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Interest Rate Derivatives

Curve, Volatility and Curve Volatility

- Rapidly shifting Fed expectations have created heightened uncertainty around the policy path, supporting upper-left volatility at unusually elevated levels and making for a dislocated implied volatility surface

- At the same time, the swap yield curve remains deeply inverted in many sectors. Although the initial flattening was consistent with rising rates, we argue that curve inversion has been exacerbated by technical flows related to hedging curve binary options positions. This is evident in the striking correlation between implied curve volatility (adjusted for overall level of vol) and the curve when the curve is inverted - a correlation that is nearly nonexistent at positive curve levels

- We developed a new metric - the Idiosyncratic Curve Movement Index or ICMI - to quantify the extent to which a given curve has been impacted by such technicals. Curve sectors with an ICMI of close to 1 indicate a high degree of technical impact. These curves are likely to eventually retrace, and curve gamma hedging flows could help accelerate any emergent retracement. We recommend initiating steepening exposure in curves with a large ICMI, where some retracement is already underway

- The implied volatility surface too is likely to eventually normalize. We summarize the vol surface via two implied volatility differentials - the 1Yx1Y minus 10Yx1Y "expiry curve" and the 1Yx1Y minus 1Yx10Y "tail curve" - and develop empirical models for these. We expect both these vol curves to eventually decline towards 1bp/day. That said, with the swap yield curve being a factor in our empirical model for the expiry curve, vol surface normalization is likely contingent on retracement in the swap yield curve from the current steeply inverted levels

US Rates Strategy

Srini Ramaswamy AC
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

J.P. Morgan Securities LLC

See page 14 for analyst certification and important disclosures.

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

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Curve, Volatility and Curve Volatility

This has been a year dominated thus far by uncertainty around the path of the Fed in this hiking cycle. The year began with OIS forwards pricing in a Fed path that was rather close to the 2017 cycle; this quickly gave way to pricing in hikes in excess of the measured pace of 2004 (25bp/meeting). Currently, forwards are pricing in 50bp hikes for the next few meetings, with nontrivial chances of 75bp hikes being priced into markets in the recent past (**Exhibit 1**). One of the most striking consequences of this considerable uncertainty around the path of the Fed has been the steep rise in implied volatility in the upper-left portion of the volatility grid, causing a sharp rise in both expiry and tail implied volatility curves (**Exhibit 2**).

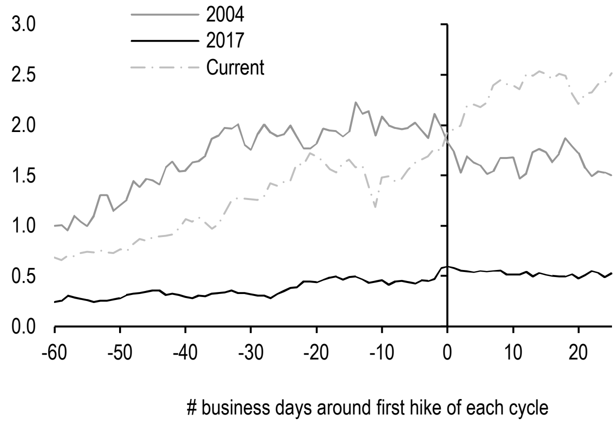
Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Exhibit 1: It has been a year marked by considerable uncertainty around the pace of Fed hikes, with markets shifting from expecting a benign 2017-style cycle at the start of the year to pricing in a much more aggressive policy path in the span of months

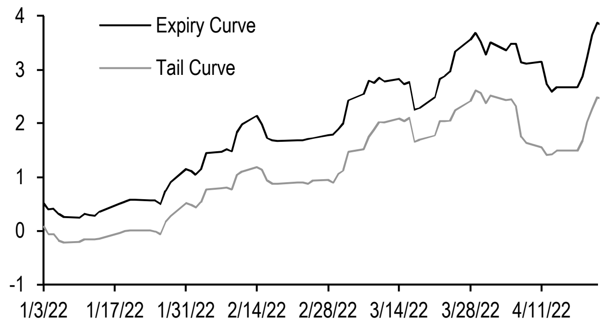
Fed hiking expectations, defined as the difference between the 12-month forward 1-month OIS rate and spot 1-month OIS rate, shown around the first hike* of the 2004, 2017 and the current hiking cycle; %



*First hikes of the 2004, 2017 and the current cycle are 6/30/2004, 12/15/2016 and 3/16/2022 respectively. For 2017, we use 12/15/2016, which was the date of the second hike, because of the large gap between first and second hikes.
Source: JPMorgan

Exhibit 2: Both the expiry and the tail curves have risen significantly since the beginning of the year as the uncertainty around the path of the Fed continues to remain

Expiry curve (defined as 1Yx1Y minus 10Yx1Y implied volatility, bp/day) and tail curve (defined as 1Yx1Y minus 1Yx10Y implied volatility, bp/day), 1/1/2022 - 4/25/2022; bp/day



Source: JPMorgan

This relentless rise in yields at the front end has flattened the swap yield curve since the beginning of the year. But **the curve, unlike prior tightening cycles in either 2004 or 1994, was already considerably flat before the onset of tightening expectations, thanks to large scale asset purchases by the Fed in response to the pandemic**.

