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Interest Rate Derivatives Seminar Series

Intro to options and gamma: | September 2020

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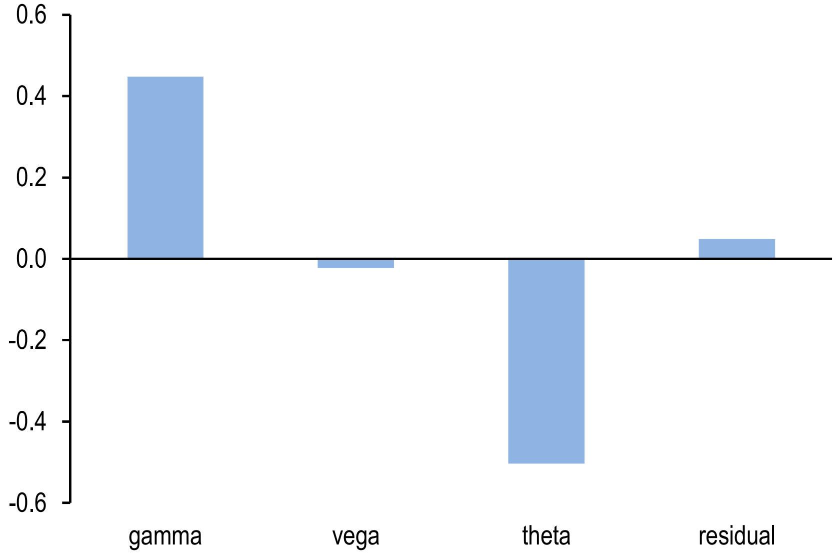
The Greeks in action ...with 3Mx10Y straddles

On average, the P/L from owning straddles is composed of gamma (+) and theta (-) components, which (nearly) cancel …

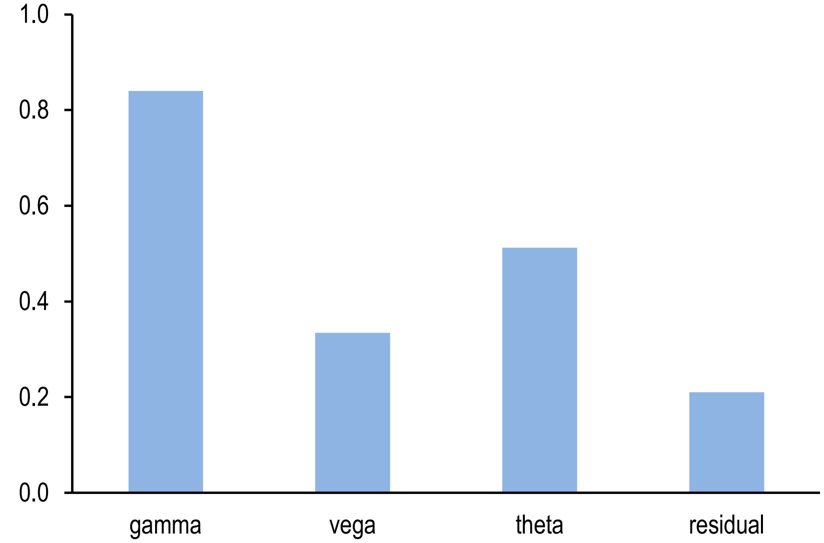
Average return of various components of P/L from straddles on 3Mx10Y held for one month, unhedged; % of notional



Note: Trades executed daily and held for one month from 2008-present.
Source: J.P. Morgan

… but, day to day, vega will likewise play an important role, and higher-order Greeks matter

RMS return of various components of P/L from straddles on 3Mx10Y held for one month, unhedged; % of notional



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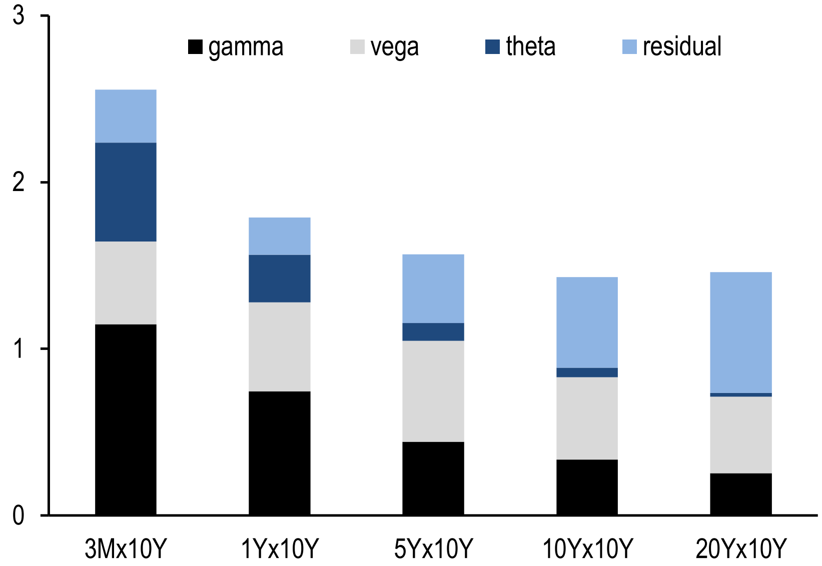
The Greeks in action ...with 3Mx10Y straddles

Gamma P/L dominates shorter-dated structures …

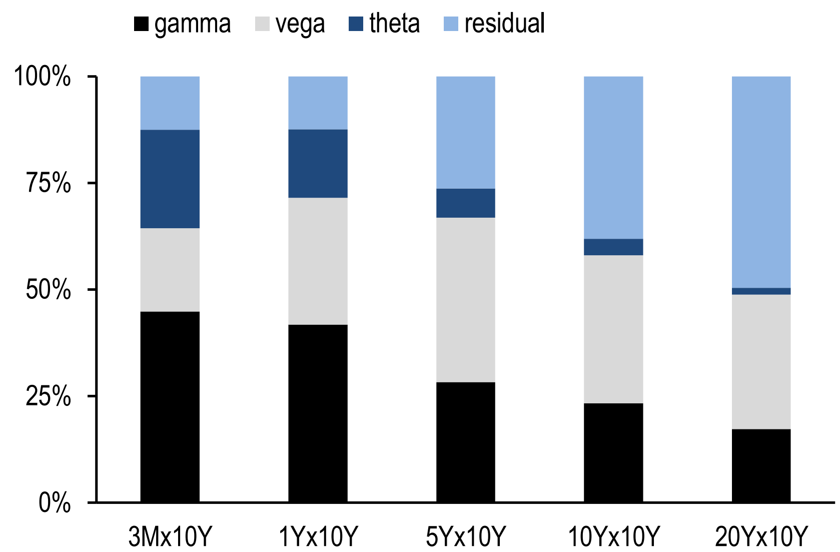
RMS return of various components of P/L from straddles of various expiries on 10Y tails, held for one month, unhedged; % of notional



