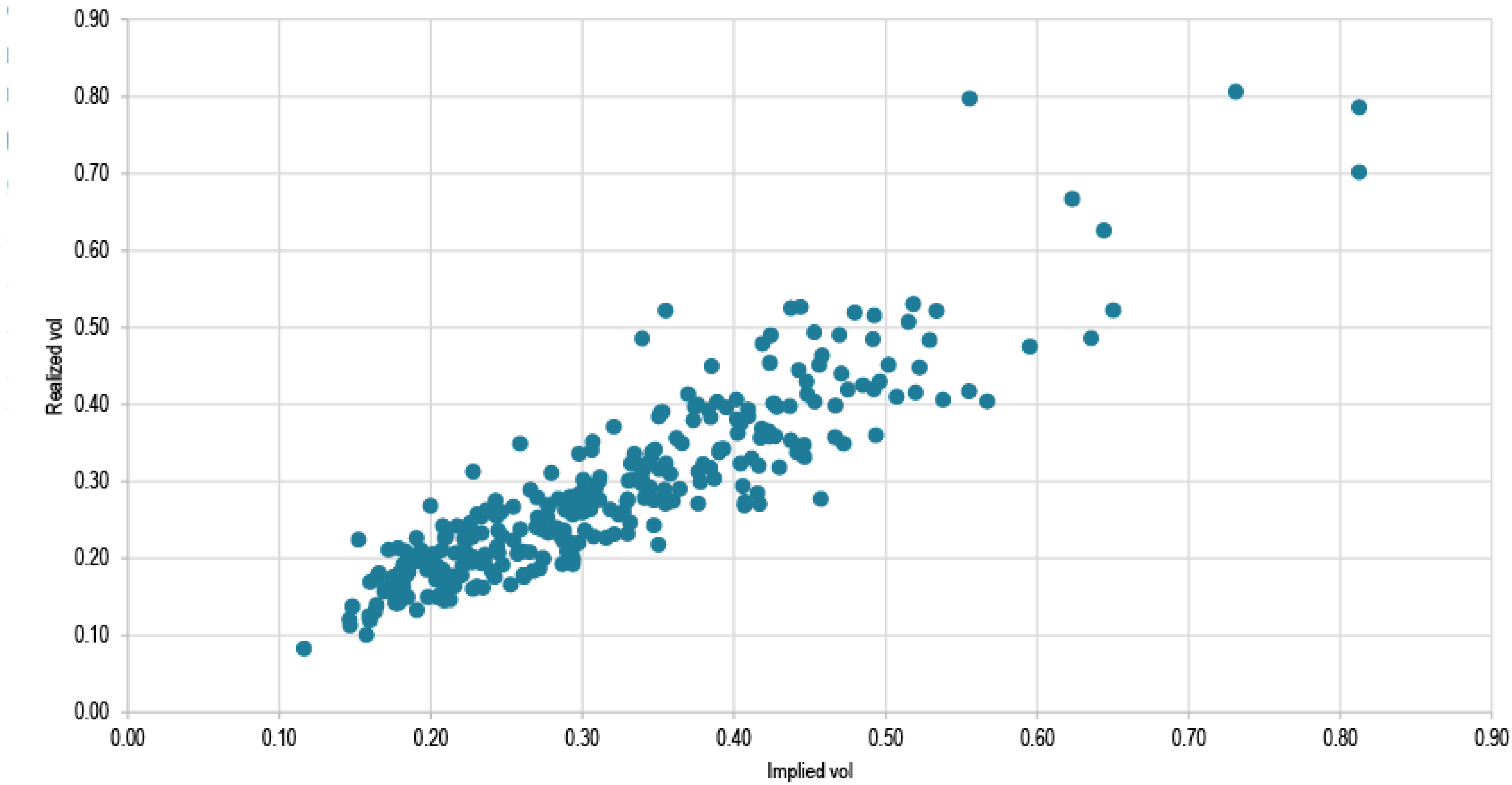
Our algorithm displays predictive power for vol premium, but not enough to use it as trading signal



Source: J.P. Morgan Quantitative and Derivatives Strategy

A high bar to clear: 0DTE market forecasts realized vol very accurately

The correlation between realized vol from 10am to 4pm and implied vol at 10am is 90%



Source: J.P. Morgan Quantitative and Derivatives Strategy

Agenda

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Zooming in on Put Ratios

Zooming in on Put Ratios

Definitions

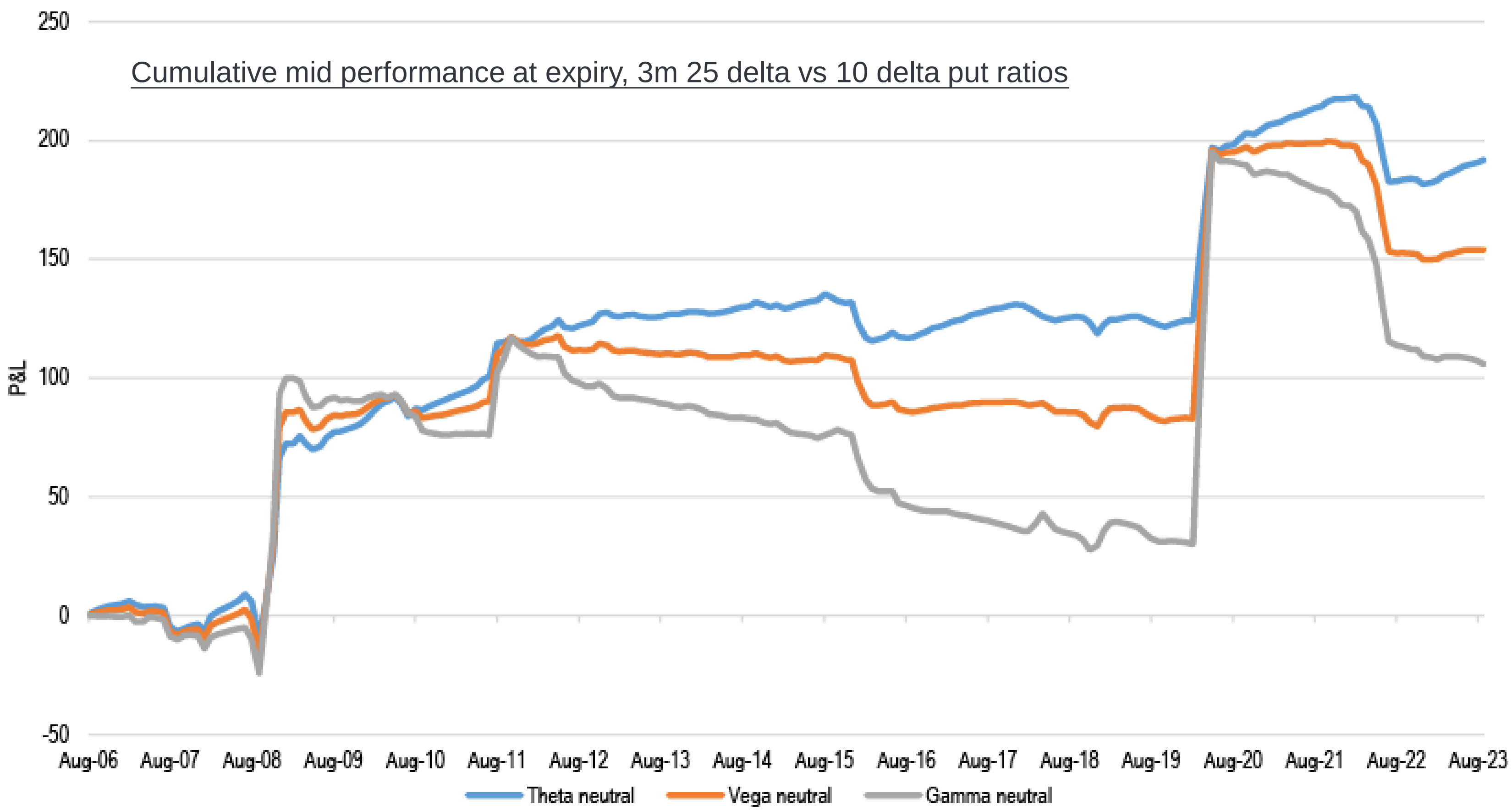
- Put ratios are a long short combination of two puts
- They’re basically put spreads whose legs notionals can differ.
- Directionally, two possibilities: long near strike and short far strike, or vice versa.
- When long far strike, can be used as defensive trade: if sized properly, the long leg dominates in a sell off.
- We focus on delta hedged version of this trade, so as to only retain exposure to vol.

Picking a weighting scheme

Amounts to choosing what exposure to neutralize

Neutralize inception exposure to:

- Implied vol → vega neutral
- Realized vol → gamma neutral
- Time → theta neutral



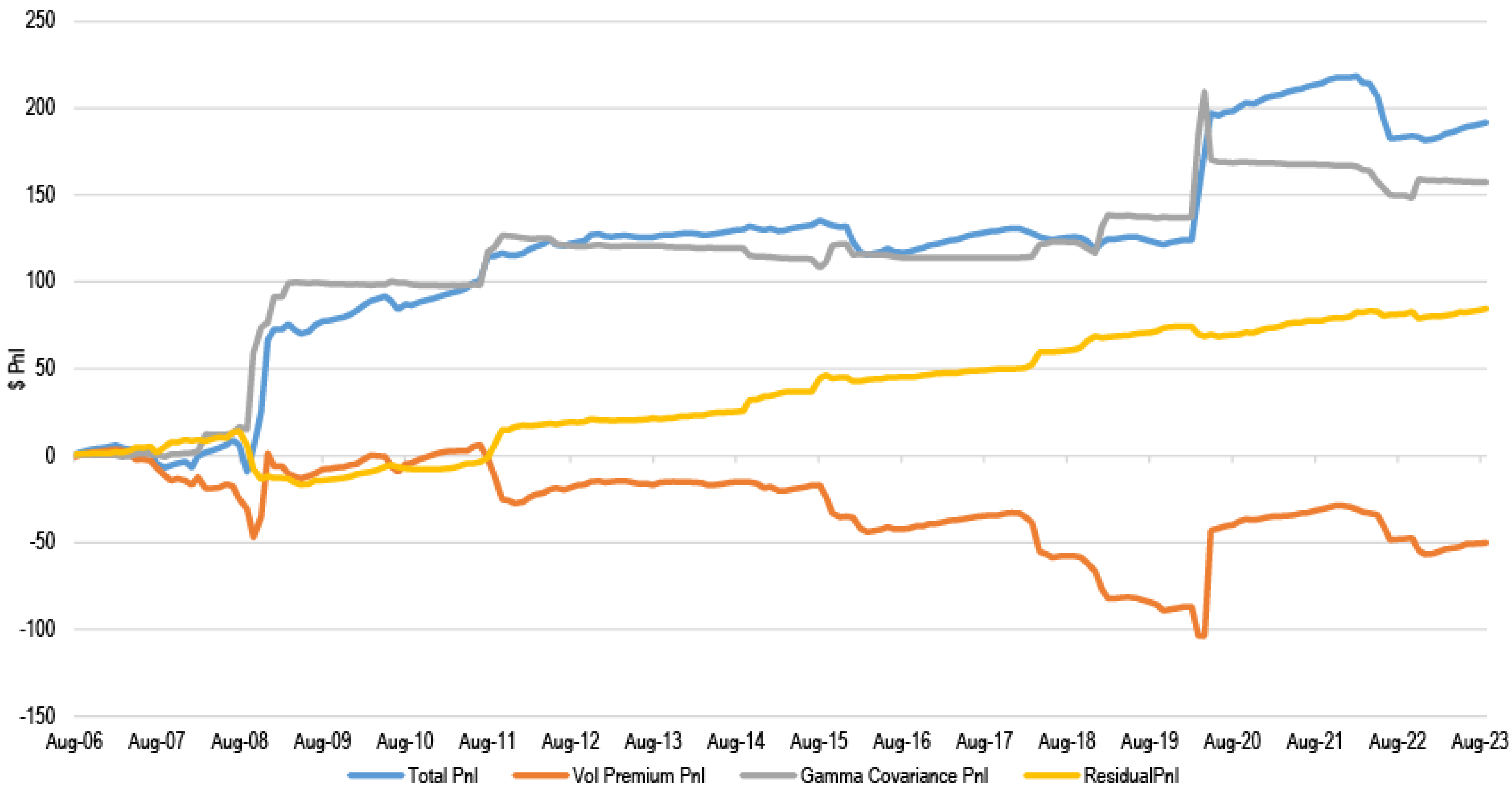
Zooming in on Put Ratios

Source: J.P. Morgan Quantitative and Derivatives Strategy

After inception, what drives P&L?

For theta neutral ratio, it's typically the gamma covariance effect

Cumulative mid performance at expiry, 3m 25 delta vs 10 delta theta neutral put ratios held to maturity



Source: J.P. Morgan Quantitative and Derivatives Strategy

Can we improve on that?

Reducing exposure to vol premium is one approach

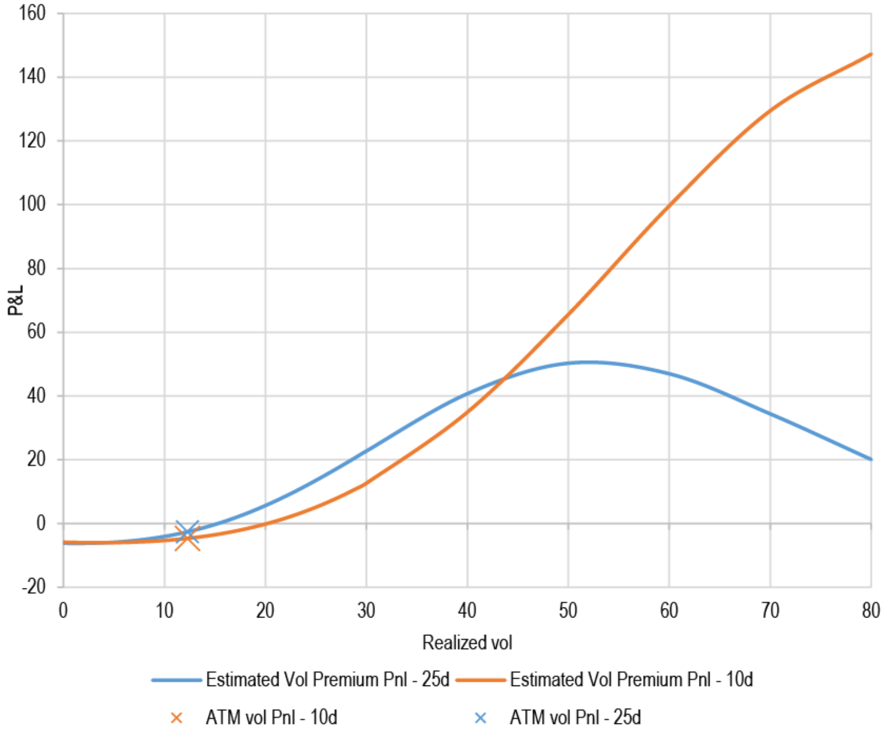
Two avenues:

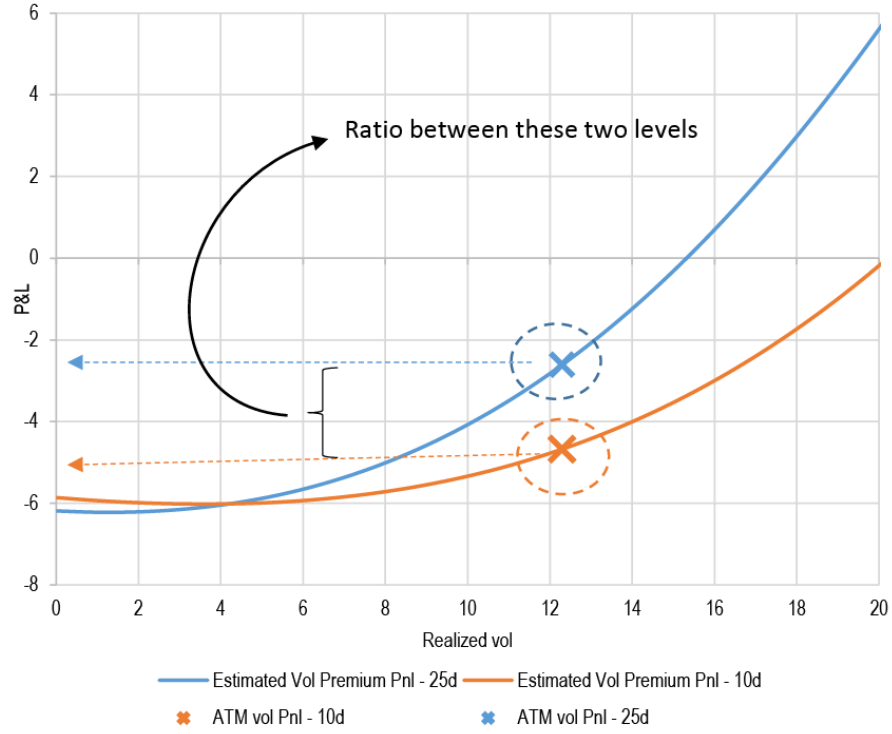
- Changing the ratio
- Changing the strikes

Changing the ratio (1/2)

Instead of neutralizing theta, neutralizing the P&L profile

Zero carry: solving for zero P&L when realized vol is equal to ATM vol.