Exhibit 3: The swap curve was much flatter coming into this hiking cycle, compared to the 1994 and 2004 hiking cycles, in part due to large QE in response to the pandemic

Coefficients and statistics from a regression* of the yield curve for various tenor-pairs versus 2-year real yields and the Fed's balance sheet assets ($Tn) as well as the curve values (%) for 11/1/1993, 3/30/2004 and 12/16/2021**

	Coeffs			T-stats				Swap curve (%)		
	Intercept	Fed Balance Sheet ($Tn)	Real Rate (%)	Intercept	Fed Balance Sheet ($Tn)	Real Rate (%)	R-squared	Nov-93	Mar-04	Dec-21
1s5s	1.40	-0.19	-0.22	61.5	-32.0	-23.0	22%	1.48	1.88	0.70
2s5s	1.14	-0.17	-0.20	73.7	-41.5	-30.6	32%	0.97	1.32	0.37
2s10s	2.27	-0.35	-0.48	98.3	-57.6	-49.3	50%	1.69	2.36	0.58
2s30s	3.12	-0.50	-0.72	116.6	-69.8	-63.8	60%	2.33	3.20	0.75
5s7s	0.58	-0.09	-0.14	112.9	-69.4	-65.1	60%	0.34	0.53	0.10
5s10s	1.13	-0.18	-0.28	124.2	-75.7	-73.1	65%	0.72	1.04	0.21
5s30s	1.98	-0.33	-0.52	138.3	-85.6	-86.1	71%	1.35	1.89	0.38
7s10s	0.55	-0.09	-0.14	134.4	-81.2	-81.0	69%	0.38	0.52	0.11
7s20s	1.24	-0.20	-0.32	145.2	-87.5	-90.6	73%	0.83	1.26	0.30
7s30s	1.40	-0.23	-0.38	143.7	-89.2	-92.3	73%	1.02	1.36	0.28
10s20s	0.69	-0.11	-0.19	148.4	-89.3	-95.0	74%	0.45	0.74	0.19
10s30s	0.85	-0.14	-0.24	142.9	-90.2	-95.3	74%	0.64	0.84	0.17

*Regression over the past 15 years. ** The dates represent a point 3 months prior to the first hike
** Uses LIBOR swap curves for Nov 1993 and Mar 2004, and SOFR swap curves for Dec 2021
Source: JPMorgan, FRED, Federal Reserve H.4.

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

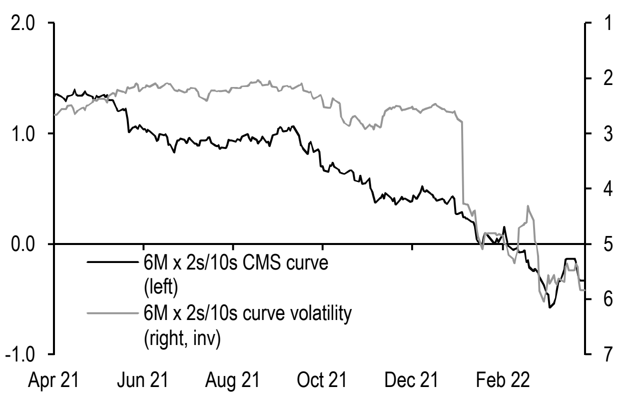
Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

In our outlook (see [Skating away on the thin ice of a new year](), 11/23/21), we quantified the impact of QE on the curve, by using a simple 2-factor model that uses the real short rate (defined as the 2-year swap yield minus 2-year inflation swap yield, measured in %) and the total size of the Fed's balance sheet assets (measured in $Tn) as factors. We present statistics from such a regression for the curve between various different tenor-pairs in **Exhibit 3.** We also show the yield curve slope as of late 2021 (i.e., 3 months before the first hike in March) versus yield curve slopes at a similar stage of the 1994 and 2004 cycles. As can be seen, even before the onset of Fed tightening, the curve this time was much flatter than at a similar stage in prior episodes.

This unusual flatness of the curve at the onset of a tightening cycle has helped set up a volatile chain of events. Yield curves flattened further in response to rising tightening expectations at the front end, eventually pushing convexity-adjusted CMS curves to and through zero by late 1Q (**Exhibit 4**). This is significant because exotics desks commonly warehouse risk stemming from CMS non-inversion structured notes. Such notes often accrue a stated coupon on days when the reference curve is non-inverted, and thus contain an embedded binary option on the curve struck at zero. The risk profile of a dealer hedging long-risk in such binaries switches rapidly from long curve gamma to short gamma as the reference curve inverts through zero (for a more detailed discussion, see *CMS Inversion Notes and the Swap Curve*, JPMorgan Research Note, Feb 2006 – available upon request). Dealer hedging flows therefore start to exacerbate curve inversion once it gets going, until eventually the magnitude of the gamma decays to zero at more deeply inverted levels of the curve.