Note: Trades executed daily and held for one month from 2008-present.
Source: J.P. Morgan

… while longer-dated straddles see a larger fraction of P/L from vega and higher order greeks

Fraction of RMS return of various components of P/L from straddles of various expiries on 10Y tails, held for one month, unhedged; %



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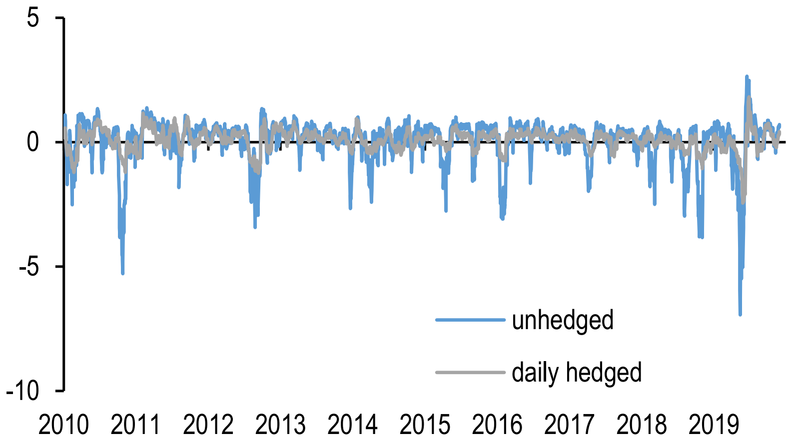
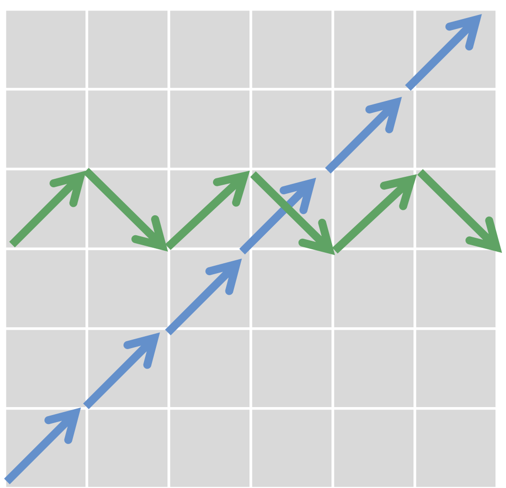
To delta hedge or not to delta hedge …

Frequent delta hedging can reduce the frequency and severity of large draw downs …

One-month returns from selling 3Mx10Y swaption straddles daily from 2010-present, both unhedged and daily delta-hedged; % notional



Source: J.P. Morgan

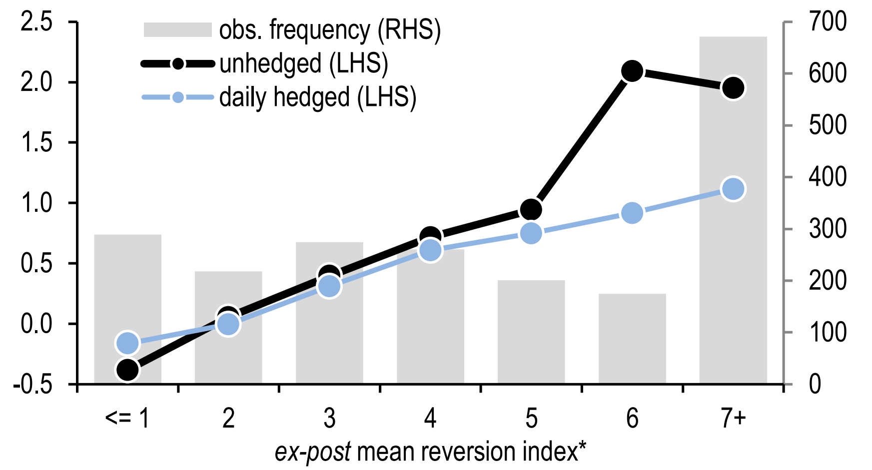


Source: J.P. Morgan

In each scenario, which long-vol position outperforms: unhedged or daily hedged?

…and delta-hedged positions tend to outperform, on a risk-adjusted basis, during periods of mean reversion

Non-parametric ratio† of returns from a daily short-vol strategy broken out by degree of ex-poste mean-reversion* from 2010-present; unitless



* Mean reversion index is the negative of the test statistic from an augmented Dickey-Fuller test applied to daily moves over option hold period

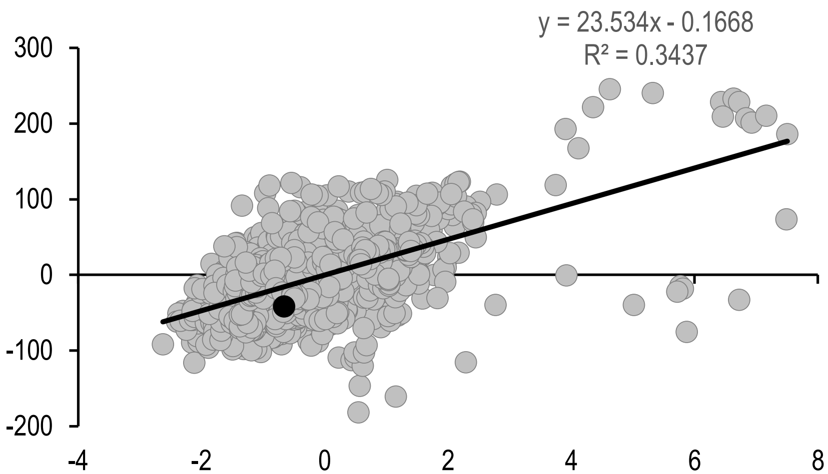
† We defined non-parametric ratio as the average of non-paramteric Sharpe, Sterling and drawdown ratios. Nonparametric Sharpe ratio: median versus inter-quartile range; Sterling ratio: median returns versus median losses; and drawdown ratio: returns versus 5th percentile as expected returns versus downside risk

Source: J.P. Morgan

…but options markets don't know any more about the future than anyone else!