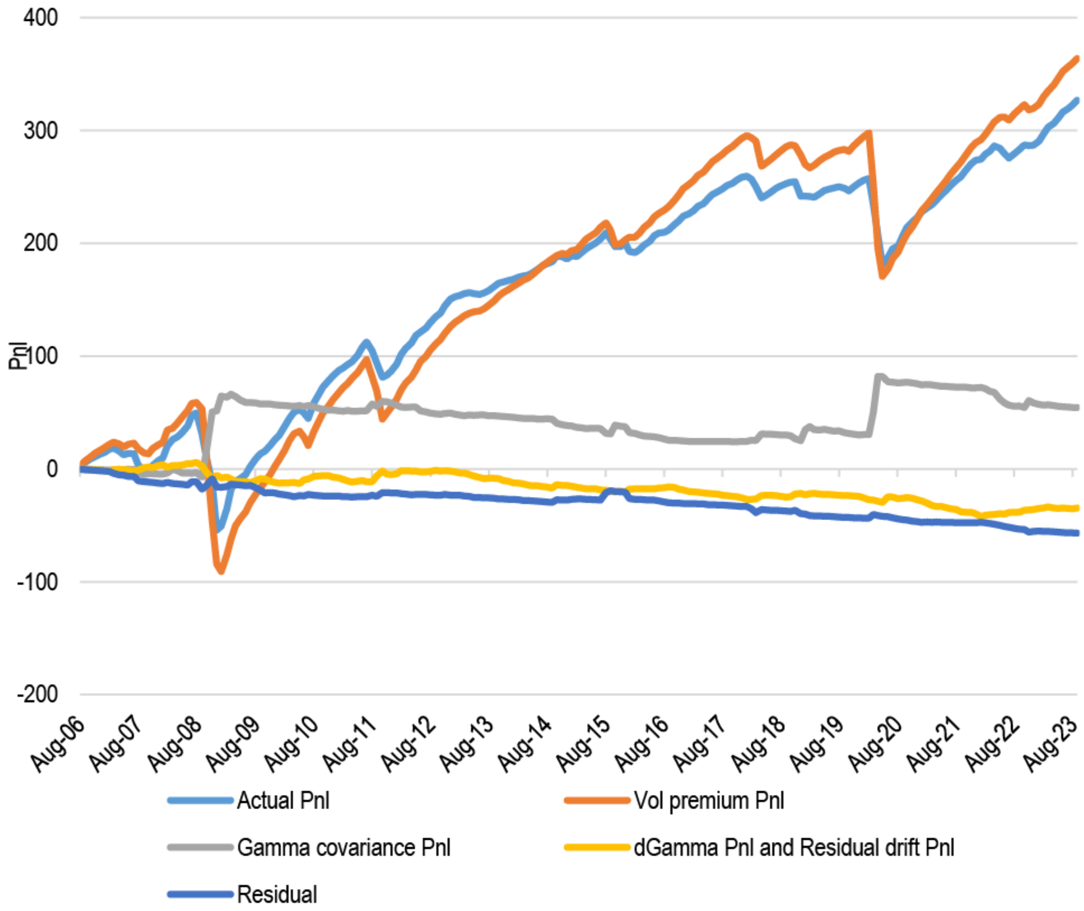




Source: J.P. Morgan Quantitative and Derivatives Strategy

Changing the ratio (2/2)

Unfortunately, this ATM neutral ratio results in a risk-on profile

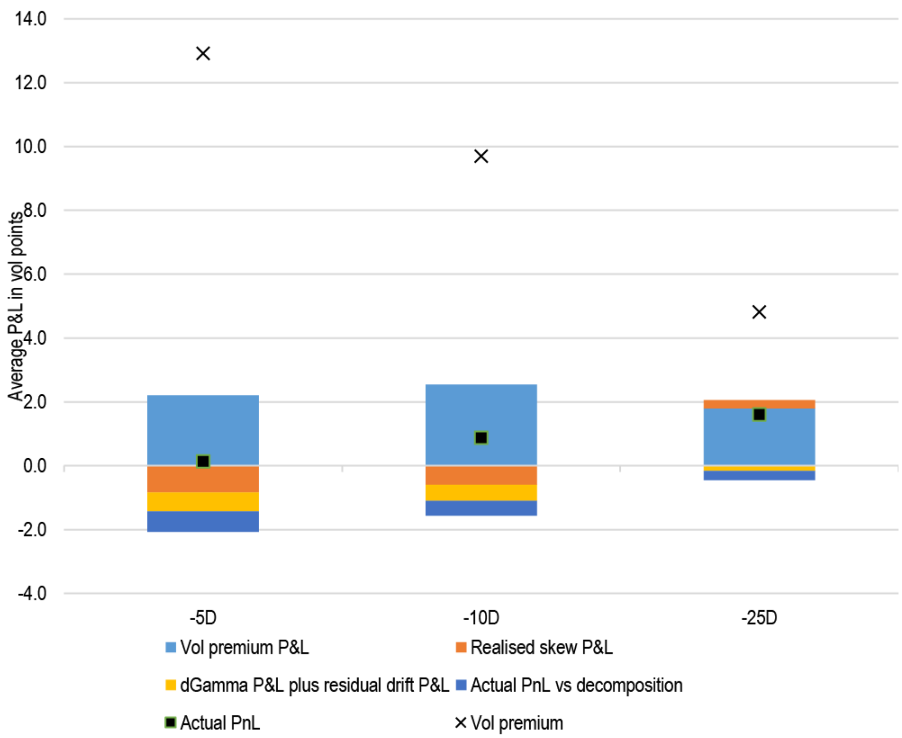


Source: J.P. Morgan Quantitative and Derivatives Strategy

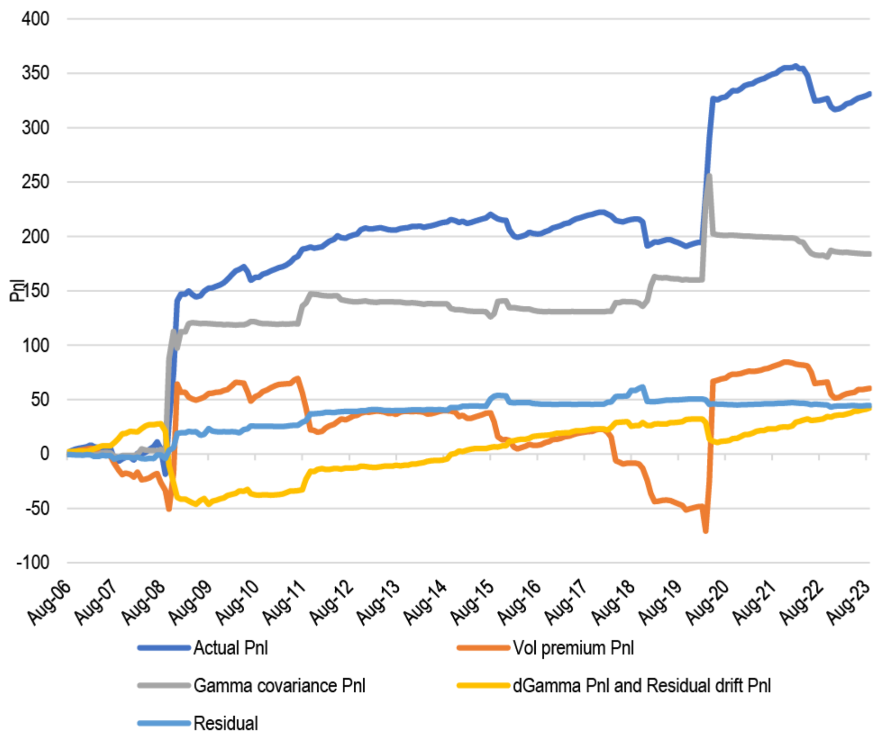
Changing the strikes

Look for more gamma covariance P&L and less vol premium P&L

Deep OTM strikes have more Gamma covariance P&L



25d vs 5d theta neutral ratios perform well as a result



Source: J.P. Morgan Quantitative and Derivatives Strategy

Conclusion

- Equity put ratios seem to be more reliant on the *directionality* of realized volatility than on its sheer quantity.
- In our framework, this means that they rely more on Gamma Covariance P&L than on Vol Premium P&L – mirror opposite of butterflies.
- Theta neutrality produces the best results in terms of neutralizing vol premium P&L and letting gamma covariance drive P&L
- Strike selection allows us to build on that approach.

Agenda

Delta hedging

Which scheme is best?

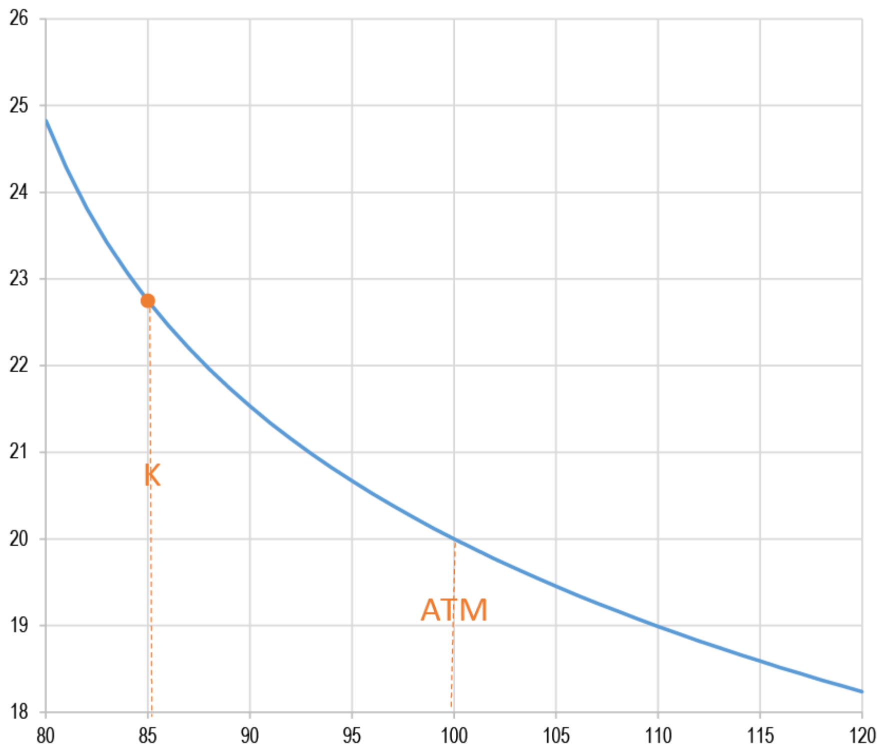
What is delta?

- Delta is the amount by which option price moves when underlying moves, all else equal.
- Its calculation requires a model.
- It is used to size the option’s delta hedge.
- Goal of delta hedge is to strip option of its dependency on underlying, so as to only retain exposure to realized vol.

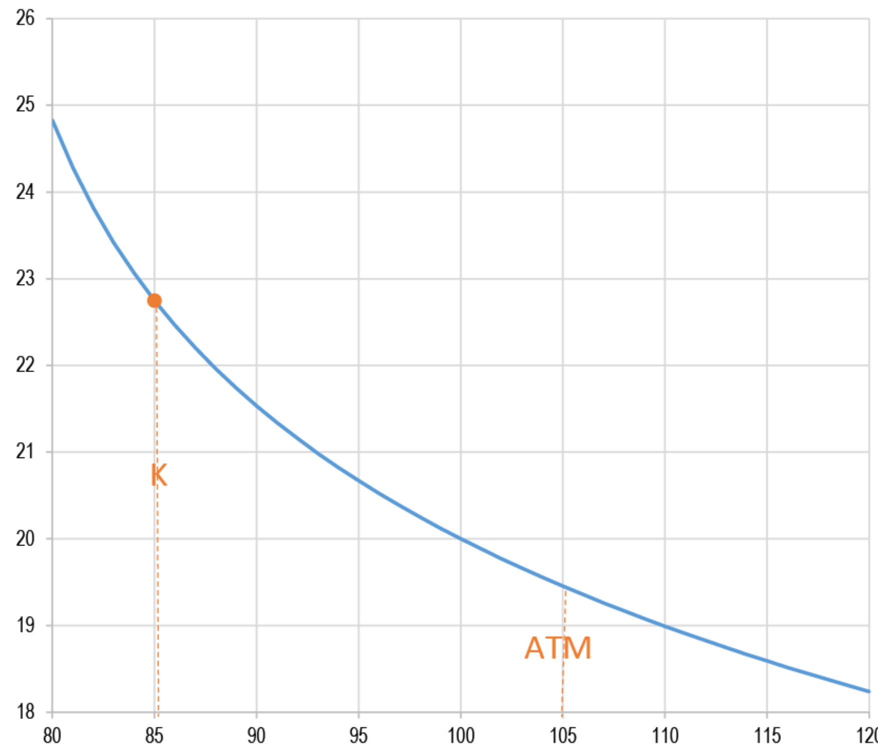
Some standard delta schemes (1/2)

The simplest of all: sticky strike, aka Black Scholes delta

Sticky strike: when spot moves…



… implied vol as a function of strike doesn't change.