Exhibit 4: The 6M forward 2s/10s CMS curve inverted sharply recently, taking curve volatility higher

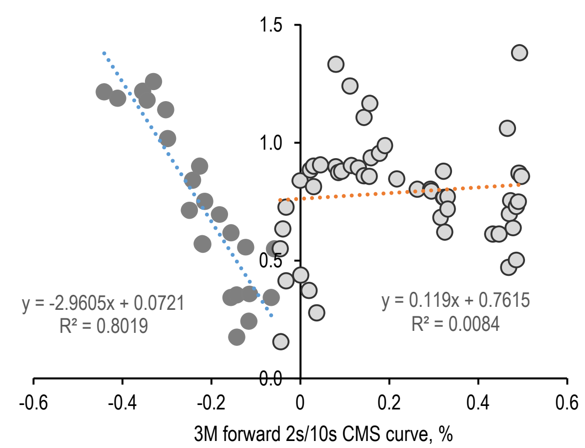
6M-forward 2s/10s CMS curve (%) and curve volatility (bp/day)*, 4/2021 - 4/2022



*Uses LIBOR CMS curve for dates prior to Feb 2022 and SOFR CMS curve for dates after
Source: JPMorgan

Exhibit 5: Implied curve volatility's correlation with curve slope is only pronounced at inverted levels of the curve, which provides some empirical evidence for the technical impact of short curve gamma positions on the curve itself

3M-expiry implied 2s/10s curve volatility, adjusted for overall level of yield volatility versus 3M forward 2s/10s CMS curve*, over the past year**



*Uses LIBOR curve volatility for dates prior to Feb 2022 and SOFR thereafter. Adjusted curve vol calculated as curve vol minus 0.7 times 3Mx10Y swaption implied vol.
** Data points where the curve was steeper than 50bp has been excluded to focus on technical impacts near 0.
Source: JPMorgan

Thus, **while dealer hedging acted as a deterrent to curve inversion for a while when the curve was in positive territory, these same hedging flows became catalysts for exacerbating curve volatility and inversion as dealer desks' curve gamma positions turned short**. Some evidence for this link between Range Accrual

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

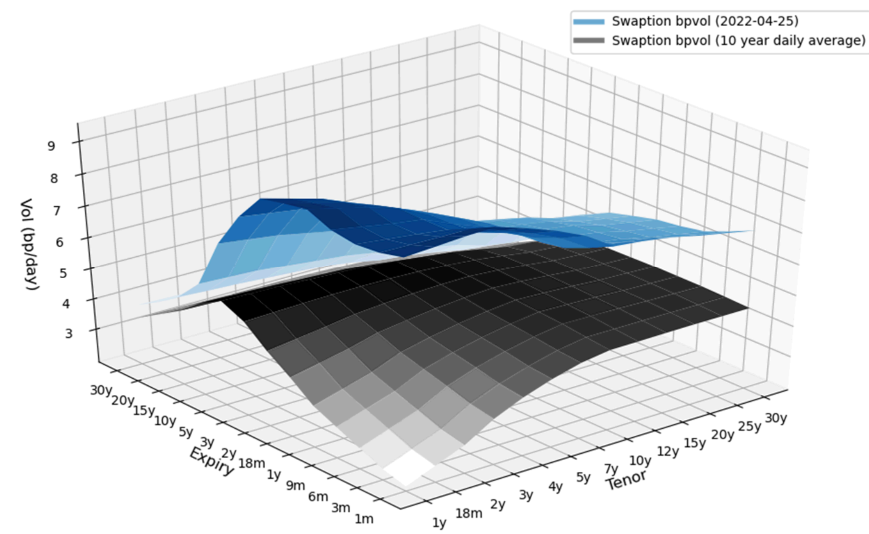
Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Notes, curve volatility and curve inversion can be found in the empirical relationship between the curve and implied curve volatility. For instance, we can look at the level of implied 2s/10s curve volatility (adjusted for the overall level of yield volatility, in order to isolate idiosyncratic curve vol movements) versus the 2s/10s CMS curve itself. As seen in **Exhibit 5**, curve volatility (adjusted for swaption volatility) exhibited little correlation to the level of the curve, when the curve was steeper than 0. But as the curve flattened through -5bp or so, implied curve volatility became sharply (and negatively) correlated with the level of the curve itself. This empirical behavior is what one might expect from dealer exposures turning short gamma, and provides some empirical corroboration of the impact of curve gamma positions on yield curve inversion.

Thanks to all these developments, fixed income markets participants find themselves in a highly unusual environment, **characterized by an extremely dislocated implied volatility surface** (**Exhibit 6**) **and steeply inverted swap yield curves** (**Exhibit 7**).