Buying straddles and actively hedging the delta generates returns that track implied vs realized vol…

1-month rolling returns* on long delta-hedged 3Mx10Y ATMF straddles; bp of notional

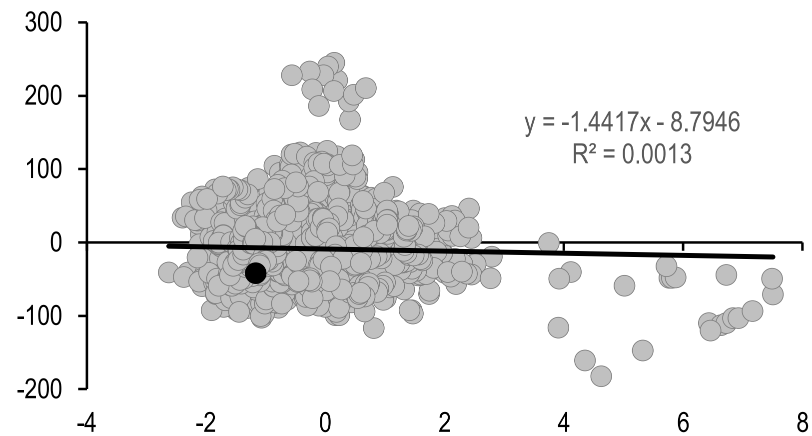


ex-post realized minus ex-ante implied vol**; bp/day

* Options are struck ATMF and rolled on the first of the month, and delta-hedged daily assuming no transaction costs.
** Delivered vol is measured as the 1-month standard deviation of daily changes in 10-year swap yields.
Source: J.P. Morgan

…but the trailing realized/implied spread is not usually a good predictor of subsequent returns

1-month rolling returns* on long delta-hedged 3Mx10Y ATMF straddles; bp of notional



ex-ante minus implied vol**; bp/day realized

Source: J.P. Morgan

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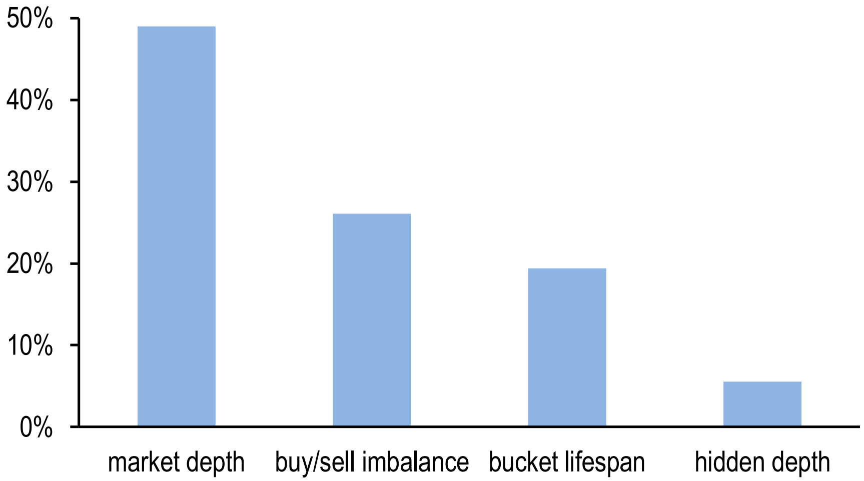
Market depth and the balance of flows are, unsurprisingly, the most important drivers of price impact globally, but lifespan and hidden depth are also important

A four-feature RF price impact classifier identifies market depth and buy/sell imbalance as most important, but trade velocity—how fast each $100mn trades—plays a substantive role ...

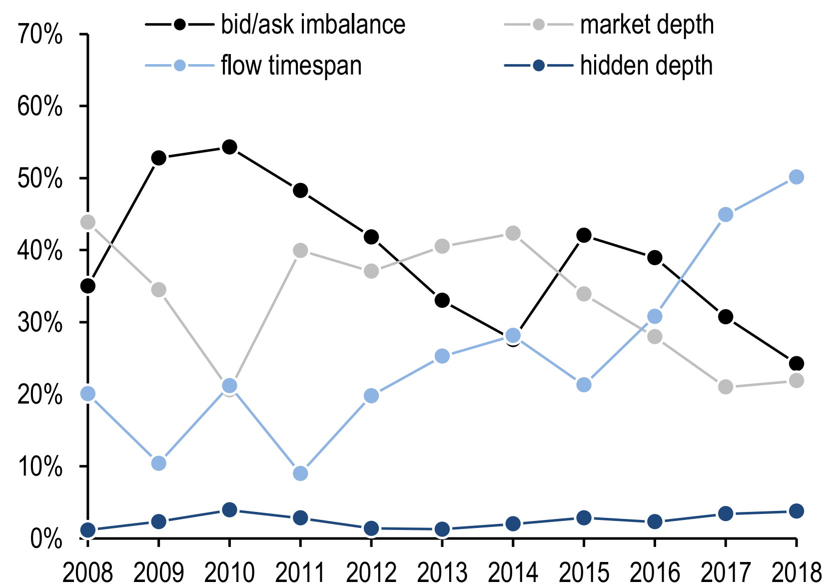
Feature importance* as identified by our random forest price impact framework; %



* "Feature importance" here measures the role each input variable plays, on average, in lowering the impurity of samples within the nodes of a random forest's constituent decision trees, via a gini coefficient metric.
Source: J.P. Morgan, BrokerTec

… and we estimate this flow-speed is now the most important determinant of price impact for individual bursts of trading

Relative feature importance for annual application of a random forest (RF) classifier* to price impact in $100mn flows in current 10s; %



* For details on this RF technique, see Liquid Lunch.
Source: J.P. Morgan, BrokerTec

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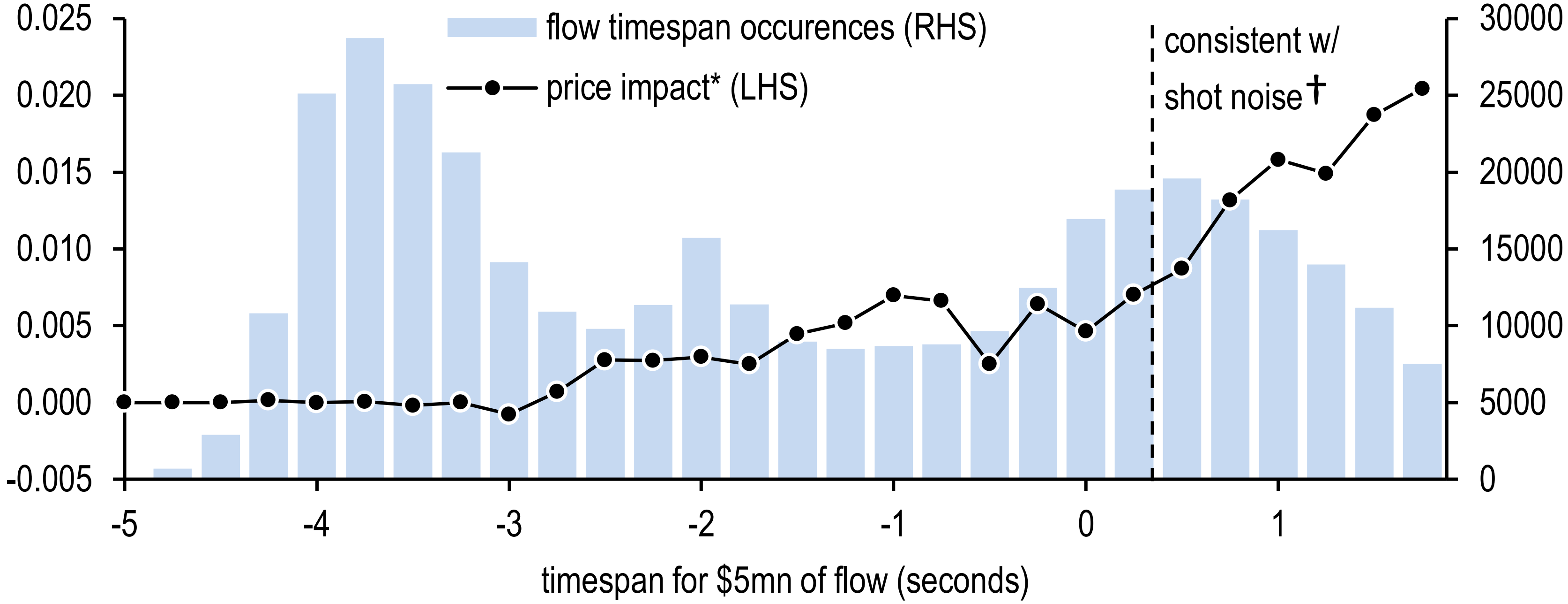
Flows in the interdealer Treasury market span an impressive range of timescales, from tens of seconds to tens of microseconds