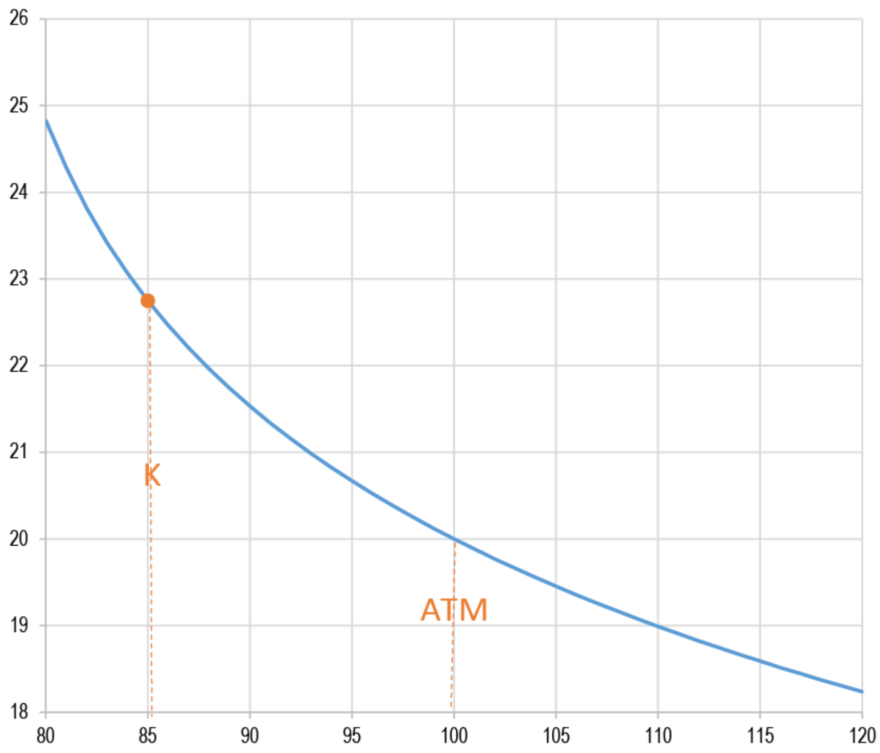


Source: J.P. Morgan Quantitative and Derivatives Strategy

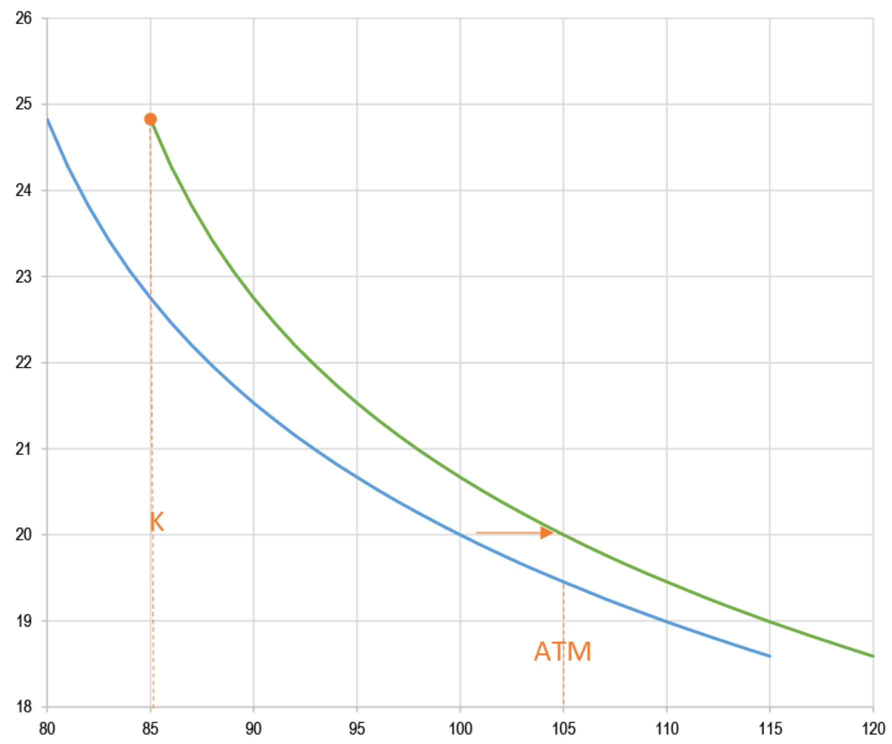
Some standard delta schemes (2/2)

The sticky delta rule: implied volatility is a constant function of moneyness

Sticky delta: vol as a function of moneyness …



… remains unchanged when spot moves.



Source: J.P. Morgan Quantitative and Derivatives Strategy

Measuring the contribution of a non Black Scholes scheme

We resort to our P&L attribution formula

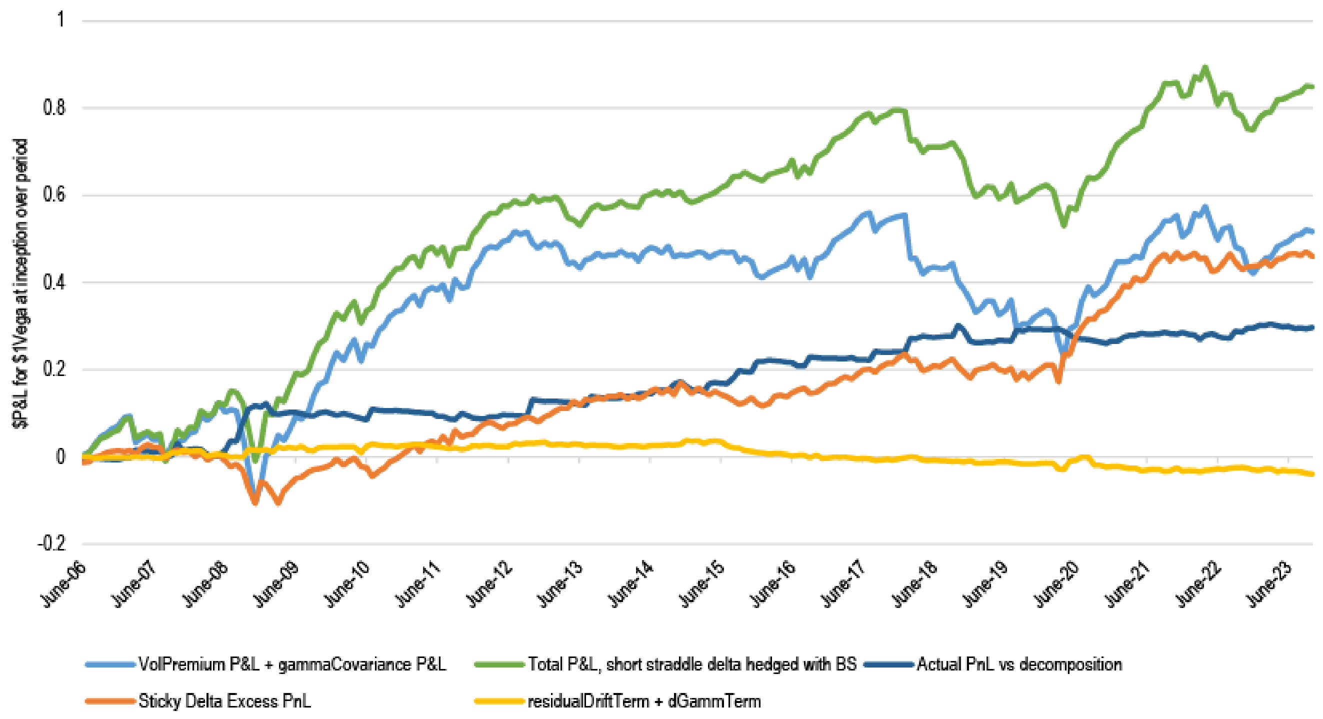
$$
\begin{aligned}
P\&L_{[0,t]} = \Bigg[& \overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*, \sigma^2\right)}^{\text{Gamma covariance effect}} \\
& + \overbrace{e^{-rt}\frac{\hat{\sigma}_t + \hat{\sigma}_0}{2\hat{\sigma}_t}\frac{\partial Q}{\partial \hat{\sigma}}(t)(\hat{\sigma}_t - \hat{\sigma}_0)}^{\text{Vega term}} - \overbrace{\int_0^t \frac{(T-s)}{2}(\hat{\sigma}_s^2 - \hat{\sigma}_0^2)\,d\Gamma_s^*}^{\text{dGamma term}} \\
& + \overbrace{\int_0^t \frac{e^{-rs}}{2}\left(\frac{1}{\hat{\sigma}}\frac{\partial Q}{\partial \hat{\sigma}} - \frac{\partial^2 Q}{\partial \hat{\sigma}^2}\right) d\left\langle \hat{\sigma}_s \right\rangle}^{\text{Residual drift term}} + \overbrace{\int_0^t \left(\text{Delta} - \frac{\partial Q}{\partial F}\right) dF_s}^{\text{Excess delta term}} \Bigg]
\end{aligned}
$$

Black-Scholes delta

Excess delta hedge P&L

Illustration: switching to sticky delta can improve performance

But it comes at a cost: a directional exposure to the underlying



Source: J.P. Morgan Quantitative and Derivatives Strategy

First do no harm (1/2)

In conventional framework, delta hedging aims to neutralize vega P&L

With the standard P&L breakdown, delta hedging:

- Reduces risk (by neutralizing noise from vega P&L)
- And does not hurt the true source of vol returns (the other Greeks)

$$\text{P\&L of a delta hedged option over } [0, t] = \sum \text{Theta P\&L} + \sum \text{Gamma P\&L} + \sum \text{Vega P\&L} + \sum \text{Vanna P\&L} + \sum \text{Volga P\&L}$$

First do no harm (2/2)

With our framework, there is no vega P&L to hedge

- With our framework, the Vega P&L of an option hedged with Black Scholes vanishes at expiry.
- So for the delta hedging scheme not to add an unwarranted source of returns, its non Black Scholes P&L must add up to zero.
- That’s a much higher bar to clear.

Conclusion

- Through the lens of our decomposition, the Black Scholes delta plays a special role:
- It alone turns the option into a pure variance derivative.
- Consequently, other delta hedging rules add a delta-1 strategy to the option's variance P&L.
- While such rules may reduce daily risk, they are subject to pitfalls:
  - Introduction of directional bias
  - Risk of strategy being risk-additive when vol dynamic changes
  - Factor overlap with other strategies in the portfolio
- For investors considering such a scheme, our decomposition provides a new way to detect potential issues.

Agenda

A simple framework

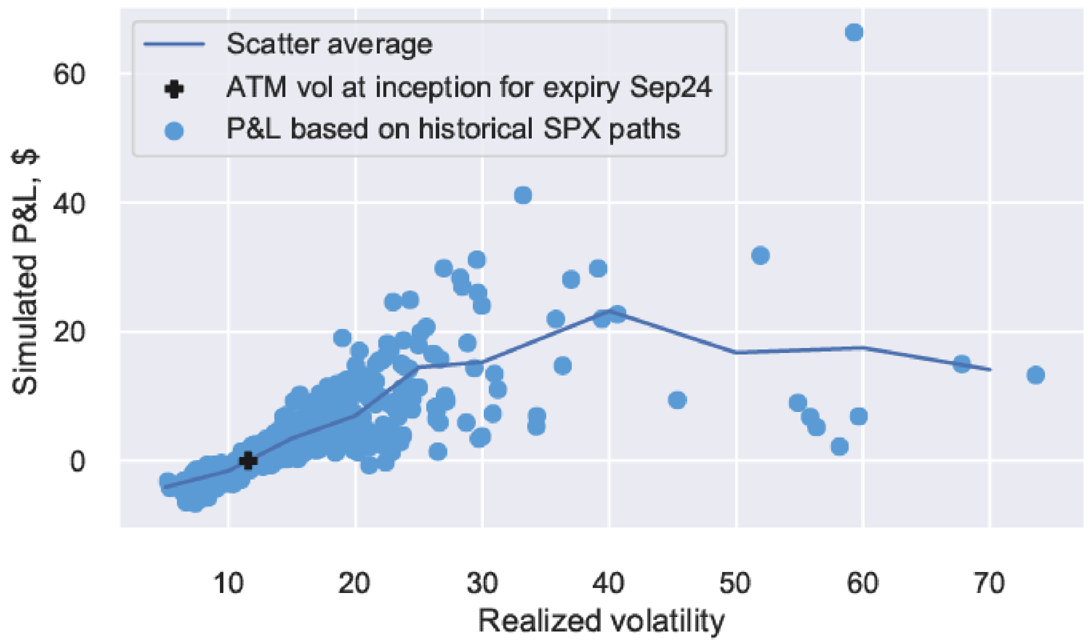
When delta-hedging with inception vol and holding to maturity, option P&L is simple

$$P\&L_{[0,T]} = \int_0^T \frac{1}{2}\Gamma_t^*(\sigma_t^2 - \hat{\sigma_0}^2)dt$$

In that framework, historical simulations are (reasonably) straightforward

All we need is historical paths for the underlying.

Simulated risk profile of a 3m ATM SPX call as of March 15th, 2024:

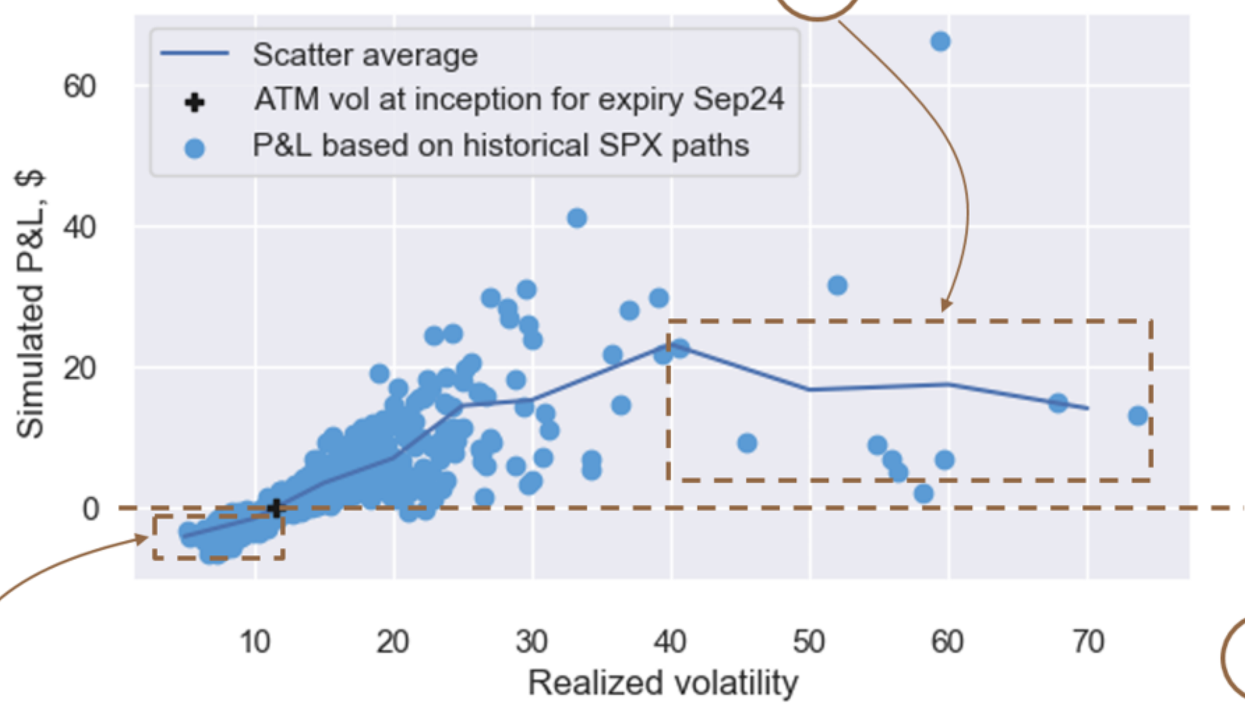


Source: J.P. Morgan Quantitative and Derivatives Strategy

Once we know how to estimate risk profile, we can optimize it

Example: a defensive strategy, for which we maximize crisis upside

1 Maximize average P&L when realized vol >= 40%



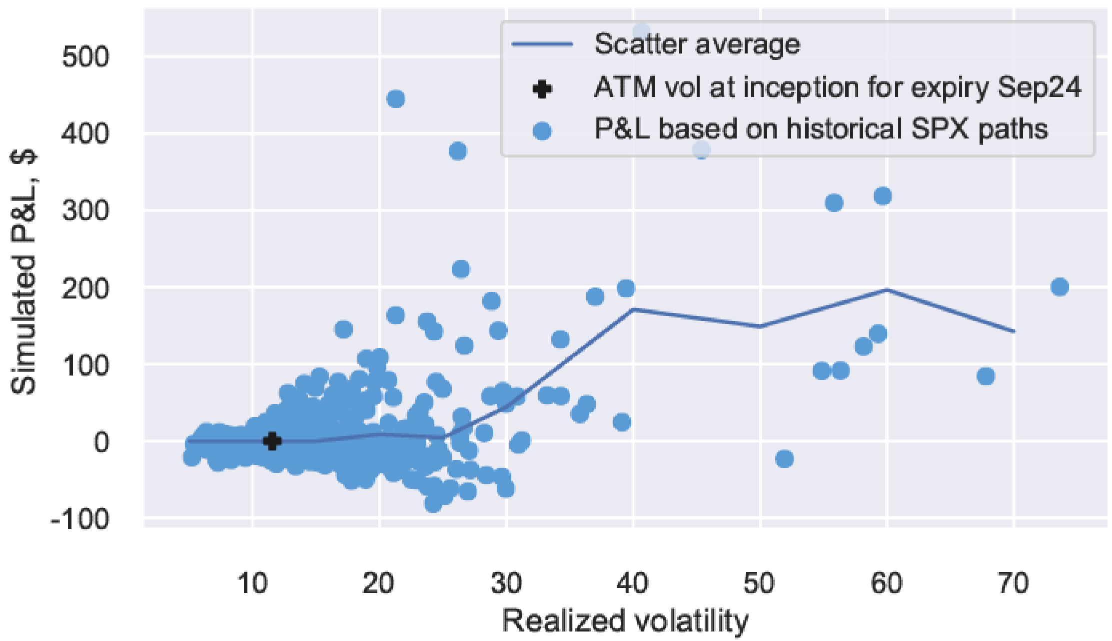
3 And size of each option range bound (here inception vega for each strike <= $2)