Exhibit 6: The shape of the swaption implied volatility surface is significantly different from its long run average

Implied volatility surface as of 4/25/2022 (blue), versus 10 year average swaption bp vol (black) surface; bp/day



Source: JPMorgan

These dislocations – both on the curve and on the volatility surface - should eventually normalize but as we will discuss later, the **normalization of the volatility surface is likely dependent on a normalization of the curve**. The curve, while it may be choppy in the short run, is unlikely to sustain such steeply inverted levels going forward. Curve inversion is currently a technical phenomenon and therefore investors should be patient and watchful in positioning for a retracement. But to do this, it is helpful to be able to identify the sectors most impacted by such technical flows. One can then watch these for nascent signs of normalization and enter such trades when they appear to be gaining steam. Indeed, it is worth stressing that **negative curve gamma in inverted curve territory also means that hedgers will need to add steepeners as the curve starts to normalize**, meaning that hedging flows may exacerbate the normalization towards zero just as they exacerbated the inversion earlier in the year.

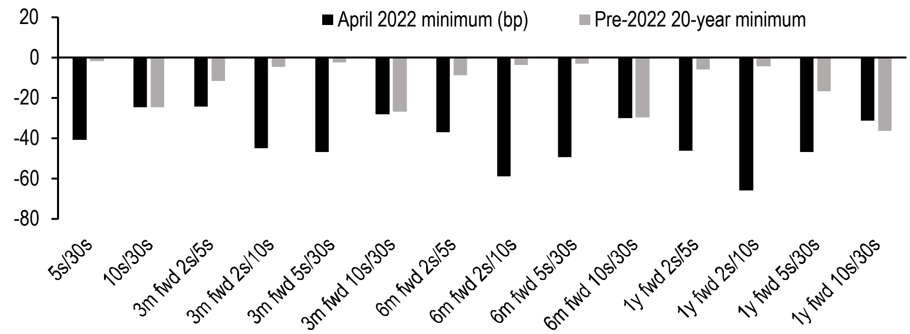
Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Exhibit 7: At its worst in early April, yield curves reached far more inverted levels than they have been prior to this year, with the notable exception of the 10s/30s curve which inverted further in 2008

Various spot and forward swap curve minimums in 2022 versus their 20-year minimum prior to 2022*, 2002 – 2022; bp



*Analysis uses LIBOR swap curves prior to 10/17/2018 and SOFR swap curves post that date

Source: JPMorgan

In this note, **we discuss the potential for normalization in both the yield curve and in the options markets**. **On the curve, we devised a metric to identify the extent to which technicals have impacted any given curve**, which can help identify the best opportunities for steepening exposure once normalization gets underway. **In the options market, we discuss what volatility surface normalization might look like by developing an outlook for two stylized vol spreads that are sufficient to describe the volatility surface**. Our empirical framework for these variables includes the curve as a factor highlighting the fact that volatility surface normalization is linked to curve normalization. Specifically, we look for **1Yx1Y-10Y1Y** and **1Yx1Y-1Yx10Y volatility curves to decline to 1bp/day** and we discuss some ways to position for this normalization.

ICYMI - Introducing the ICMI (Idiosyncratic Movement Index)

As we noted above, the inversion in the yield curve that we observed in late 1Q22 was likely technical and likely the result of hedging activity associated with yield curve range accrual notes and/or other similar curve gamma positions. The natural question that follows is this - **how do we identify which moves have been technical and when is a good time to re-enter steepeners**? To answer this, we begin by **devising a metric that measures the extent to which moves in a given curve (such as 6M forward 2s/10s) have been technical and idiosyncratic in nature**. We do this by comparing actual curve movements to the movement that might be expected based on changes in fundamental factors.

Forward curves (we use OIS curves here rather than SOFR swap yields in order to draw upon a much longer history) across many different tenor-pairs have been well explained over long history by (i) front end swap yields (defined specifically as 1Yx2Y swap yields), (ii) long term inflation swap yields (defined as 1Yx10Y inflation swap yields), and (iii) the size of the Fed balance sheet to account for the stock effect of QE related purchases of longer maturity securities. Details of the model, illustrated for one specific case of the 6M forward 2s/10s curve, are shown in **Exhibit 8**.

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Exhibit 8: Yield curve slopes are well explained by inflation expectations, nominal front end yields, and the size of the Fed's balance sheet, as illustrated here for the specific case of the 6M forward 2s/10s curve

Statistics from regressing the 6M forward 2s/10s OIS swap yield curve (%) against 1Yx10Y inflation swap yield (%), 1Yx2Y OIS swap yield (%), and the size of the Fed's total balance sheet assets ($Tn). 2007-2022

Factor	Coefficient	T-statistic
Intercept	-0.54	-8.0
1Yx2Y swap yield (%)	-0.45	-60.2
1Yx10Y inflation swap (%)	1.28	55.9
Fed B/S assets, $Tn	-0.18	-36.5
R-squared	68%	

Source: JPMorgan, Federal Reserve H.4

Exhibit 9: Shorter dated forwards with the long leg anchored in the belly have exhibited the most idiosyncratic movements, and retracement appears to be underway even if nascent

Idiosyncratic movement index*, current curve slope (%), residuals** (%) and retracement*** metrics for various forward curves; as of 4/26/2022