The distribution of timescales for volume-weighted buckets in 10-year Treasury trading reveals a bimodal distribution



**We define trade velocity as the timespan, in seconds, for $5mn of notional to trade in the current 10-year Treasury note interdealer market. See US Fixed Income 2019 Outlook for details.
Note: We exclude $5mn+ flows composed of only a single trade
* Defined as the expected price move per $5mn of traded volume, holding flow timespan constant but including an otherwise representative sample of bid/ask imbalance and market depth this year. For details see Liquid Lunch, M. Salem et al., 4/6/18.

†Given average daily volume this year in hot-run Treasuries during the NY session, you'd expect roughly 3.5 seconds, on average, for $5mn of notional to turn over in non-clustered trades, thus this region of the distribution is consistent with randomly timed trades and show no evidence of fast, algorithmic decision-making

Source: J.P. Morgan, BrokerTec

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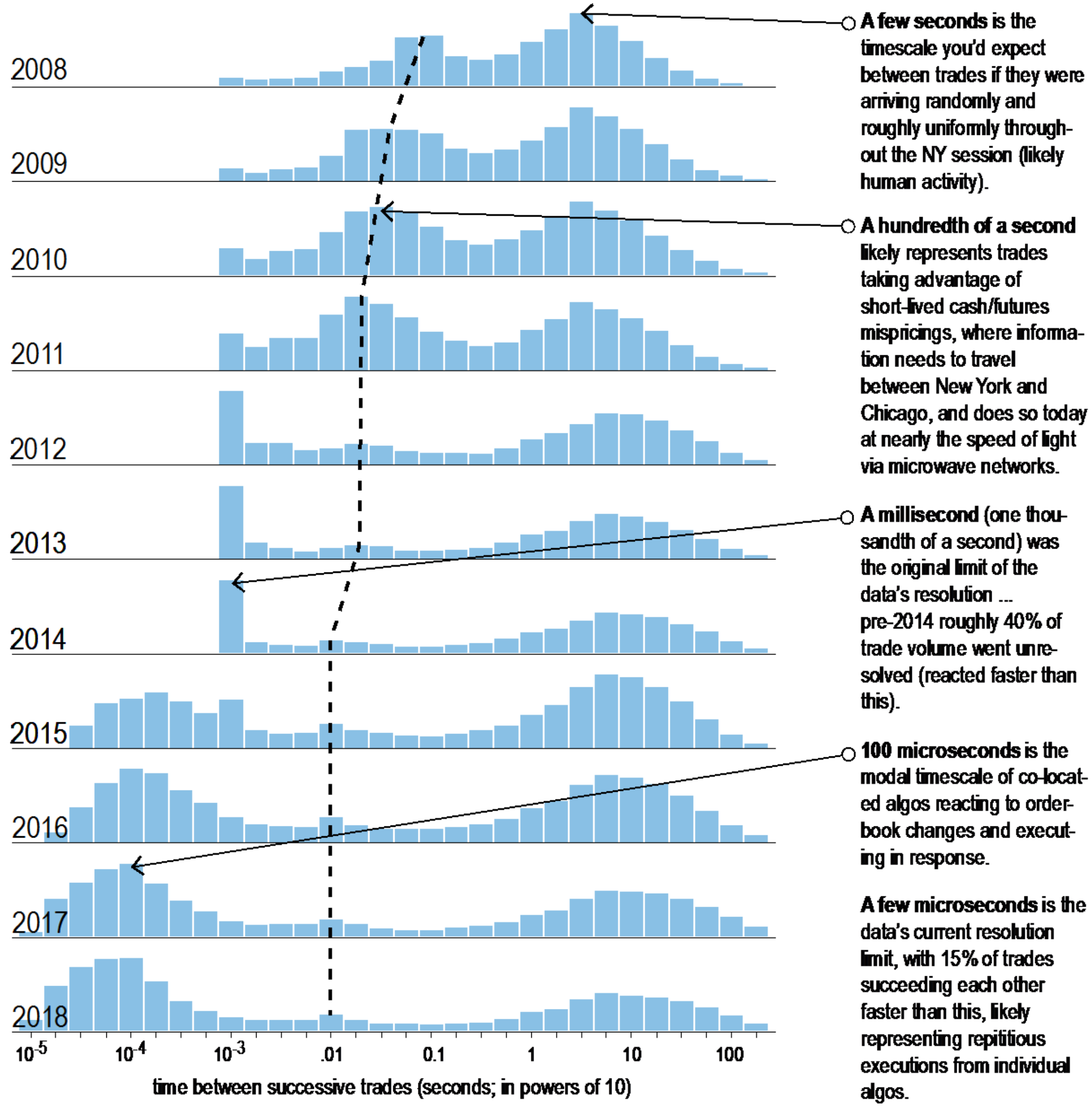
Strategies have grown faster over the years …

Share of trade volume broken out by time elapsed since the prior trade, in seconds



Note: These distributions comes from observing the time elapsed between consecutive discrete transactions in the interdealer market for 10-year notes on BrokerTec (i.e. the elapsed time between the current trade and the prior transaction), grouping trades into quarter-decades by this elapsed time (i.e. on a logarithmic scale) and then summing by gross traded notional across both aggressor buys and sells. We include transactions across all 23 hours of trading. Trades that appear to have happened simultaneously are not shown in the distribution above, but represent roughly 40% of volume by 2014, and then roughly 10-15% in subsequent years when the recorded timestamp goes from a resolution of milliseconds to a resolution of 10s of microseconds.