2 Subject to average P&L for each realized vol bucket >=0 …

Source: J.P. Morgan Quantitative and Derivatives Strategy

Resulting risk profile: as expected

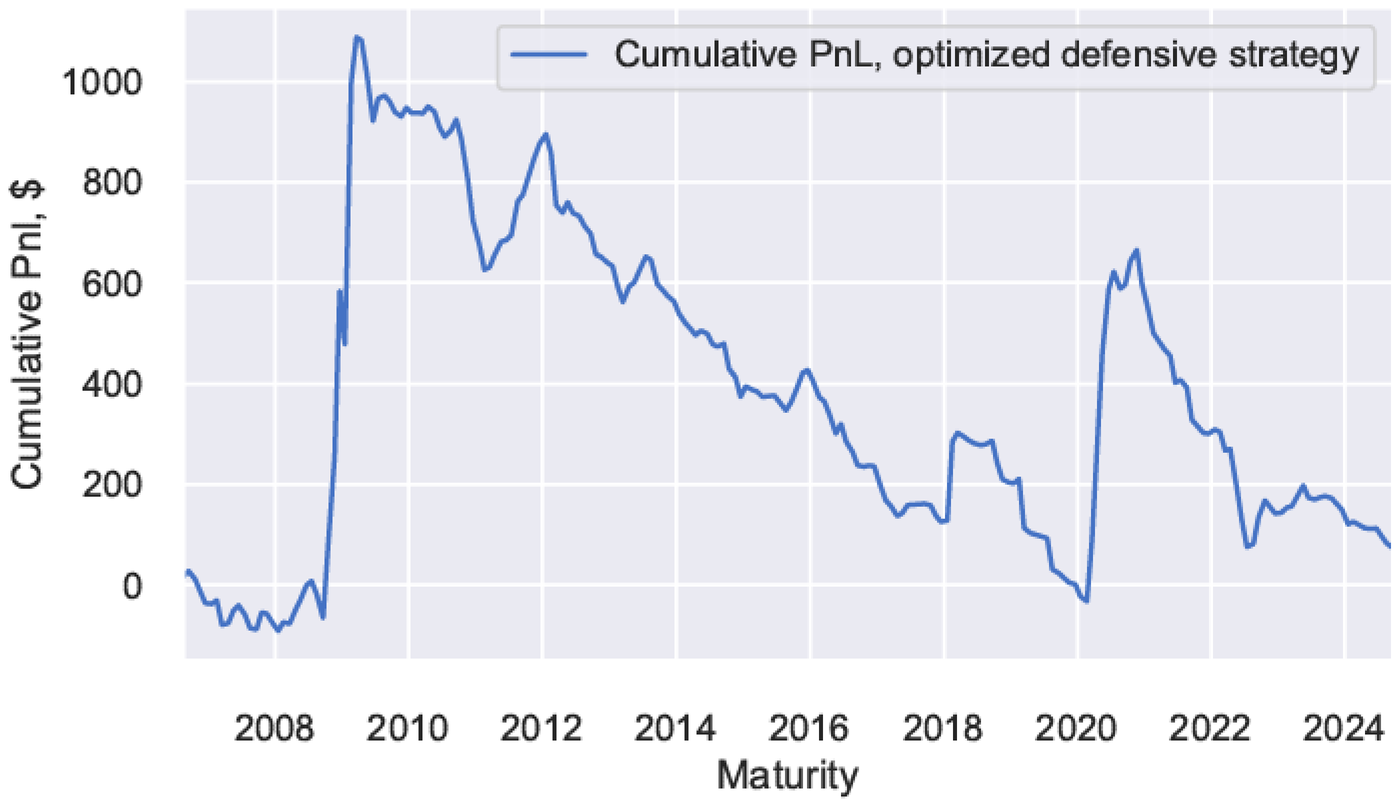
Large average payout in a crisis, non negative average payout elsewhere



Source: J.P. Morgan Quantitative and Derivatives Strategy

Addressing the carry issue

Our strategy behaves as expected during crises, but carries poorly the rest of the time

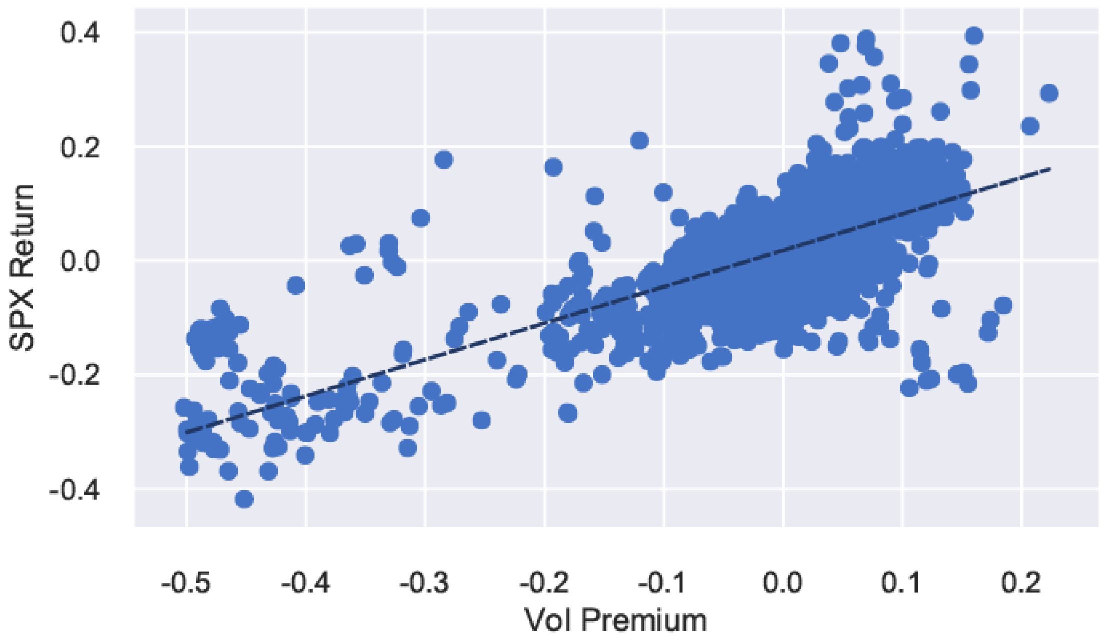


Source: J.P. Morgan Quantitative and Derivatives Strategy

Maybe not all historical path are equally likely?

Historically, a significant correlation between vol premium and SPX returns. .

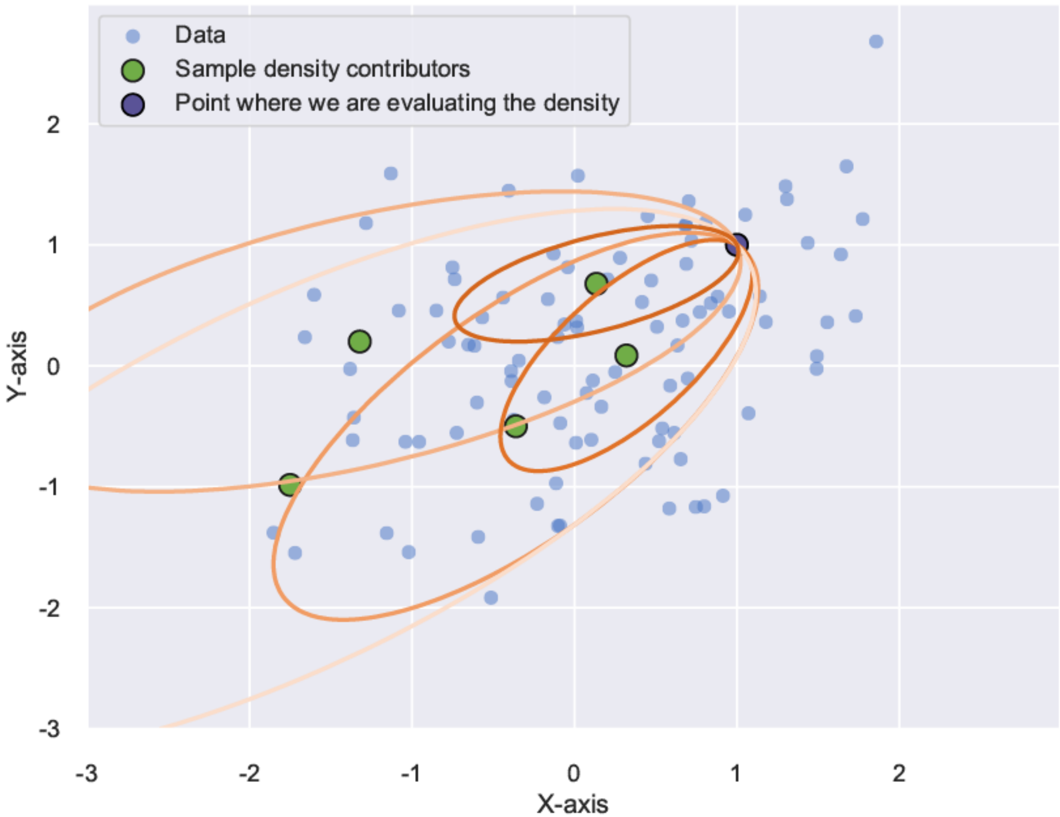
So historically paths for which spot rallied but realized vol was below implied are less likely.



Source: J.P. Morgan Quantitative and Derivatives Strategy

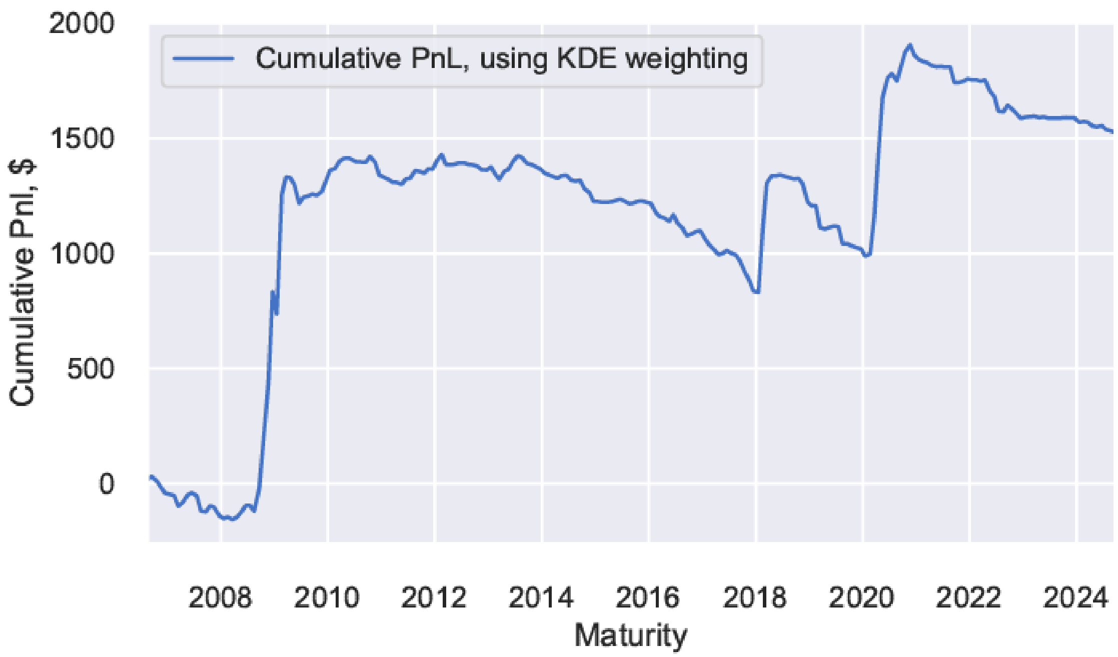
Weighting historical outcomes based on their likelihood

Kernel Density Estimators come in handy



Source: J.P. Morgan Quantitative and Derivatives Strategy

Optimisation using KDE-weighted data improves carry significantly



Source: J.P. Morgan Quantitative and Derivatives Strategy

Conclusion

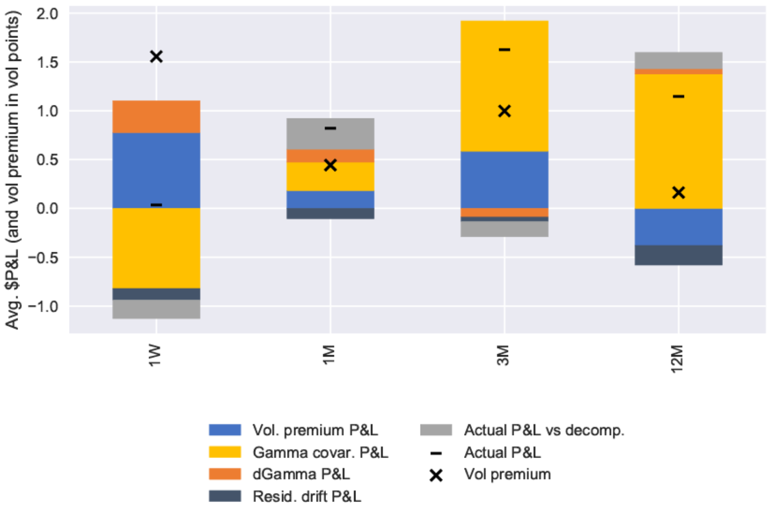
- Probability-weighting the historical universe resulted in out-of-sample behaviour much more in line with what we expected.
- Some room for improvement, however: in spite of flat performance during extended periods (2010-2014, 2023-2024), average carry is negative over backtest period.
- One avenue to explore is bucketing mechanism used in calculating average expected P&L.