	Current Value	ICM index	Current Residual	Recent Min Residual	Retracement	% Retracement
3m fwd 2s/5s	-0.12	1.17	-0.36	-0.48	0.11	24%
3m fwd 2s/10s	-0.19	0.83	-0.40	-0.69	0.29	42%
3m fwd 2s/30s	-0.41	0.65	-0.50	-0.86	0.36	42%
3m fwd 5s/10s	-0.07	0.30	-0.03	-0.21	0.18	84%
3m fwd 5s/30s	-0.29	0.30	-0.14	-0.38	0.24	64%
3m fwd 10s/30s	-0.22	0.31	-0.10	-0.17	0.07	39%
6m fwd 2s/5s	-0.20	1.02	-0.36	-0.51	0.15	30%
6m fwd 2s/10s	-0.28	0.74	-0.38	-0.69	0.30	44%
6m fwd 2s/30s	-0.51	0.61	-0.49	-0.85	0.36	42%
6m fwd 5s/10s	-0.08	0.26	-0.02	-0.19	0.17	88%
6m fwd 5s/30s	-0.31	0.29	-0.13	-0.36	0.23	63%
6m fwd 10s/30s	-0.24	0.32	-0.11	-0.17	0.06	37%
1y fwd 2s/5s	-0.23	0.83	-0.26	-0.47	0.21	44%
1y fwd 2s/10s	-0.29	0.57	-0.23	-0.57	0.34	60%
1y fwd 2s/30s	-0.54	0.49	-0.33	-0.72	0.38	53%
1y fwd 5s/10s	-0.06	0.10	0.03	-0.14	0.17	121%
1y fwd 5s/30s	-0.31	0.20	-0.07	-0.28	0.21	74%
1y fwd 10s/30s	-0.25	0.30	-0.10	-0.16	0.06	37%

*Idiosyncratic movement index is defined as beta between a regression of the residual from a long term regression (of the curve versus its fundamental drivers as described above) and the underlying curve during the recent period of curve inversion (2/9/2022 - 4/1/2022)

**Residual is calculated as the difference between the curve and the fair value for the curve generated by using the coefficients from a 15-year regression of the curve versus its fundamental drivers: 1Y forward 2Y OIS rates, 1Y forward 10Y inflation swap yields and the Fed balance sheet. This regression is performed 2/2007 to 2/2022

***Retracement is defined as the difference between the current residual and recent minimum of the residual; % retracement is defined as absolute retracement divided by the recent minimum residual times minus 1

Source: JPMorgan, Federal Reserve H.4.

Thus, changes in residual from such a regression capture the idiosyncratic variation in the curve. Specifically, a large move in the residual (relative to the move in the curve itself) would indicate largely idiosyncratic curve behavior, while a small move in the residual would suggest that curve moves have mostly been fundamental in nature. **This observation motivates our definition of an Idiosyncratic Curve Movement index (ICMI for short)** – for a given tenor-pair, we define this index as the beta of the residual (from the regression discussed earlier) with respect to the actual curve itself, where the beta is specifically calculated over recent history

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

between February 9th (when idiosyncratic curve inversions began to occur) and April 1st (approximately when most yield curve slopes reached peak inversion). We may think of an ICM index of close to 1 as describing a sector of the curve that has been highly impacted by these technical flows; conversely, a low beta would indicate little impact from technicals.

Exhibit 9 shows this ICM index for selected curve pairs, as well as summary statistics that describe the recent behavior of the residual. From the ICM index shown in this table, we infer that the curve sectors most impacted by technicals have been near term forward curves (such as 3M and 6M forward curves) where the long leg is anchored in the belly (rather than the long end).

But, **what is also notable is that retracement is now underway, even if somewhat nascent**. Also in this exhibit, we quantify amount of retracement in each curve since reaching its most inverted earlier in the month. We again use the residual from our long term regression model for each curve to quantify this retracement, rather than the changes in the curve levels itself. This is consistent with our goal of measuring the extent to which idiosyncratic curve moves are retracing. The exhibit also includes the minimum levels of the residual in 2022, and the relative and absolute changes in the residual since its minimum level. As can be seen, even the most impacted curve sectors have begun to retrace, with retracements of 20-40% already under our belts. For instance, as seen in **Exhibit 10**, the 3M forward 2s/7s swap yield curve has retraced by about 25bp since it reached its minimum in April.

Exhibit 10: Short-forward-term yield curves have begun to retrace, suggesting that technical flows may be abating

3M forward 2s/7s curve versus residual*, 1/2022 - 4/25/2022; %

*Residual from a regression of 3M forward 2s/7s OIS swap yield curve (%) against 1Yx10Y inflation swap yield (%), 1Yx2Y OIS swap yield (%), and the size of the Fed's total balance sheet assets ($Tn), regression period: 2/9/2007 - 2/9/2022

Source: JPMorgan, Federal Reserve H.4.