Source: J.P. Morgan, BrokerTec

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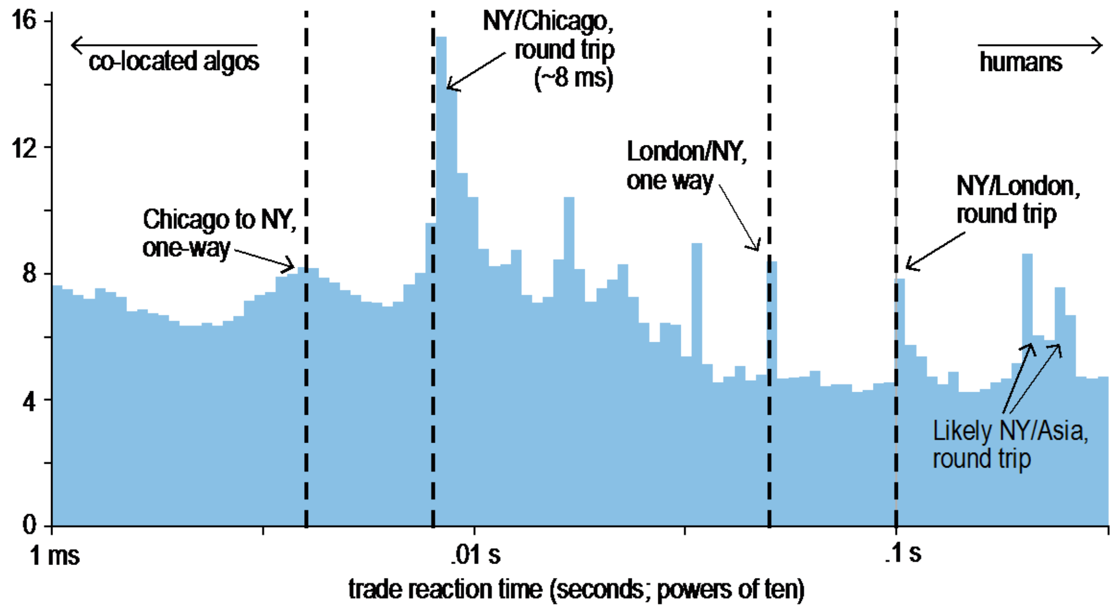
At roughly 1/100th of a second, we see a rich structure of inter-city trading activity

Share of trade volume in 2018 broken out by time elapsed since the prior trade in seconds, focused on timescales associated with inter-city information travel, with some estimated travel times overlaid; thousands of trades



Notes: Shown here is the count of trades (in '000s) that follow on the prior transaction at a timescale of roughly a millisecond to a third of a second.
Chicago/NY: We take the geodesic (shortest path) distance between these cities and divide by the speed of light, to obtain the fastest possible one-way and two-way travel times (roughly 4 and 8 milliseconds—consistent with published latency statistics for microwave networks).
London/NY: We again take the geodesic distance, but now assume information travels on average at an appreciable fraction of light-speed, consistent with fiber optic cable. Solving for a match, we arrive at 40% light speed, which seems a bit slower than what a fiber optic cable is capable of (70% light speed).
Asia/NY: Although harder to assert exact locations, these peaks are roughly consistent with shortest distance from NY to Tokyo, again applying the propagation speed found for London/NY.
Source: J.P. Morgan, BrokerTec, Quincy Data

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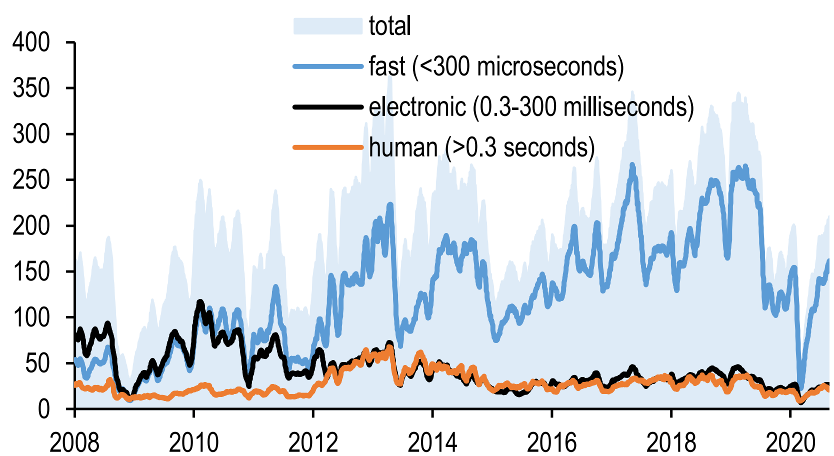
HFT activity represents a majority of liquidity provision in today's intradealer Treasury market…

Fast trading flows mostly initiated by principal trading firms (PTFs) have grown to dominate market depth in the central limit order book (CLOB) of the interdealer Treasury market

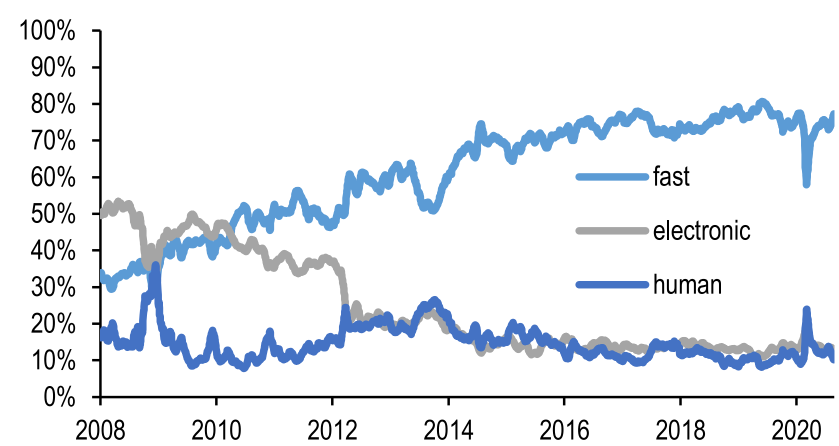
Rolling 1-month volume-weighted average of market depth* broken into the characteristic reaction speed† of individual orders; $mn



* Market depth defined as the total notional available in the central limit order book (CLOB) at the best three prices, averaged across both the bid and ask stacks, see Drivers of price impact and the role of hidden liquidity, J. Younger et al., 1/13/17. We take snapshots of the live order book for every $500mn in traded notional, and average market depth measurements from these snapshots, thus forming a volume-weighted average.
Source: J.P. Morgan, BrokerTec

HFT share of market depth has risen in the past 10 years, and has in the past been sensitive to spikes in volatility

Rolling 5-day volume-weighted averaged of the percentage of market depth* provided by order book participants of different reaction speeds†; %



† Reaction speed is defined as the minimum time between when an order is created or explicitly deleted by the user and the previous change to the CLOB. Whereas the tail outcome from random updates is perhaps a fraction of a second, we find reaction speeds remarkably faster than this, inconsistent with human reaction speed or random noise. Here we define reaction speeds as follows: human: slower than 0.3 seconds (300 milliseconds); electronic: between 0.3-300 milliseconds; fast: faster than 300 micro-seconds.
Source: J.P. Morgan, BrokerTec