Agenda

Where vol realizes has a strong impact on option P&L

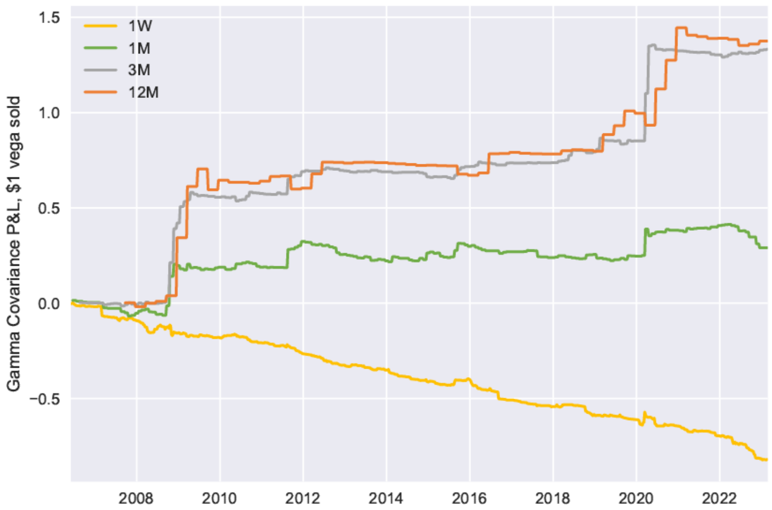
Path-dependent P&L is a significant driver

P&L breakdown, short delta-hedged straddles held to maturity, average over past 15 years



For one-week options, a drift-like effect

Cumulative P&L contribution from gamma covariance effect (short delta-hedged straddles)



Source: J.P. Morgan Quantitative and Derivatives Strategy

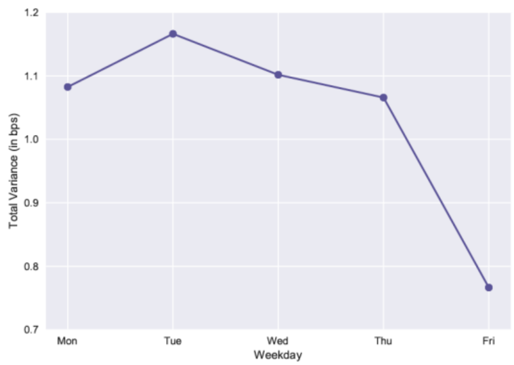
A possible explanation: intraweek vol pattern and upward SPX drift

When SPX rises through the week, Friday vol tends to be lower

Zooming in on weeks when the gamma covariance effect was negative:

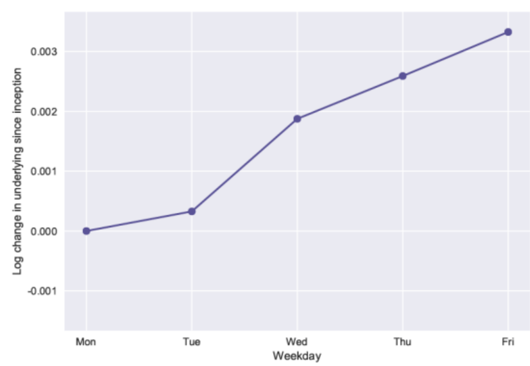
Vol drops on Fridays

Avg. close-to-close squared returns



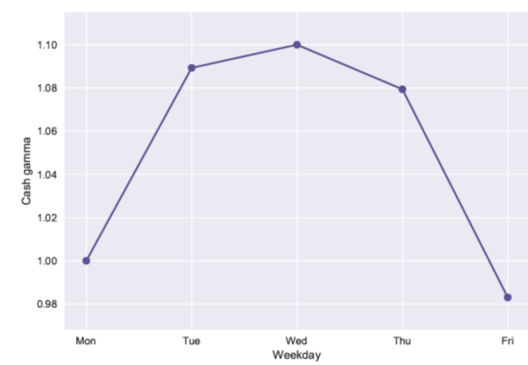
SPX rises through the week

Cumulative log SPX returns



Gamma rises then falls

Avg. cash gamma

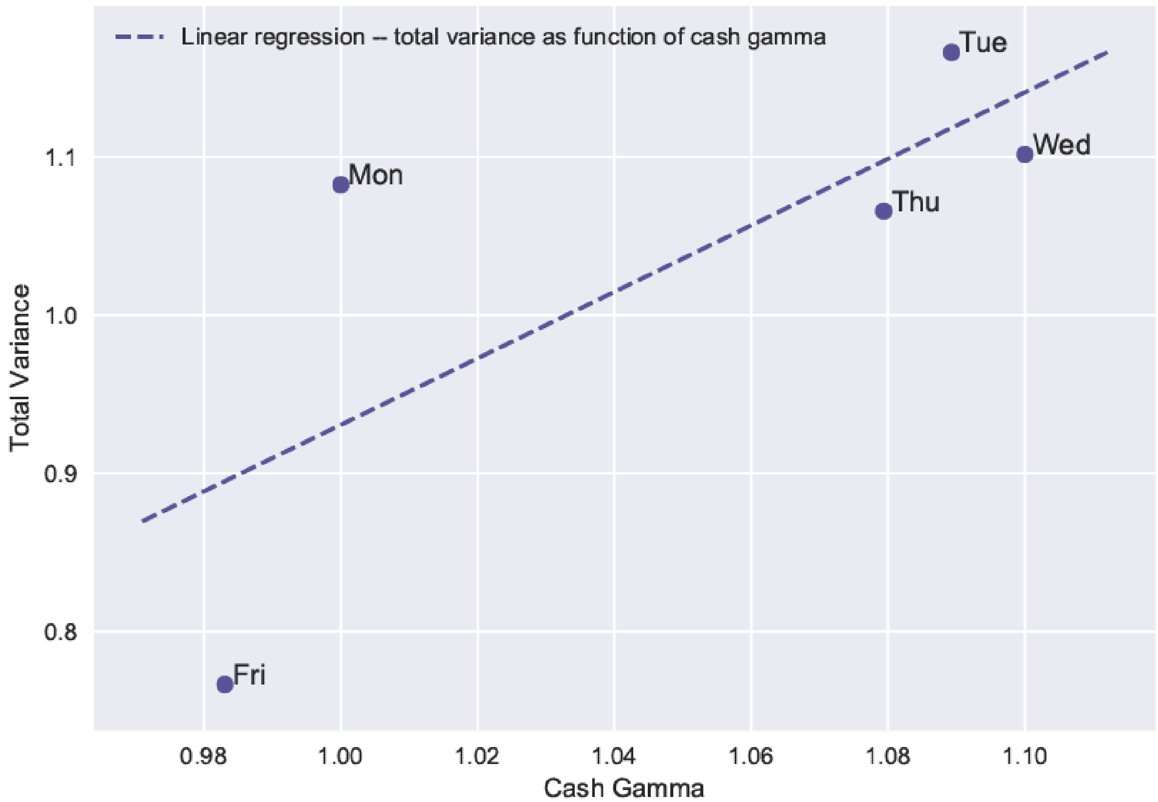


Source: J.P. Morgan Quantitative and Derivatives Strategy

Taken together, these effects generate a headwind for vol sellers

As gamma is low when realized vol is low

For each day of the week, average total variance vs average cash gamma (scaled by inception gamma):

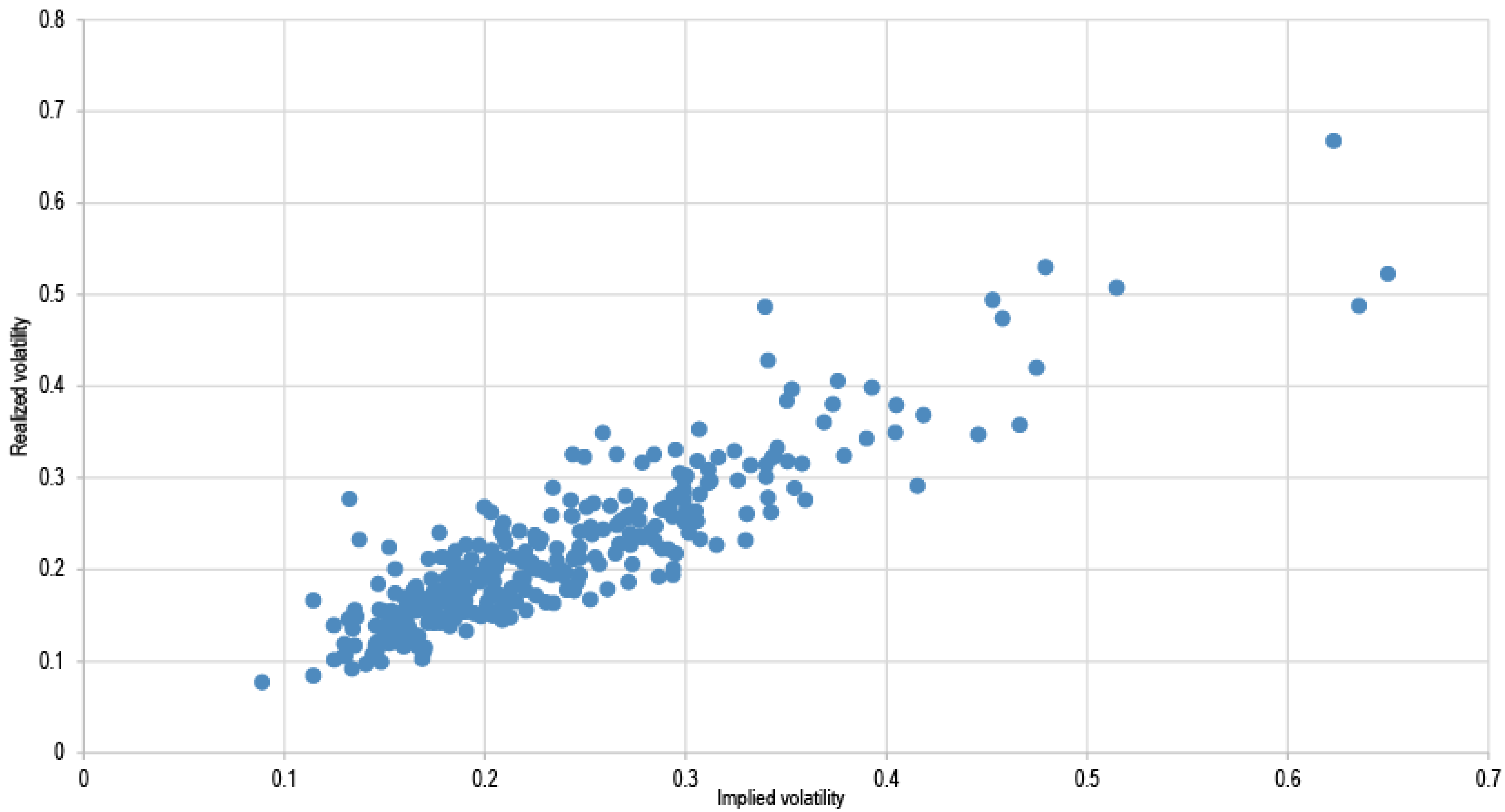


Source: J.P. Morgan Quantitative and Derivatives Strategy

Agenda

0DTE implied vol is a very good predictor of realized volatility

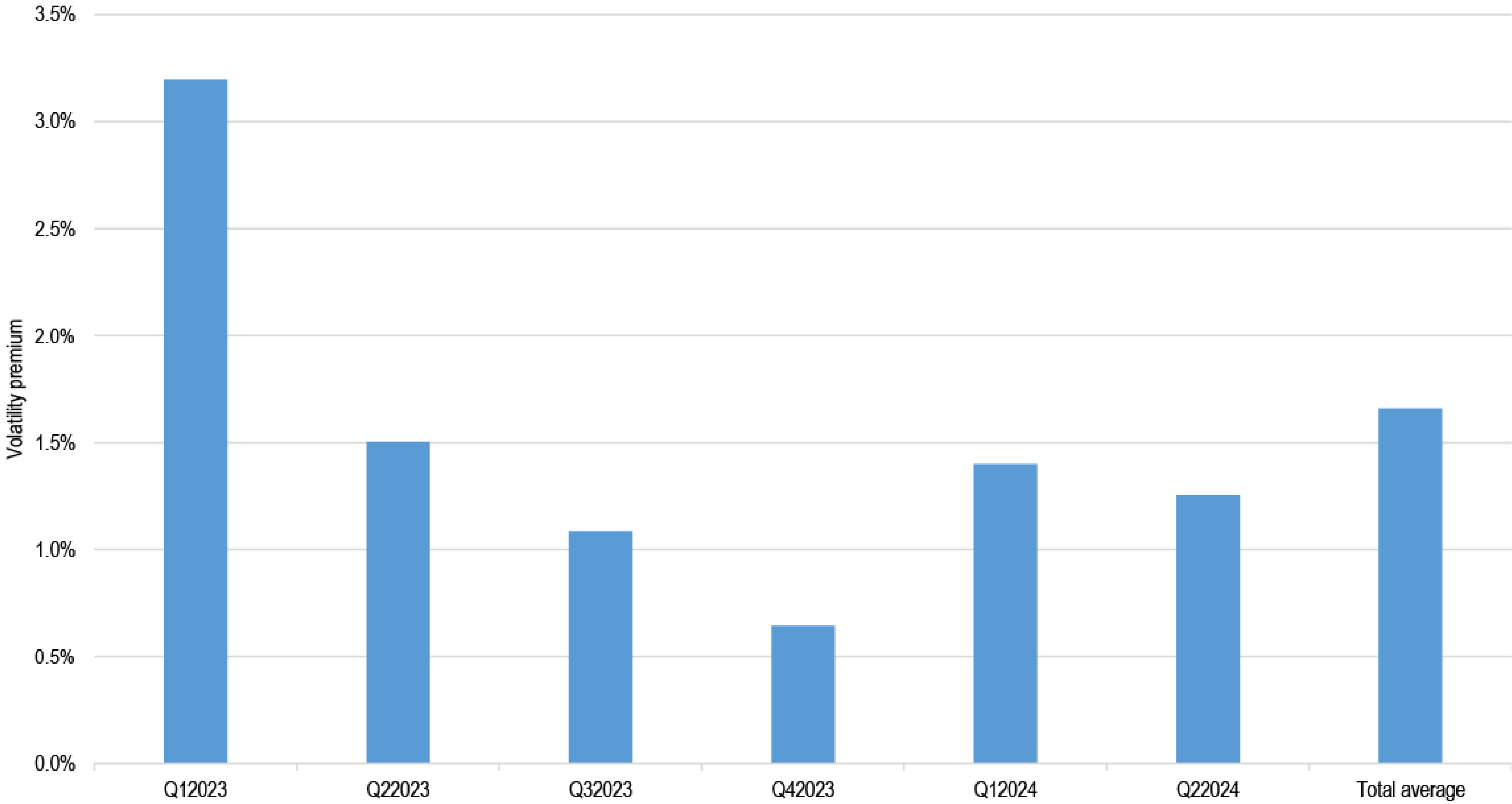
Correlation between implied at 10am and realized from 10am to 4pm is 89%



Source: J.P. Morgan Quantitative and Derivatives Strategy

Since 2023 the volatility premium has come down

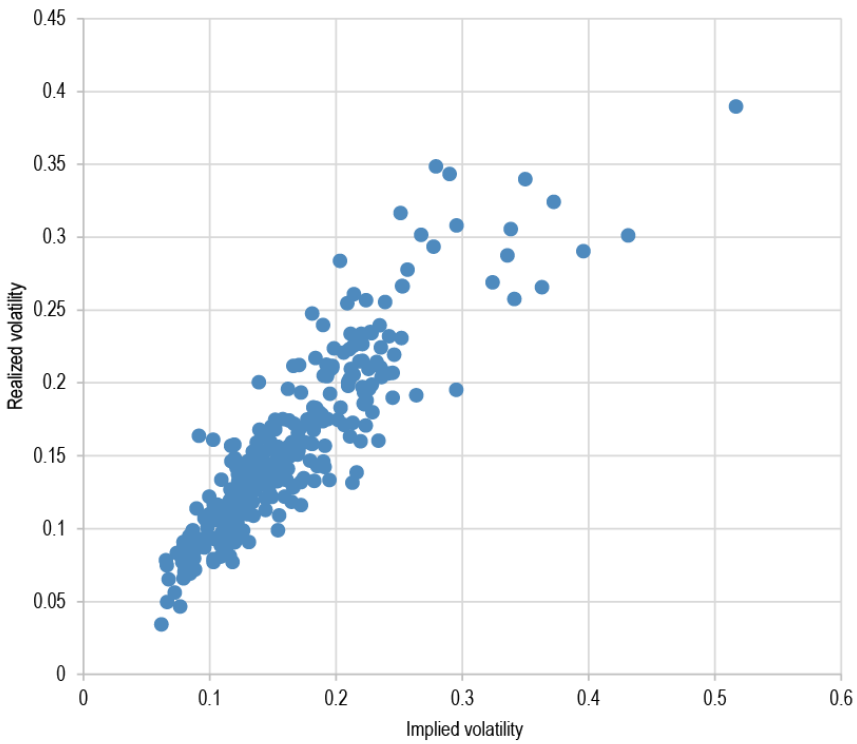
A sign of lower risk aversion and/or increased market efficiency