We recommend positioning for continued normalization in the yield curve. Specifically, our approach centers around picking curve sectors which have a significant ICMI, and then initiating steepeners as percent retracements reach 25% or more. The reason for waiting for some retracement is to improve the odds of continued normalization - as we noted earlier, dealer desks likely remain short curve gamma at inverted curve levels, which means that should a retracement take hold, dealer hedging flows will exacerbate the retracement. **In this vein, we have recently recommended initiating 6-month forward 3s/7s swap curve steepeners (**see April showers, Flowers bloom, Hikes loom, 4/22/22).

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Normalization of the implied volatility surface

As we noted earlier, the drumbeat of rising Fed hiking expectations has gained steam in recent months, and it has led to a significant reshaping of the implied volatility surface (see Exhibit 6). In this section, we explore the vol surface further by studying its drivers and discuss our outlook going forward.

To facilitate empirical analysis, we begin by defining four implied vol differentials that collectively describe the shape of the vol surface. Specifically, we use:

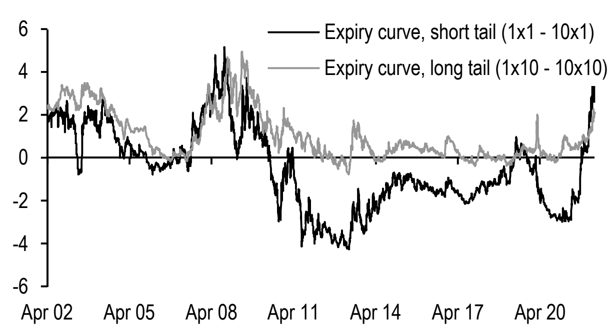
- The expiry curve on short tails, or the 1Yx1Y minus 10Yx1Y implied vol difference,
- The expiry curve on long tails, or the 1Yx10Y minus 10Yx10Y implied vol difference,
- The tail curve in short expiries, or the 1Yx1Y minus 1Yx10Y implied vol difference, and
- The tail curve in long expiries, or the 10Yx1Y minus 10Yx10Y implied vol difference.

The benefit of choosing to describe the vol surface through these four differentials is that we may study each empirically over long periods of history.

Additionally, we note that of the four differentials enumerated above, only two exhibit sizeable variation. As seen in **Exhibits 11** and **12**, the expiry curve on short tails and the tail curve in short expiries have both exhibited significant variation recently and over time, while the other two differentials have been relatively more stable. Thus, understanding the drivers of the short-expiry tail curve and the short-tail expiry curve will likely suffice for the purpose of developing an outlook for the vol surface in coming months.

Exhibit 11: The expiry curve on short tails has exhibited more variation than the expiry curve in longer tails

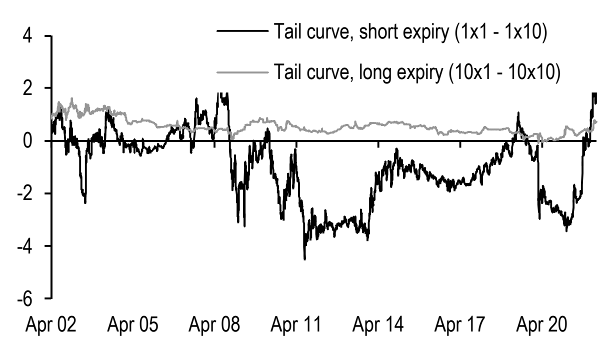
1Yx1Y minus 10Yx1Y implied vol spread, and the 1Yx10Y minus 10Yx10Y implied vol spread, over the past 20 years; bp/day



Source: JPMorgan

Exhibit 12: Similarly, the tail curve in shorter expiries has exhibited considerable variation, versus the stability in longer expiries

1Yx1Y minus 1Yx10Y implied vol spread, and the 10Yx1Y minus 10Yx10Y implied vol spread, over the past 20 years; bp/day



Source: JPMorgan

An empirical model for the expiry curve on short tails

We begin by developing an empirical model that describes the 1Yx1Y minus 10Yx1Y implied volatility differential. Since 10Yx1Y likely captures the anticipated volatility of the short rate over a 10-year horizon (which is comparable to the length of a business cycle), we may expect this differential to be driven by factors that drive

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

near term policy uncertainty, as well as factors that could drive volatility overall. With this as context, we choose the following drivers.

The first driver is the real 2Y rate (2Y swap yield minus 2Y inflation swap yield), which proxies the current policy stance at any point in time. Significantly negative levels of this factor might be expected to correlate to heightened expectations of tightening in the near term, and thus drive the vol differential higher

Our second driver is the squared deviation in inflation expectations from a neutral level. We specifically define this as the 5Y TIPS breakeven (in %) minus 2%, squared. While the previous variable measures the contemporaneous policy stance, this variable captures the 2-sided impetus for policy action.

The slope of the yield curve, which has been empirically significant for implied vol levels and for vol differentials, is our third factor. Specifically, we use the 5s/30s swap yield curve slope, but after adjusting for the Fed's QE effects (we do this by adding 0.1 times the total size of the Fed's balance sheet assets measured in trillions to the raw 5s/30s curve slope, where 0.1 is approximately equal to the partial beta of the 5s/30s curve with respect to the Fed's Balance Sheet size).