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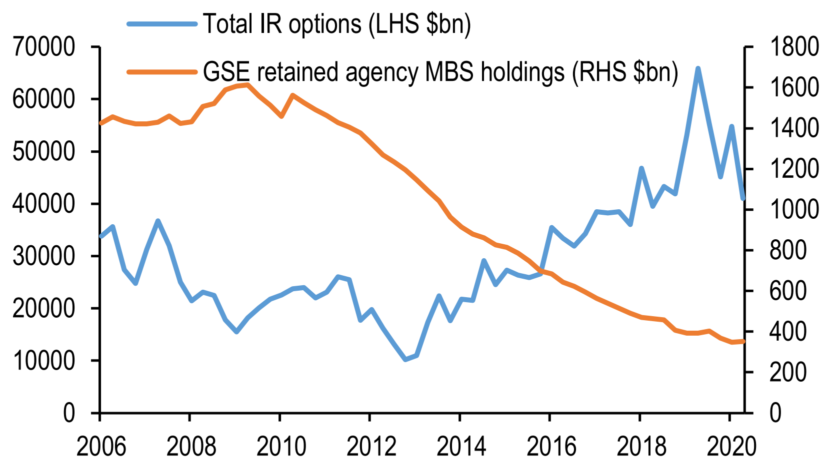
Gamma demand: the growth of interest rate volatility markets was closely tied to the mortgage market—though this is less true recently

The growth of the market in U.S. interest rate options is closely tied to the mortgage market, and in particularly the rise and fall of the GSEs…

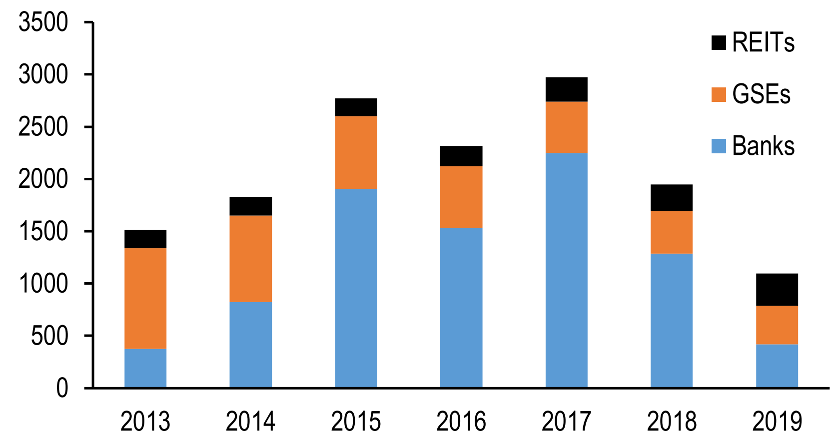
Gross market value of USD IR options (LHS),and total retained agency MBS holdings (RHS); both axes in $bn



Source: J.P. Morgan, BIS, FHMC, FNMA

…but more recently the decline in GSE holdings has left other, smaller dynamic hedgers as the primary driver of volatility markets

Total balance of dynamically hedged mortgages held by REITs, GSEs, and bank servicers*; $bn



Note: Bank servicer adjusts for holdings by non-bank servicers, who do not hedge, and is dollar-convexity weighted versus the overall agency MBS index
Source: J.P. Morgan, ISDA

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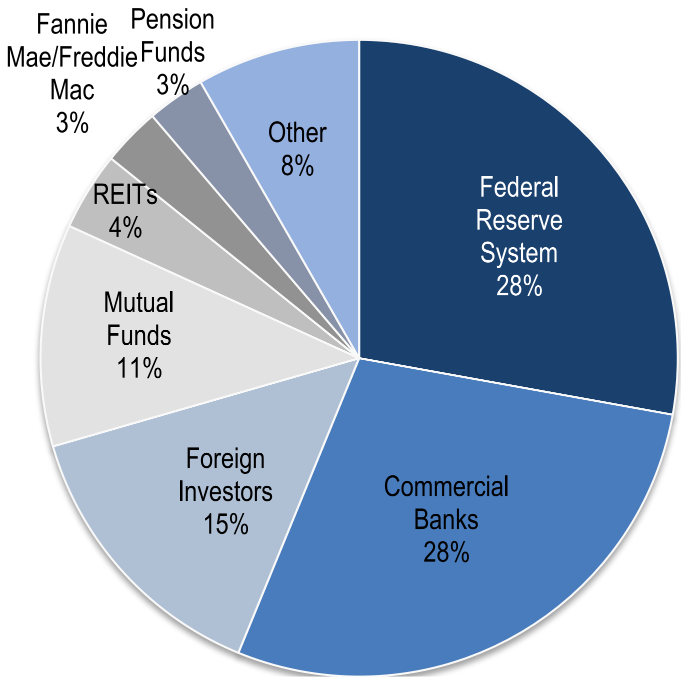
Most mortgages aren't hedged anymore, but the market still generates a non-trivial amount of options demand

Composition of the MBS market as of March 2020



Source: J.P. Morgan

MBS Investors ($ billlion)

Holder	Amount
US Treasury/NY Fed	1,764
Commercial Banks	1,624
Foreign Investors	909
Mutual Funds	715
REITs	252
Fannie Mae/Freddie Mac	188
Private Pension Funds	187
Savings Institutions	172
Life Insurance Cos.	152
FHLBanks	127
Federal Credit Unions	100
Other Investors	64
Securities Brokers & Dealers	38
State/Local Government	23
Property/Casualty Insurers	21
Public Pension Funds	-

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A closer look at prepayments: The major components

- Rate refinancing
  - Largest component of prepayments
  - Borrowers take advantage of lower interest rates to refinance
  - A steep curve can cause borrowers to refinance into shorter mortgages (ARMs)
- Turnover
  - Prepayment occurs when borrower moves from one home to another
  - As loans age (or “season”) they show higher turnover speeds
  - Seasonality is an important driver of turnover, as most families move during the summer (when kids are out of school)
- Cash-out refinancing
  - Borrowers with accumulated equity can refinance and take out a larger mortgage
  - Cash can be used for home improvement, paying off bills, or other debt consolidation
  - This effect is driven primarily by home price appreciation (HPA)