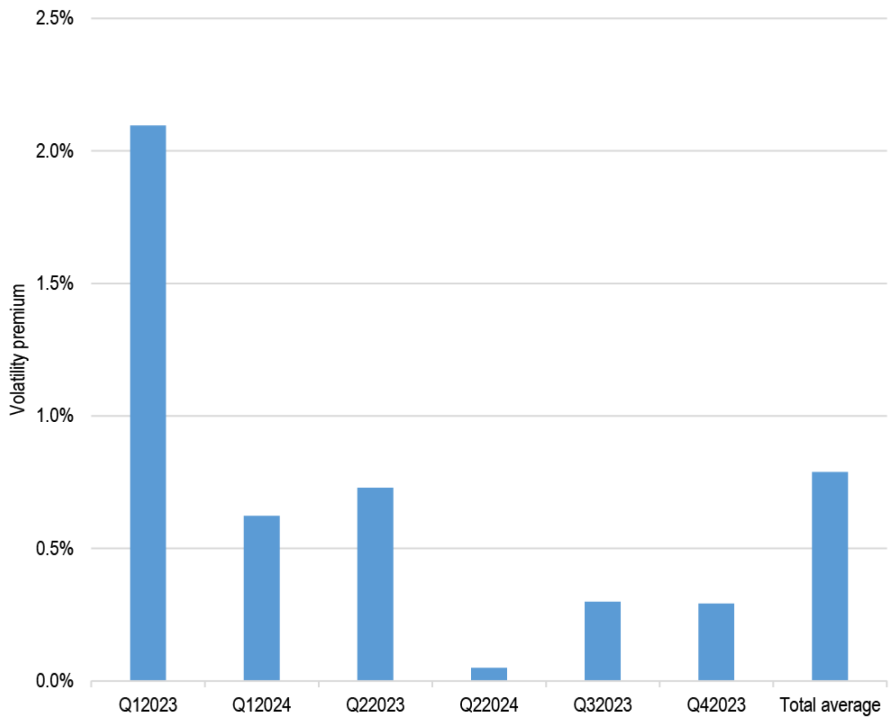


Source: J.P. Morgan Quantitative and Derivatives Strategy

One-day-to-expiry options (1DTEs) exhibit simiilar properties

89% correlation between implied and realized, and a similar drop in vol premium since 2023?





Source: J.P. Morgan Quantitative and Derivatives Strategy

Are these options more expensive around economic releases?

US CPI has traded at a premium, but not NFP

Table 4: Some additional vol premium for FOMC and US CPI, but not for NFP.

Implied vol and vol premium statistics around three type of events. Data since 1st Jan 2023.

	FOMC	US CPI	NFP	All days, since 1st Jan 2023
Average vol premium	0.98%	2.90%	0.45%	0.79%
Stdev of vol premium	2.06%	5.46%	3.74%	2.86%
Average implied vol	21.0%	22.6%	20.4%	16.1%

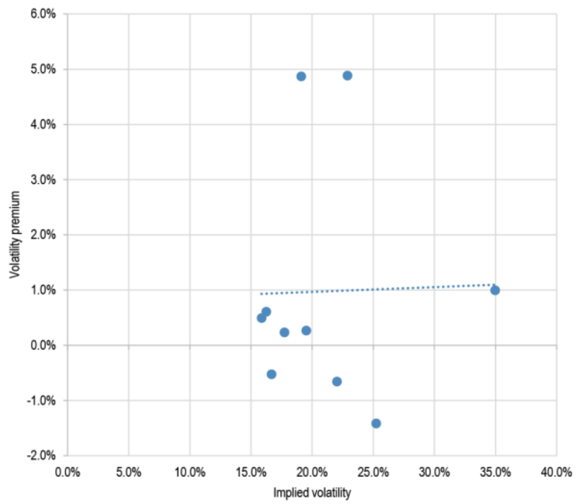
Source: J.P. Morgan Quantitative and Derivatives Strategy.

Tactival trading of 0DTEs on event days

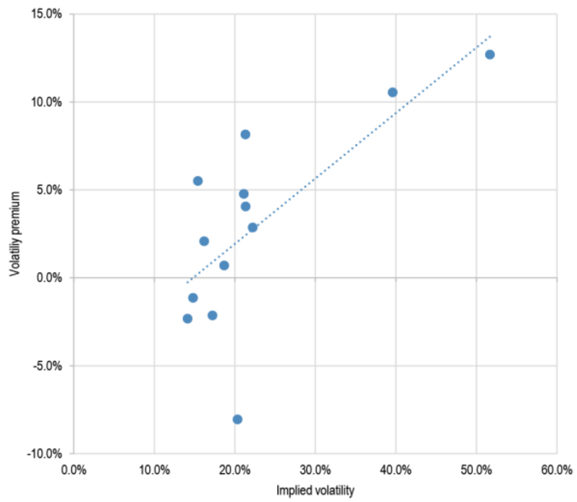
Unfortunately, a low implied vol is not necessarily a buy

On event days, a low implied vol does not translate into a negative vol premium

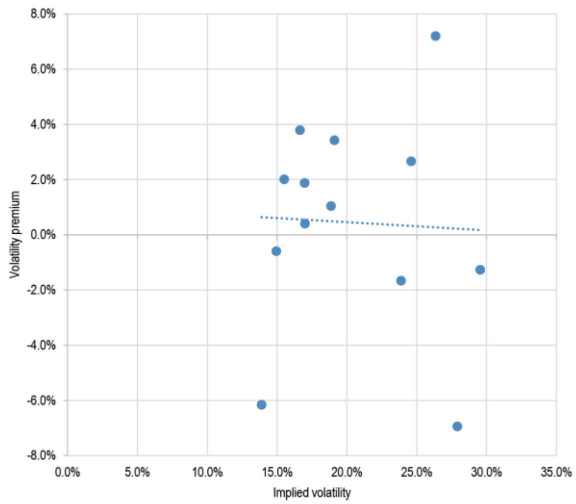
FOMC



CPI



NFP



Source: J.P. Morgan Quantitative and Derivatives Strategy

Agenda

SPY also offers 0DTEs

A very similar instrument to SPX 0DTEs, but some differences exist

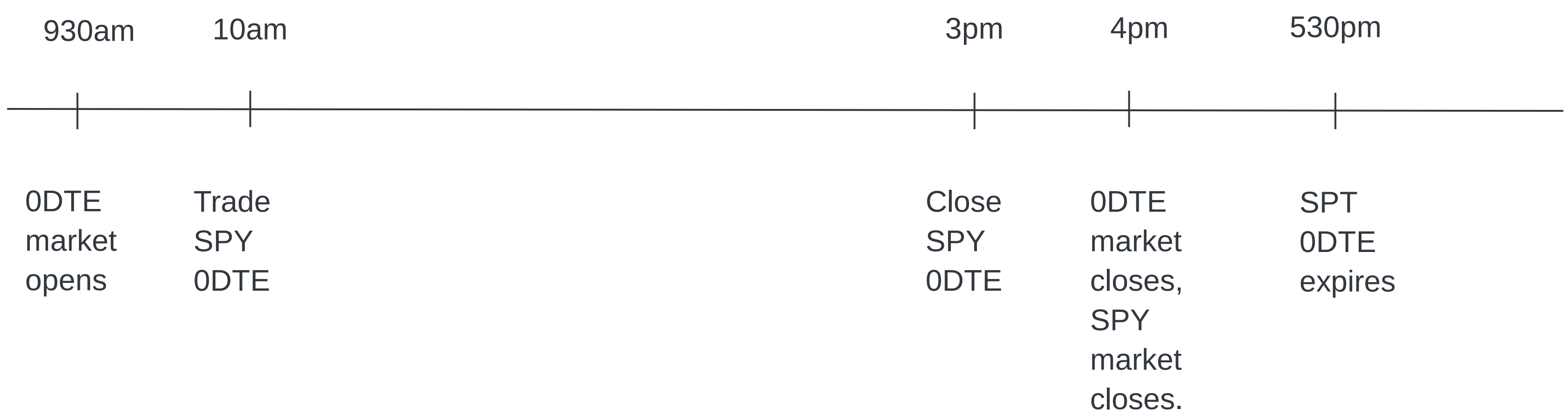
- **Exercise style:** SPX European, SPY American
- **Settlement:** SPX cash settled, SPY physically settled
- **Regular trading hours:** same (9:30am to 4pm)
- **Exercise time:** 4pm for SPX, up to 5:30pm for SPY
- **Liquidity of the underlying:** Virtually none for SPY from 5 to 5:30pm as SPX futures are closed during that period.
- **Dividends:** SPY pays quarterly dividends.

SPX vs SPY: our comparison setup (1/2)

SPY realized to 530pm is ill defined, so we can’t calculate vol premium

SPX goes dark from 5 to 6pm → no SPY liquidity from 5 to 5:30 → can’t calculate realized vol to expiry for SPY.

Instead, we close the SPY 0DTE before SPX 0DTE expires.



SPX vs SPY: our comparison setup (2/2)

We track P&L using well known formula for option delta hedged with inception vol

$$P\&L_{[0,t]} = \boxed{\int_0^t \frac{1}{2}\Gamma_s^*(\sigma_s^2 - \hat{\sigma_0}^2)ds} + e^{-rt}\left(\boxed{P(t,F_t,K,\hat{\sigma}_t) - P(t,F_t,K,\hat{\sigma}_0)}\right)$$

$$\overbrace{\frac{t\overline{\Gamma^*}}{2}\left(\frac{1}{t}\int_0^t \sigma_s^2 ds - \hat{\sigma_0}^2\right)}^{\text{Volatility premium component}} + \overbrace{\frac{t}{2}\,\mathrm{Cov}\left(\Gamma^*,\sigma^2\right)}^{\text{Gamma covariance effect}}$$

Close-out P&L

Selling SPY 0DTEs in 2024

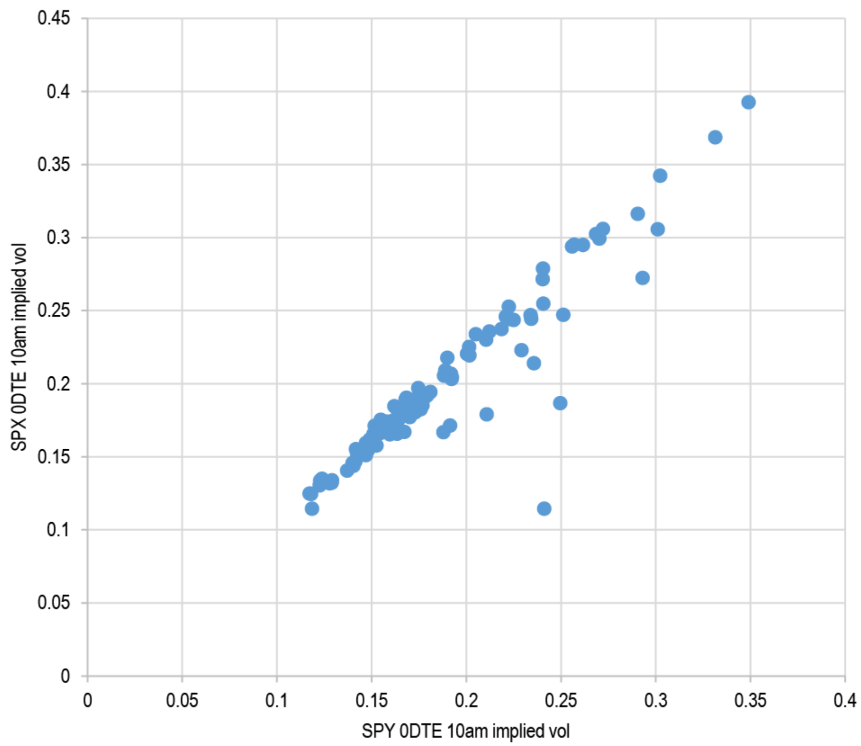
A positive vol premium, and a drop in implied toward the end of the session.

	Vol Premium (vol points)	Vol Premium P&L ($)	Gamma Covariance P&L ($)	Close-out P&L ($)
Average 2024 $P&L for $1 inception vega	3.90	2.24	0.03	0.58

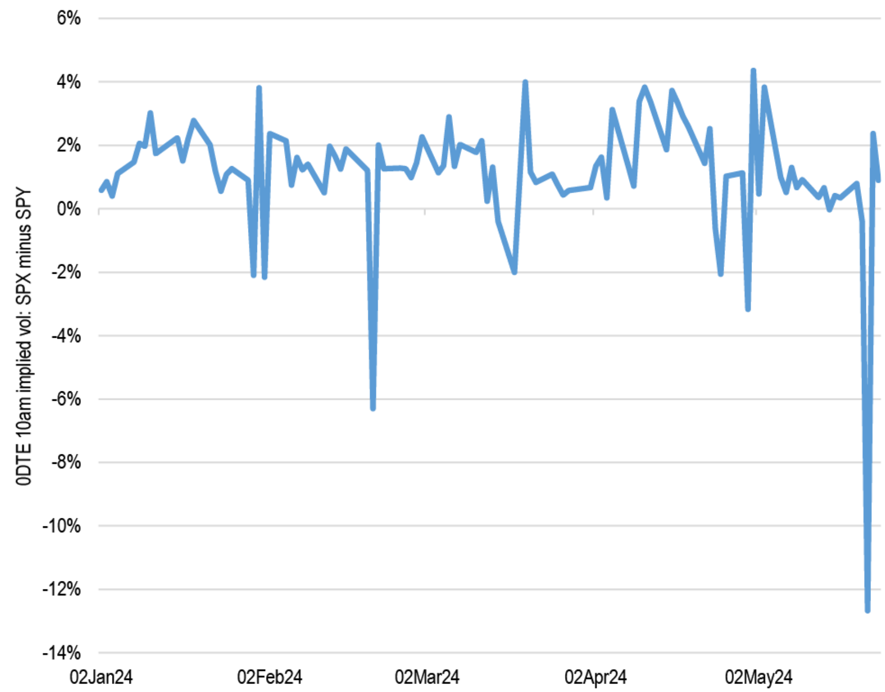
SPX implied vol tends to trade slight above SPX