Fourth, we also include in our model the Mortgage Index vega, which can be interpreted as a driver of overall implied vol levels. Although the scale of actively hedged MBS portfolios has fluctuated over the years, there is nevertheless a correlation between how negative the MBS index vega is, and implied vol levels. This is therefore a relevant driver of this implied vol differential.

Lastly, any empirical model for implied volatility that spans a reasonably amount of historical data must contend with the Fed's non-traditional policy actions such as forward guidance which can depress volatility. Since there have been times when the Fed has signaled an "on-hold" stance for an extended period of time (as much as 36 months in 2012 and again in 2020), we include a "forward policy guidance" factor, which simply denotes the number of months for which the Fed is expected to remain on hold as of any given date in history.

We present model coefficients and statistics in **Exhibit 13**, and **Exhibit 14** demonstrates that this model has helped explain a significant part of the variation in this expiry curve over the past twenty years - a historical period that also includes the 2004-06 tightening cycle. One conclusion we can draw from this model is of course that the expiry curve is currently too steep relative to model fair value. To be sure, this residual could be due to other exogenous factors that are not captured in this model, and may not converge back to zero in the short run. But even if we look past that, 3 out of the 5 drivers are likely to trend in a direction that points to a narrowing in this expiry curve, while the other 2 factors are unlikely to move much. If we assume that 5-year breakevens moderate to ~305bp (in line with our TIPS strategists' expectations), 2-year real swap yields rise by 120-130bp (in line with what is priced into forwards), the 5s/30s swap yield curve reverses its inversion and steepens to 0, and the Fed balance sheet shrinks by about ~500bn in the next six months, then we see fair value for this expiry curve at closer to 0.2bp/day. This represents a change in fair value of about 1.3bp/day, and an overall decline of nearly thrice that amount if the residual were to converge to zero. Thus, we would look for this expiry curve to decline considerably from current levels as the vol surface normalizes in coming months.

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Exhibit 13: Our empirical model for the expiry curve on short tails…

Statistics from regressing the 1Yx1Y minus 10Yx1Y expiry curve (bp/day) against its drivers*, current value as of 4/25/2022; 2004-2022

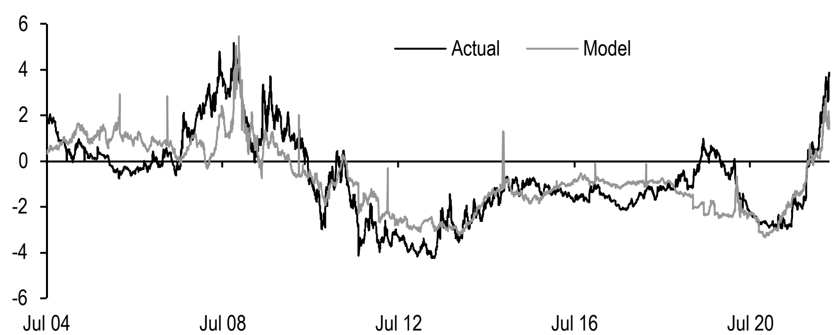
			Value of driver	
Driver	Coeff.	T-statistic	Current	6M fwd. proj.
5Y breakeven, squared deviation from 2%	0.69	34.7	1.67	1.10
MBS Index Vega	-21.7	-48.7	-0.045	-0.05
5s/30s SOFR curve, adj. for Fed B/S	-1.48	-35.3	0.650	0.725
Policy guidance, # months	-0.045	-27.6	0	0
2Y real swap yield	-0.67	-26.6	-1.86	-0.5
Intercept	-0.92	-18.9		
R-squared	66%			
Std. Error	1.05			
Expiry curve - predicted value			1.49	0.19
Expiry curve - actual			3.70	

* 5s/30s SOFR curve adjusted for Fed B/S defined as the 30Y minus 5Y SOFR swap yield (%) plus 0.1 * total Fed B/S assets ($Tn). Policy guidance refers to the number of months the Fed was expected to remain on hold at each point in time, based on FOMC signaling in periods where forward guidance was utilized as a monetary policy tool. 2Y real swap yield defined as 2Y SOFR swap yield minus 2Y inflation swap yield. For dates prior to 2019, SOFR swap yields are estimates derived from OIS swaps and an empirical model for the basis

Source: JPMorgan

Exhibit 14: … has explained much of its variation in the past two decades

1Yx1Y minus 10Yx1Y implied volatility spread, versus its predicted value*, 7/2004 - 4/25/2022; bp/day



Source: JPMorgan

Modeling the tail curve in short expiries

Our model for the tail curve in short expiries is similar in character. We use policy guidance and the 5s/30s curve (adjusted for QE effects) as two of our factors. A third factor is the 10Y TIPS breakeven, which captures the effect of long term inflation expectations on this volatility tail curve. Our fourth and final factor is the residual from the previous model for the expiry curve. This variable serves as a stand-in for the collective influence of other exogenous factors that could be in play at any given point in time. By including this residual, which incorporates these exogenous effects, we are also better able to develop an empirical model for the tail curve which will be self-consistent with the expiry curve model.