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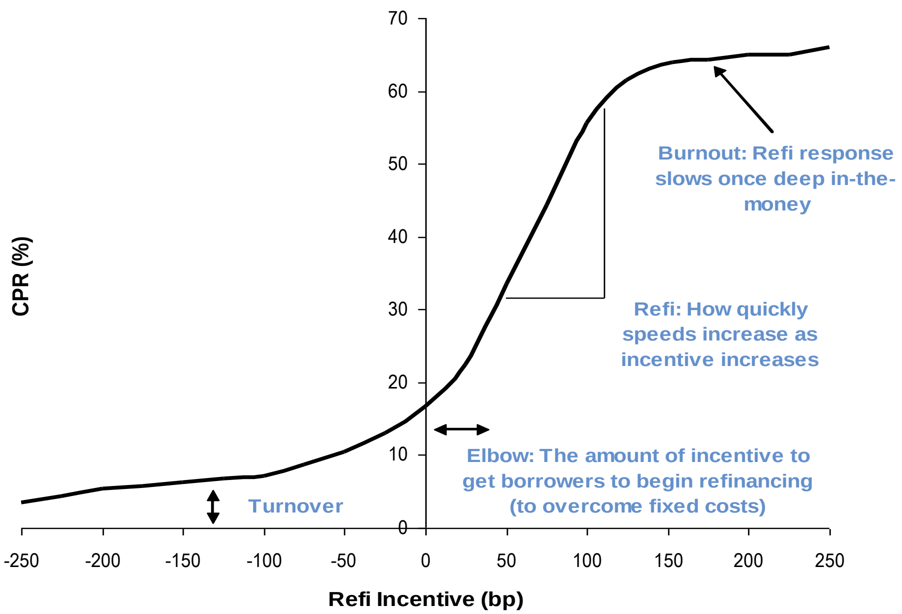
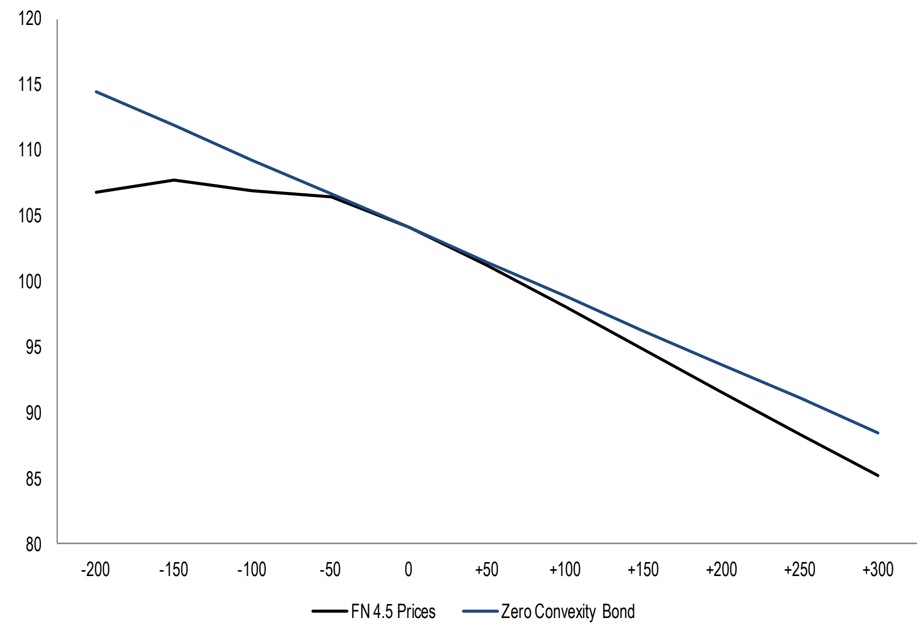
Mortgages are long duration, short convexity and short volatility…

Different areas of the S-curve reflect different patterns in borrower behavior



Source: J.P. Morgan

FN 4.5 prices ($) vs. shift in rates (bps)



Source: J.P. Morgan

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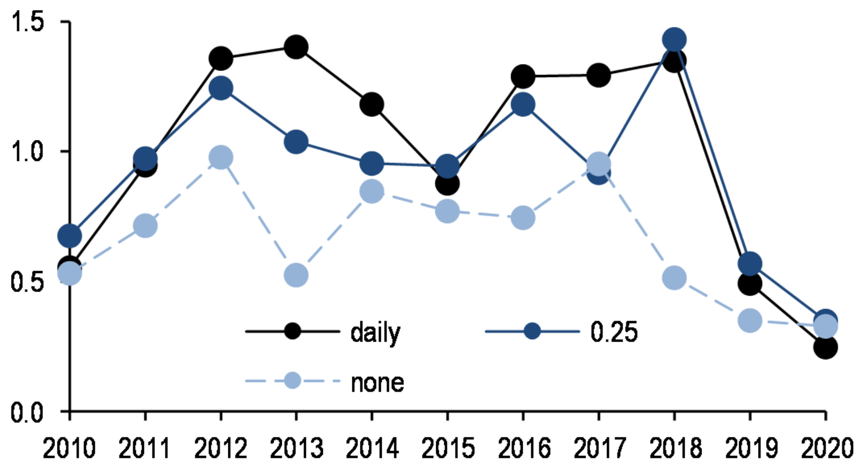
Gamma supply: taking the other side of the mortgage bid

YTD risk-adjusted returns from short gamma programs have likely been the worst of the past ten years

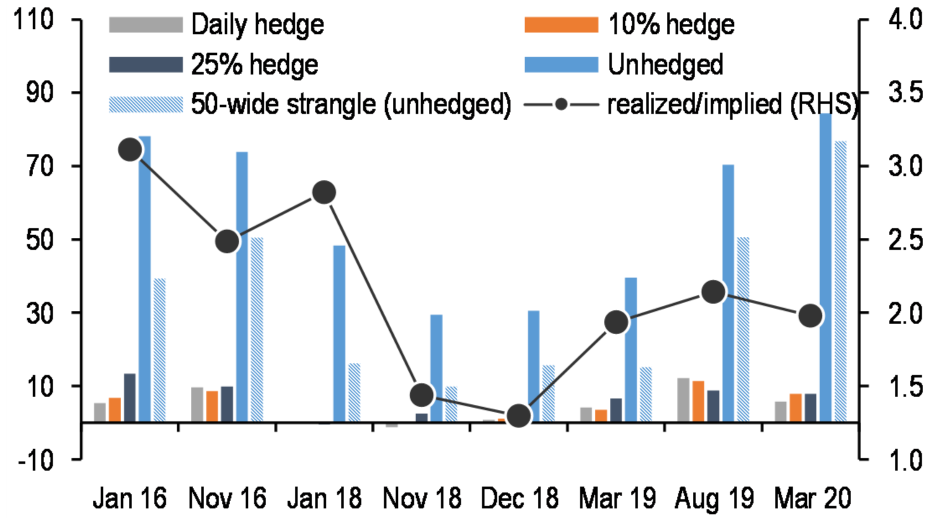
Risk-adjusted returns of uniform daily sales of 1Mx10Y swaptions held to expiry, hedged (or not) on a portfolio level, normalized to performance of daily hedged positions and aggregated over individual years



* Note: We use a nonparametric Sharpe ratio composed of the simple average of three metrics: median versus inter-quartile range; Sterling ratio: median returns versus median losses; and drawdown ratio: returns versus 5th percentile as expected returns versus downside risk.
Source: J.P. Morgan

The peak drawdown from systematic shorts in March on an unhedged basis was the largest episode of its kind in recent years

Drawdown in cumulative P/L from uniform daily sales of 1Mx10Y swaption straddles/strangles held to expiry under various, portfolio-level hedging strategies (LHS; %), compared to the coterminous move in rates normalized to the market-implied 1-sigma one-month move from implied vol (RHS; unitless) compared to past notable episodes