Except for a few instances, when SPY implied vol is much higher

SPX and SPY implied vols are very correlated



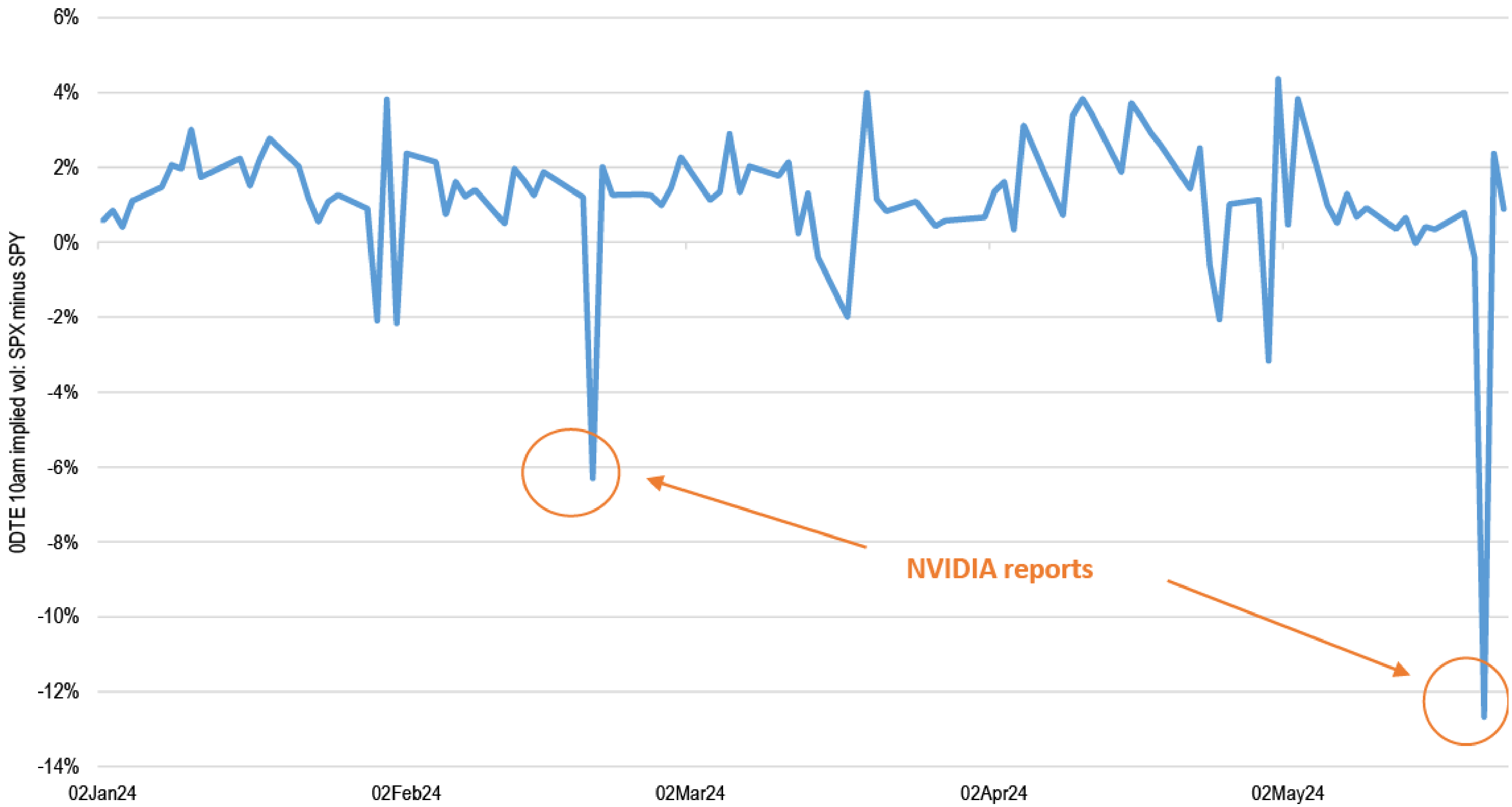
SPX vol tends to trade above SPY vol



Source: J.P. Morgan Quantitative and Derivatives Strategy

What causes SPY vol to trade well above SPX vol?

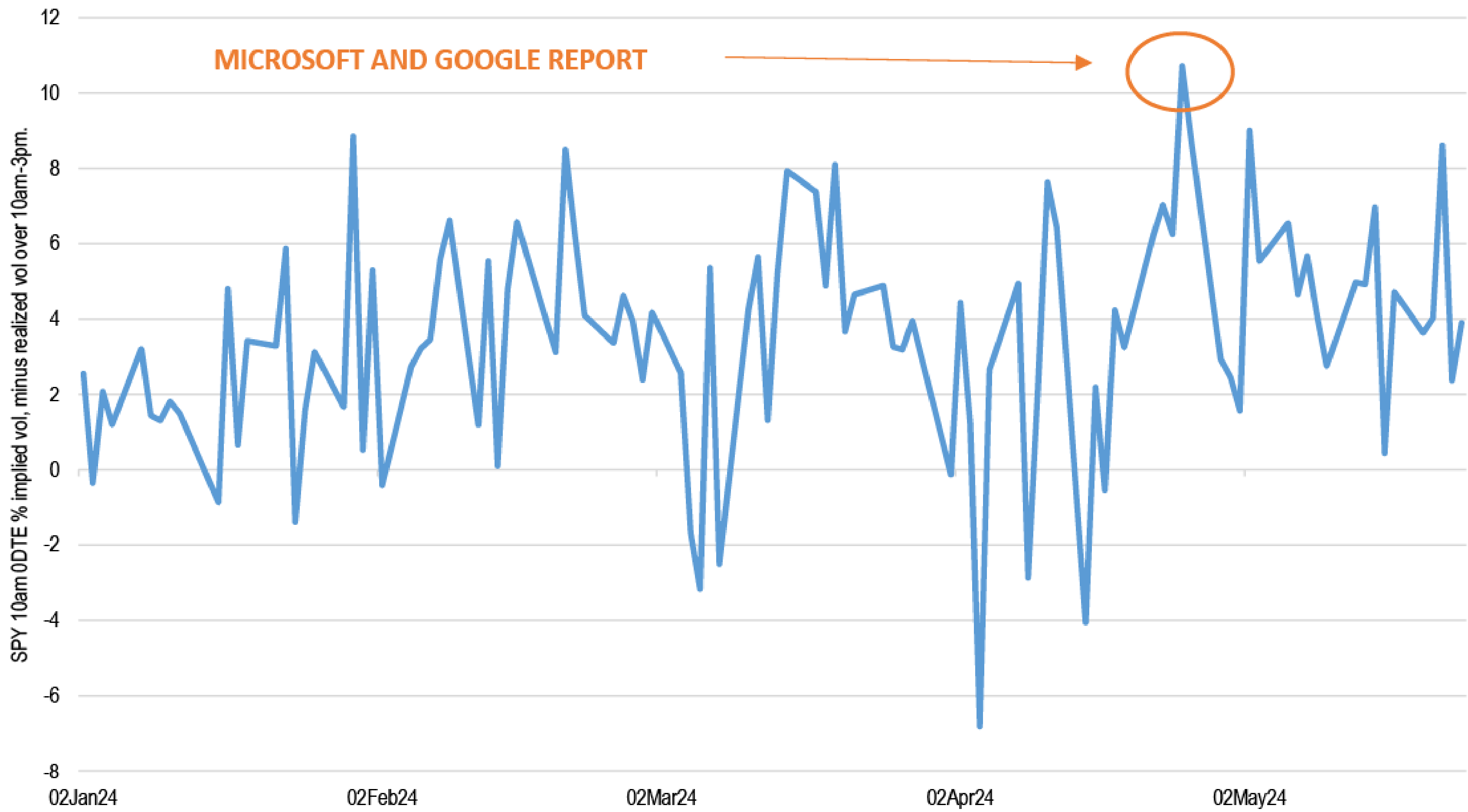
Answer: earnings releases for high beta names



Source: J.P. Morgan Quantitative and Derivatives Strategy

Earnings calendar also impact SPY vol premium

In addition to SPY-SPX relative value



Source: J.P. Morgan Quantitative and Derivatives Strategy

Relative value considerations

At first sight, no free lunch

- Tempting to sell SPY 0DTE vs SPX 0DTE on days with significant earnings releases, to lock in implied vol differential.
- But buying back the SPY 0DTE before the close can be costly.
- The rest of the time, SPX 0DTE vs SPY 0DTE to monetize the SPX vs SPY vol basis suffers from sale of SPY 0DTE before the close.
- So at first sight, no obvious relative value opportunity between the two.

Agenda

Day-of-the-week pattern for SPX

A vast body of literature, but a dwindling effect

- French, K (1980): « Stock Returns and the Weekend Effect »: Monday worst-performing day for SPX.
- That is indeed the case, if we go back long enough:

	Monday	Tuesday	Wednesday	Thursday	Friday
Average SPX return since 1970	-0.02%	0.06%	0.06%	0.03%	0.04%

Source: J.P. Morgan Quantitative and Derivatives Strategy

- But the effect does not seem to be there anymore:

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
2020	0.13%	0.37%	0.10%	-0.19%	0.01%
2021	0.10%	0.01%	0.05%	0.20%	0.13%
2022	-0.20%	0.01%	0.09%	-0.18%	-0.11%
2023	0.27%	0.00%	-0.10%	0.10%	0.21%
2024	0.12%	0.00%	0.04%	0.17%	0.17%
Average SPX return	**0.08%**	**0.08%**	**0.03%**	**0.01%**	**0.08%**

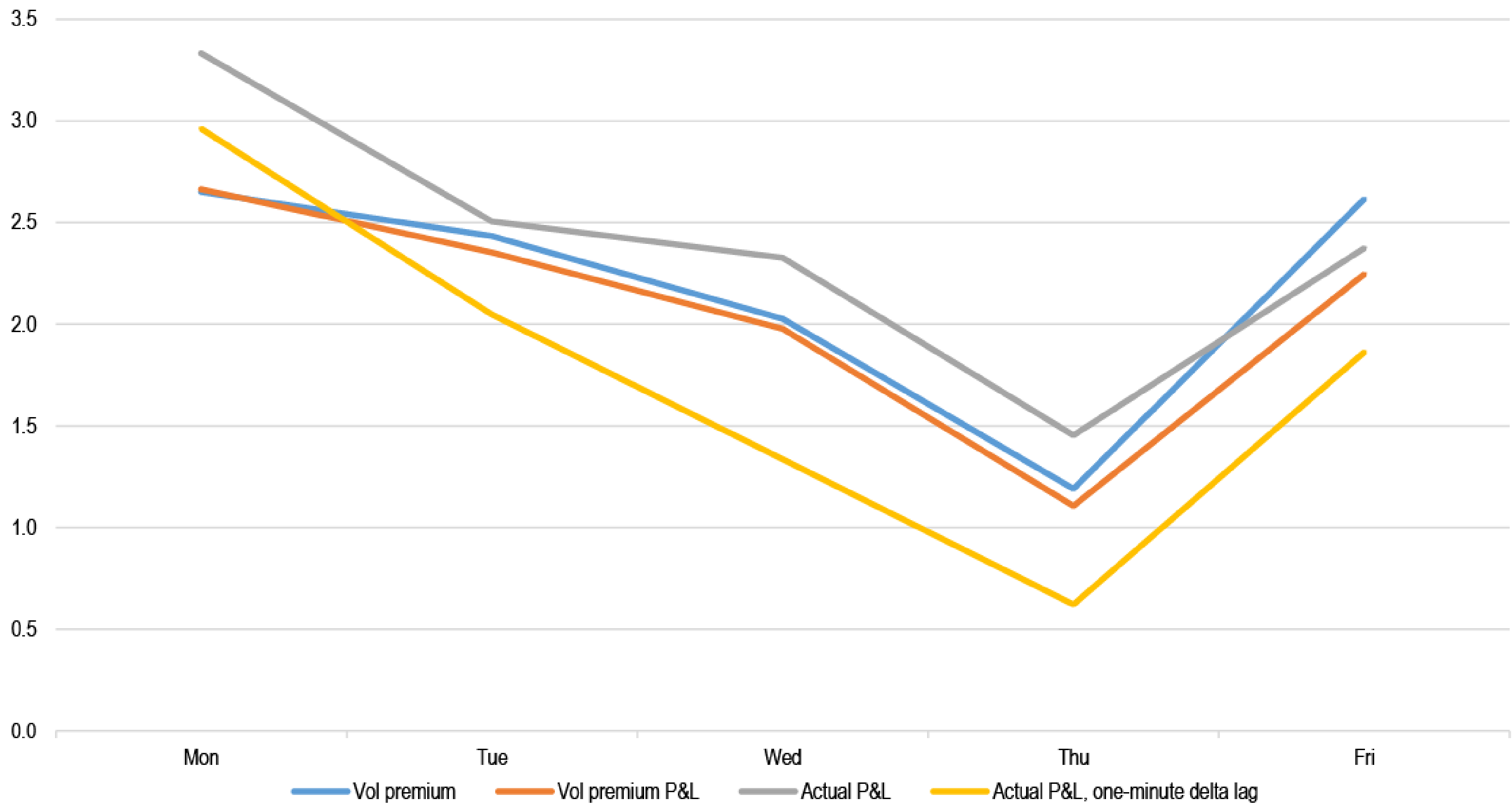
Source: J.P. Morgan Quantitative and Derivatives Strategy

For same day options, a legitimate question

And a clear pattern

Source: J.P. Morgan Quantitative and Derivatives Strategy

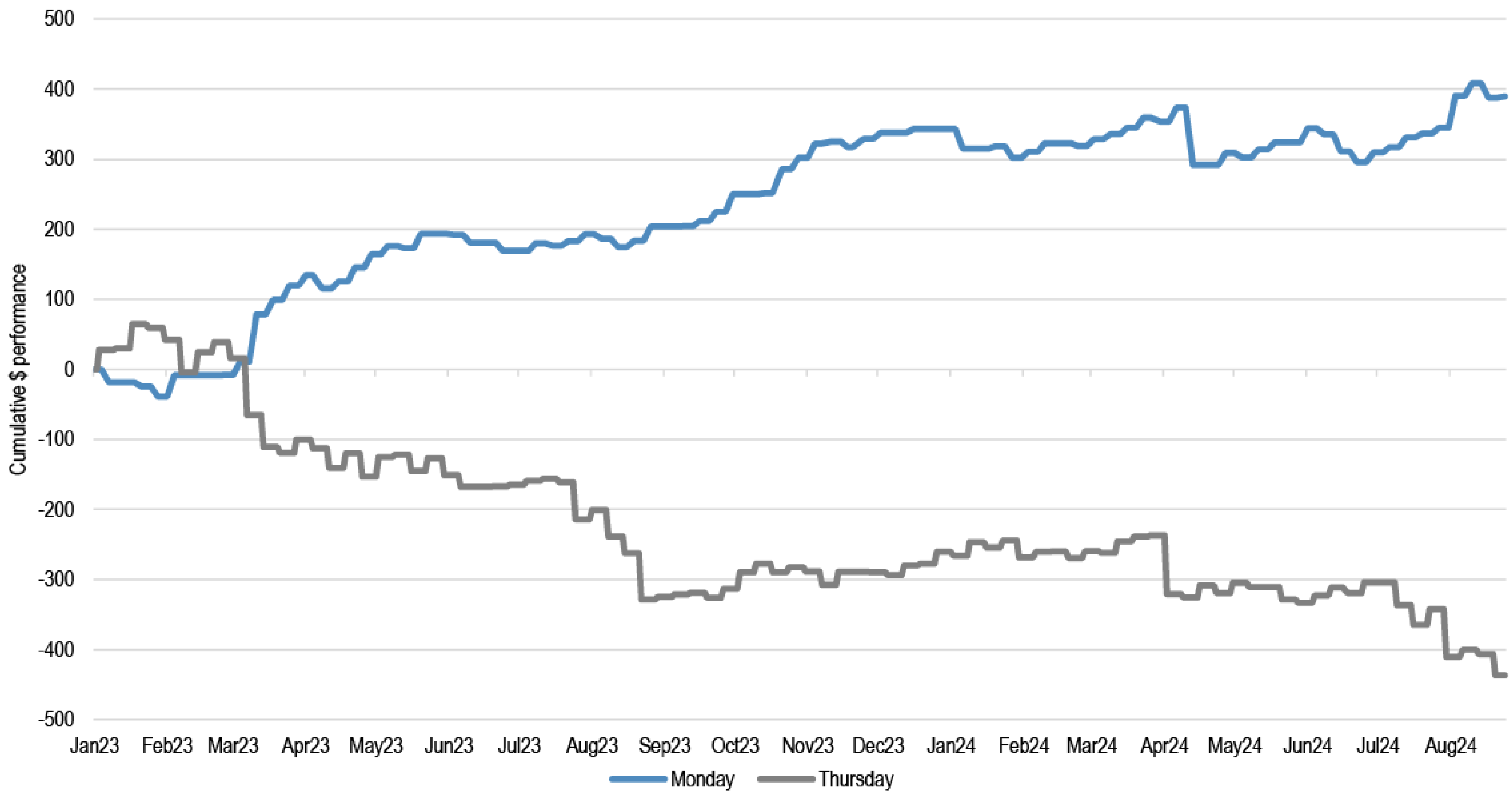
The pattern carries over to delta-hedged option P&L



Source: J.P. Morgan Quantitative and Derivatives Strategy

And when we remove delta-rebalancing

Chart shows performance at mid for sale of naked 0DTE SPX straddle at 10am.