Our model for the short-expiry tail curve is shown in **Exhibit 15**.

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Exhibit 15: An empirical model for the 1Yx1Y minus 1Yx10Y implied volatility tail curve

Statistics from regressing the 1Yx1Y minus 1Yx10Y tail curve (bp/day) against its drivers*, current value as of 4/25/2022; 2004-2022

Driver	Coeff	T-statistic	Value of driver: Current	Value of driver: 6M fwd. proj.
10Y TIPS breakeven (%)	0.84	44.4	2.92	2.70
5s/30s SOFR curve, adj. for Fed B/S (%)	-1.0	-77.9	0.65	0.725
Policy guidance, # months	-0.04	-63.1	0	0
Expiry curve residual (bp/day)	0.66	87.5	2.21	1.1
Intercept	-1.24	-29.6		
R-squared	85%			
Std. Error	0.52			
Tail curve - predicted value			2.05	1.07
Tail curve - actual			2.30	

* 5s/30s SOFR curve adjusted for Fed B/S defined as the 30Y minus 5Y SOFR swap yield (%) plus 0.1 * total Fed B/S assets ($Tn). Policy guidance refers to the number of months the Fed was expected to remain on hold at each point in time, based on FOMC signaling in periods where forward guidance was utilized as a monetary policy tool. The expiry curve residual refers to 1Yx1Y minus 10Yx1Y implied vol differential minus its predicted value as per the expiry curve model described earlier. For dates prior to 2019, SOFR swap yields are estimates derived from OIS swaps and an empirical model for the basis

Source: JPMorgan

Putting it all together

We can now piece together some conclusions regarding the likely evolution of the volatility surface in coming months. First, as seen in Exhibit 13, we project that fair value for the 1Yx1Y minus 10Yx1Y expiry curve will decline to around 0.2bp/day at a 6M forward horizon. But this presumes a complete convergence in the current residual to 0. If instead we conservatively assume a halving of the current residual, **we still project that the 1Yx1Y minus 10Yx1Y expiry curve should narrow to about 1-1.5bp/day**, which is more than 2bp/day narrower from current levels.

Second, using projected values for the drivers and assuming a halving of the expiry curve's current residual, we project that the **1Yx1Y minus 1Yx10Y tail switch should also narrow to about 1bp/day over a similar time horizon**.

Exhibit 16: Armed with an outlook for the expiry and tail curves as detailed previously, we can estimate fair values for the implied vol differential between other pairs of structures on the vol surface

Statistics from regressing selected implied vol differentials against the 1Yx1Y-10Yx1Y expiry curve and the 1Yx1Y-1Yx10Y tail curve, and projected fair values*; regression over past 1Y history, current level as of 4/25/2022

Vol switch	Intercept	Beta wrt Expiry curve	Beta wrt Tail curve	Residual	R-squared	Standard Error	Current Level	Fair Value	6M ahead projection
1yx1y-5yx30y	0.42	0.97	0.07	0.19	1.00	0.10	4.37	4.17	1.46
2yx1y-2yx10y	0.37	0.39	0.13	0.36	0.96	0.19	2.90	2.13	0.89
5yx5y-7yx7y	0.20	0.29	-0.27	0.05	0.83	0.06	3.08	0.64	0.23
2yx2y-5yx5y	0.11	0.85	-0.54	0.27	0.96	0.16	3.41	1.95	0.42
1yx3y-3yx10y	0.21	0.56	-0.04	0.12	0.99	0.12	3.60	2.21	0.74
7yx7y-10yx10y	0.34	0.30	-0.29	0.09	0.61	0.09	3.87	0.75	0.35

* Fair value based on current levels of the expiry curve and tail curve. The 6M ahead projection assumes that the expiry curve and tail curves both converge to 1bp/day, as discussed earlier

Source: JPMorgan

Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Last, armed with our outlook for the expiry and tail curves, we can take the empirical relationship between other implied volatility differentials and these two vol-surface factors. For instance, the 2Yx2Y minus 5Yx5Y implied vol switch has betas of 0.85 and -0.54 respectively over the past year, with respect to the expiry and tail curves respectively. Using this relationship, we see fair value for this vol spread at 2bp/day currently, but also note that this spread is likely to narrow further to about 0.4bp/day if our views on the expiry curve and tail curves prove correct (see **Exhibit 16**). Therefore, we recommend underweighting the upper left versus middle-of-grid structures, such as the 1Yx3Y versus 3Yx10Y switch we have recommended in recent weeks (see Keep your eyes on me, 4/8/22).

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Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

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Srini Ramaswamy
(1-415) 315-8117
Srini.Ramaswamy@jpmorgan.com

Mike Fu
(1-212) 834-4067
mike.fu@jpmorgan.com

Ipek Ozil
(1-212) 834-2305
ipek.ozil@jpmorgan.com

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