Note: We take the net move in 10-year swap rates over the course of the portfolio's drawdown and divide by the market-implied 1-sigma move for one month, from 1Mx10Y swaption implied volatility.
Source: J.P. Morgan

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Taking the other side of this imbalance of flows via programmatic short gamma strategies

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

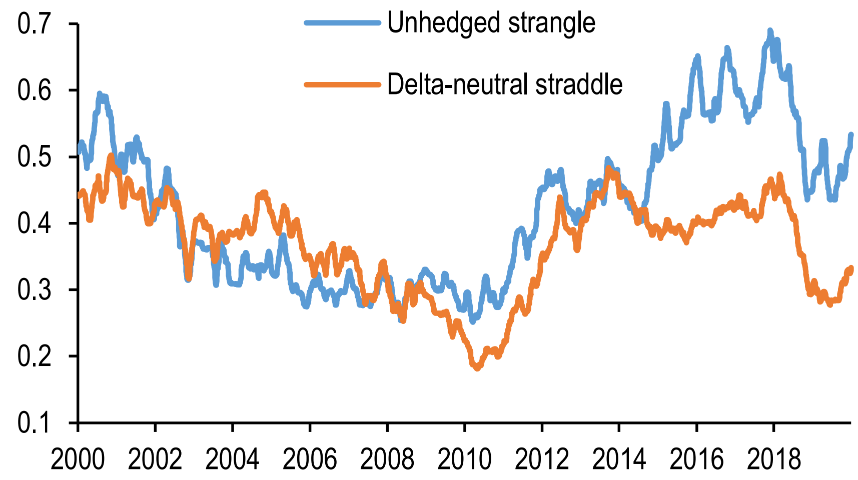
5-year median divided by inter-quartile range of monthly total returns from systematic short gamma strategies in interest rate*, FX†, equity** and credit‡ markets by currency; unitless

	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 options with daily delta rebalancing, held to maturity.
** Taken from J.P. Morgan NexusSM 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

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

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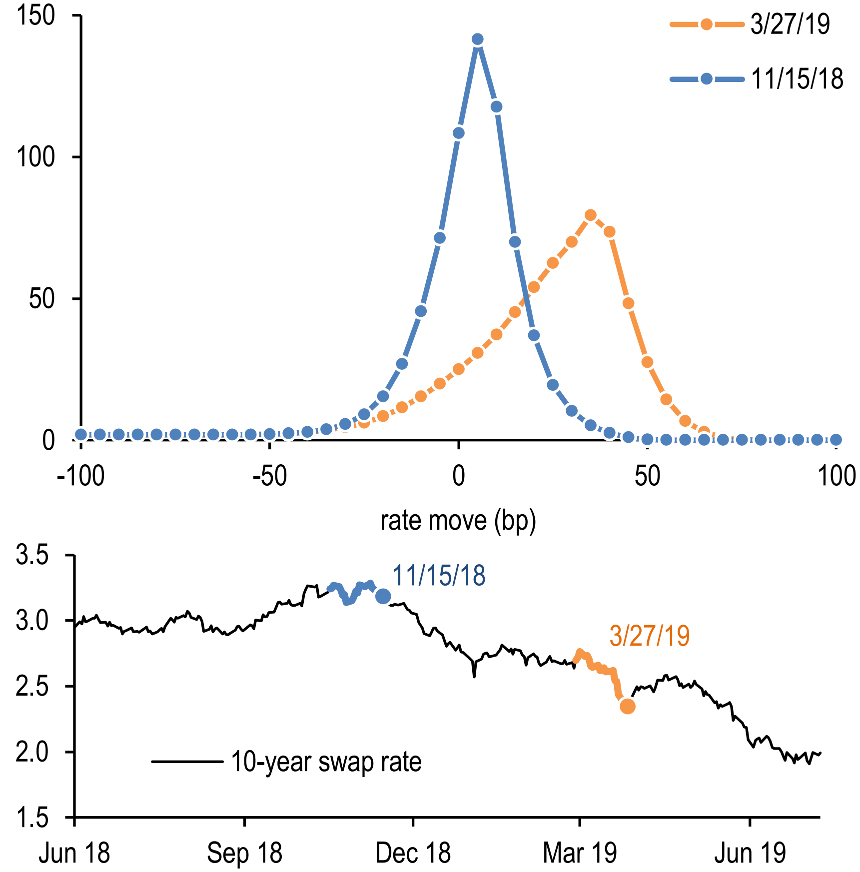
As dealers take the other side of program sales, active management of the gamma risk influences implied vol fair value…

The build-up of long-vol exposure by dealers can lead to a cuspy gamma profile…

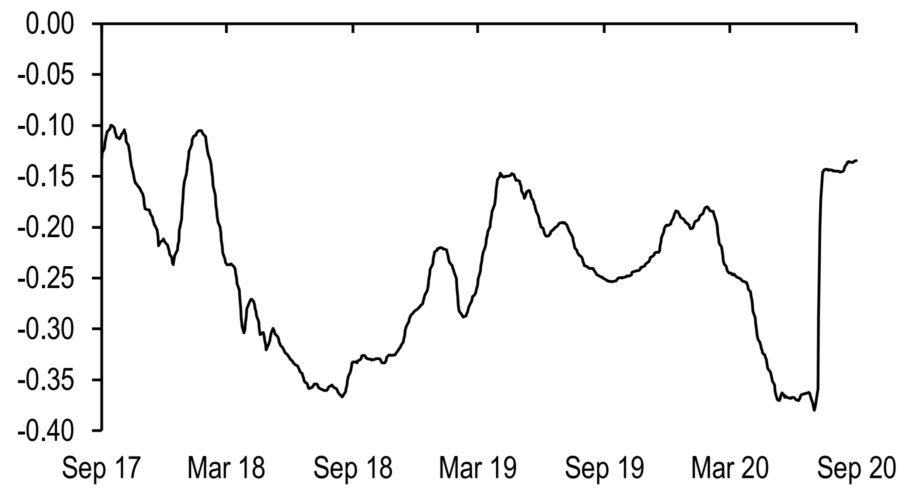
TOP: Modeled dealer gamma exposure* from daily sales of 1Mx10Y swaptions under rate shocks, in units of 1Mx10Y ATMF gamma; unitless; BOTTOM: recent history of 10Y swaps



* Assumes daily sales of 1Mx10Y ATMF straddles held to maturity.
Source: J.P. Morgan

…which leads to impactful gamma hedging flows in the event of a range break

Rolling 2-year beta of 3Mx10Y implied vol versus dealer gamma hedging flows, controlling for other factors*; abp per $bn 10s/25bp



* We regress 3Mx10Y ATMF implied vol versus price impact (liquidity), 10y UST market depth, 10y ACM term premium, US monetary policy uncertainty index, Whites/Greens OIS slope, and programmatic supply modeled as daily sales of $500mn notional 1Mx10Y ATMF straddles, all held to expiry.
Source: J.P. Morgan, BrokerTec, policyuncertainty.com

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