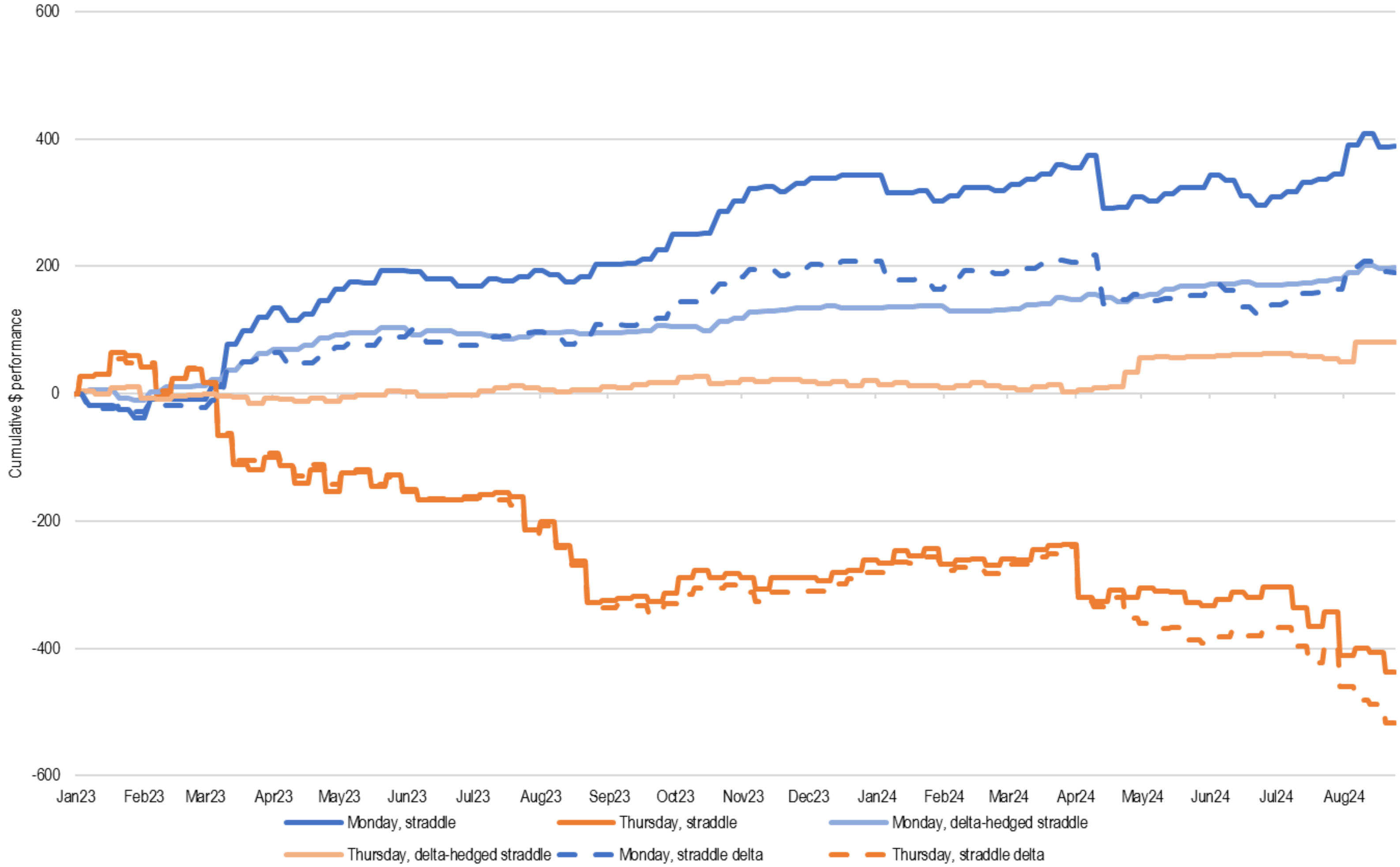


Source: J.P. Morgan Quantitative and Derivatives Strategy

That is because we find the same pattern in the straddle's delta

Thursdays exhibit more trend then Mondays

Breakdown of straddle into delta-hedged straddle plus delta:



Source: J.P. Morgan Quantitative and Derivatives Strategy

What is causing this?

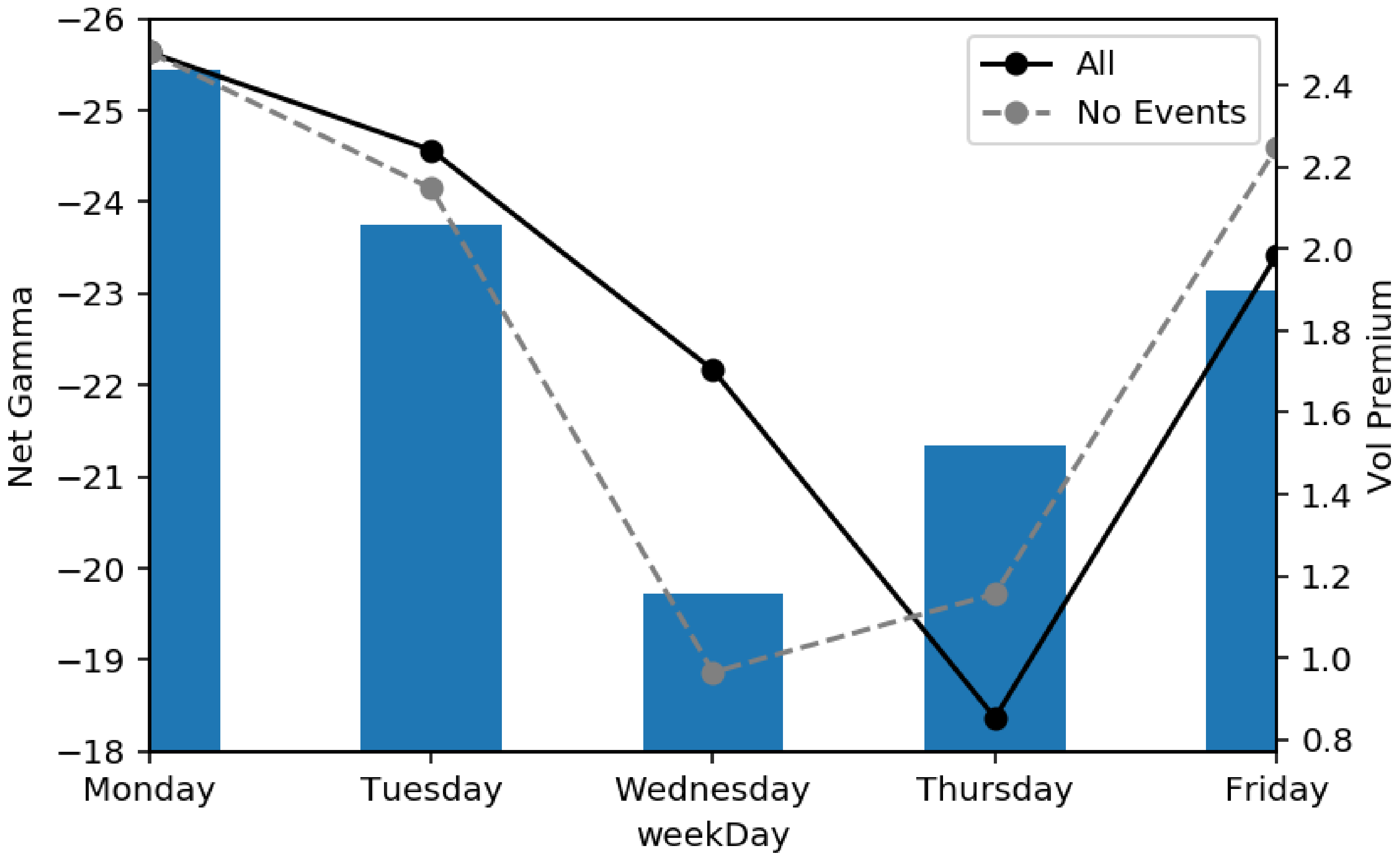
Two avenues

- Differences in risk premium because of events (eg economic releases, central bank decisions)
- Flows (impacting realized volatility)

To control for event risk we will remove event dates from the sample, and analyze flows on that sample.

Flows display a pattern similar to vol premium

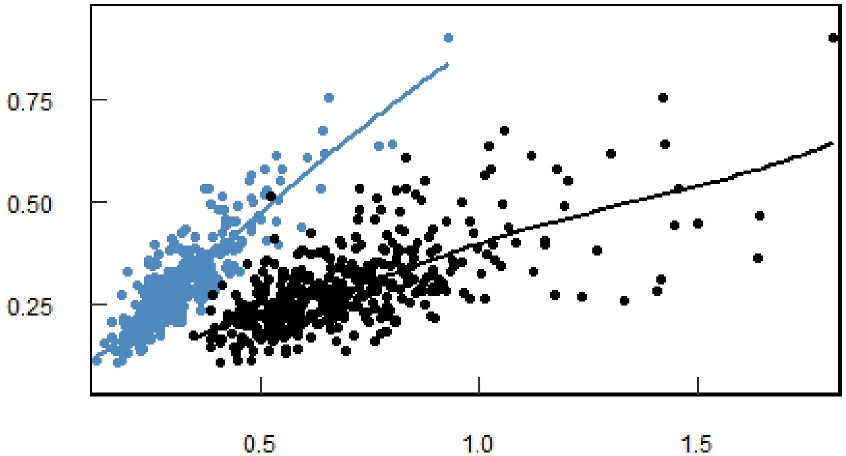
More gamma selling from investors on Monday, less in the middle of the week.



Beyond SPX: applying the same methodology to Nasdaq

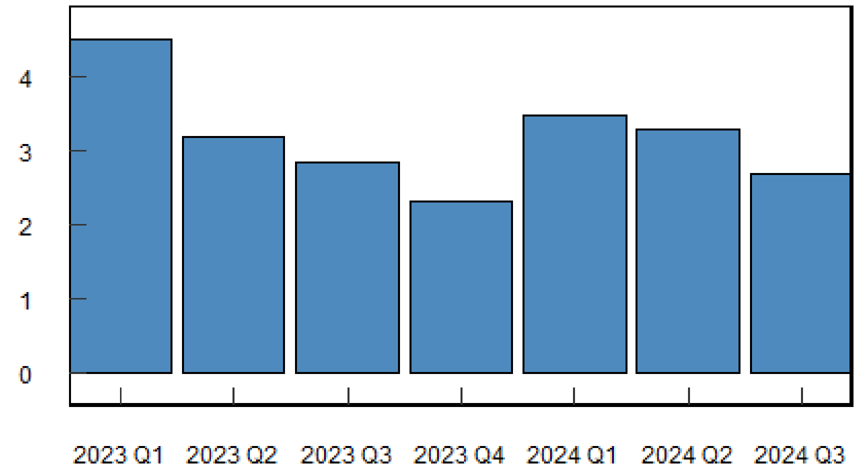
NDX 0DTE market has grown significantly, and accounts for 60% of options volume.

NDX implied vol a good predictor of realized vol



Source: J.P. Morgan

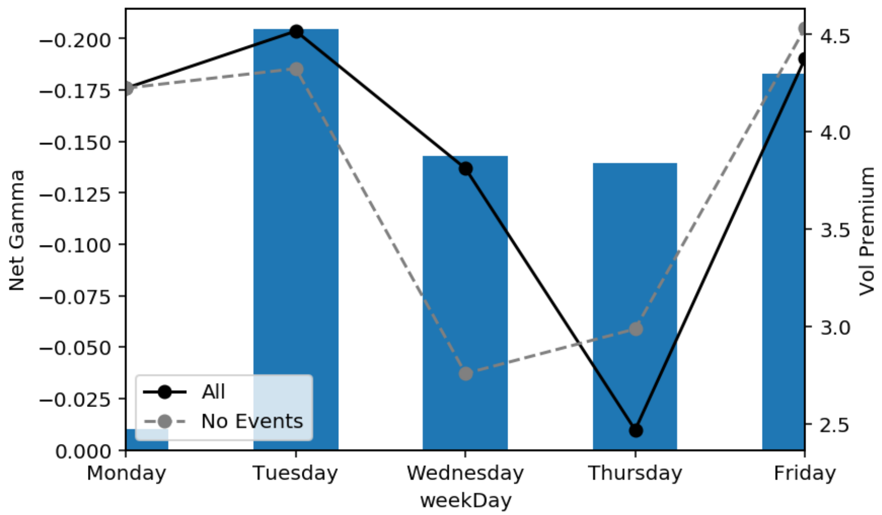
NDX vol premium is positive and has come down some



Source: J.P. Morgan

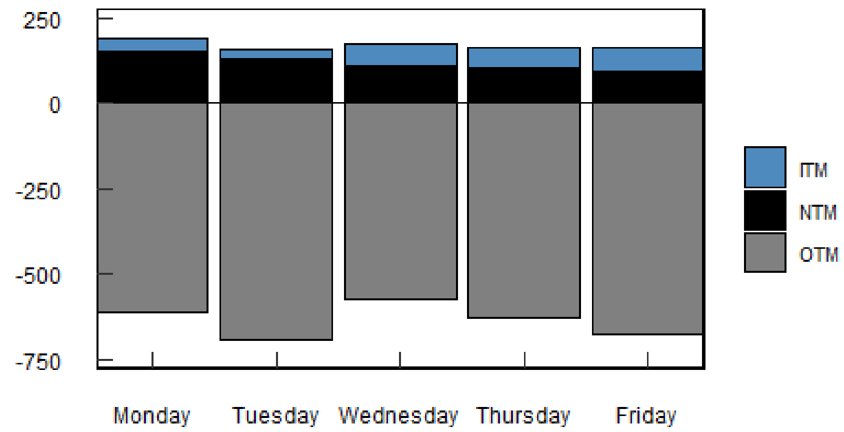
A similar vol premium pattern, partially echoed by flows

Flows pattern echoes vol premium pattern, except on Monday



Source: J.P. Morgan

Possibly because of larger near-the-money flows, which make gamma imbalance noisier.



Source: J.P. Morgan

Agenda

Disclosures

Risks of Common Option Strategies

Risks to Strategies: Not all option strategies are suitable for investors; certain strategies may expose investors to significant potential losses. We have summarized the risks of selected derivative strategies. For additional risk information, please call your sales representative for a copy of “Characteristics and Risks of Standardized Options.” We advise investors to consult their tax advisors and legal counsel about the tax implications of these strategies. Please also refer to option risk disclosure documents.

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.

Pricing Is Illustrative Only: Prices quoted in the above trade ideas are our estimate of current market levels, and are not indicative trading levels.

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