Midcurve options primer

Mechanics, fair value analysis, typical trades, and JPM analytics

- Midcurve options, both listed and OTC, have become increasingly popular over the past few years
- We discuss the pricing of a midcurve option and its estimation of fair value using the underlying vanilla swaptions
- We highlight various typical trades implemented via midcurves. We look at the following categories: *1)* Delta based trades; *2)* Conditional curve trades; *3)* Delta-hedged trades; and *4)* Volatility relative value trades
- We present JPM analytics which help in identifying and analyzing the attractiveness of these trades
- These reports are available on www.jpmm.com and their underlying data is available to clients via Dataquery ®

Rates Strategy
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See page 9 for analyst certification and important disclosures.

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Midcurve options primer

Midcurve options are interest rate options where the underlying asset is a forward interest rate instrument. Midcurve options have existed for a while in money market listed space where investors could trade short dated options (less than one-year) on forward money market rates (in term of Euribor/Libor futures contracts). However, these instruments, which once traded as exotic OTC products, have recently witnessed an increase in liquidity and become more widely used across investors, especially in OTC space.

The simple principle behind midcurve options is to separate the expiry date of the options to the start date of the interest rate (either swap or single forward/futures rate), which is the underlying instrument of the option. With central banks' policy rates close to the lower bound and firmly on hold, investors have generally shifted their tactical/strategic trading further out the yield curve. This has, on one side, led exchanges to list longer midcurve options (up to 5 years are listed on Eurodollar, 4 years on Euribor and Short Sterling futures) and on the other side to the OTC midcurve option market to become increasingly liquid and popular.

In this note, we focus on: *1)* the basics of the pricing of midcurve options, *2)* the estimation of its fair value using vanilla swaptions, *3)* typical trades involving midcurve options, and *4)* J.P.Morgan analytics to identify potential trading opportunities and provide a relative value framework.

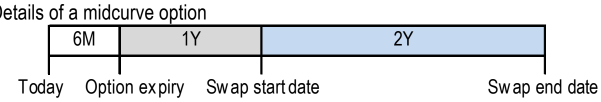
As discussed above, midcurve options trade both as listed products on the exchange and as over-the-counter instruments, like vanilla swaptions. Typically, the listed midcurve market allow investors to buy or sell option on forward money market rates, whereas the underlying instrument in OTC midcurve options is a forward swap rate. One notable difference between these two types (listed and OTC) is that the midcurve on the exchange are "American-style" option (and can be exercised at any time before expiry) whereas the OTC midcurve market is generally "European" (with exercise of the option only at expiry) in nature.

What is a midcurve option?

A midcurve swaption, traded in the OTC market, is a swaption where the underlying is a forward interest rate swap. For instance, upon maturity of a midcurve receiver swaption, the counterparty that is long the option has the right, but not the obligation, to receive (fixed)

Exhibit 1: Timings associated with a midcurve option

Details of a midcurve option



into a forward starting swap at a pre-determined strike. **Exhibit 1** shows the details of the timing associated with midcurve options and the underlying swaps. For instance, a 6Mx(1Yx2Y) receiver midcurve swaption is an option with 6-months to expiry to receive fixed in a 2Y swap which starts 1Y after the option expiry; the strike of the forward starting swap is fixed at trade initiation. Thus, these structures provide a natural way of expressing views on forward starting swaps, across the yield curve.

With the notable difference of the underlying rate being a forward starting swap as opposed to a spot starting swap, the midcurve swaptions are identical, in principle, to vanilla swaptions. This means that the calculation and intuition behind the various risk parameters associated with options remain the same for midcurves as well.

In OTC space for example, a 3M ATMF option on 5Yx5Y swap rate will have a strike equivalent to the 5Y rate starting in 5Y and 3M. The tradeable underlying and strikes can be tailored to investors' need with dealers typically quoting prices for midcurve options between 3M and 5Y or 10Y expiries. In the listed space, the exchange sets the expiries and strikes that can be traded. The expiries range from the first to the fourth IMM dates and the underlying instruments are money market futures (Eurodollar, Euribor, and Short Sterling). These are therefore options on futures contracts further out the curve. For example, the Jun15 1Y (reds) Euribor midcurve option is the option expiring in June 2015 and has the *Jun16* Euribor future as the underlying instrument. Similarly, a Jun15 2Y midcurve option has the Jun17 Euribor future as the underlying instrument. For comparison, the Jun15 quarterly (or front) option is an option on the *Jun15* Euribor futures expiring in Jun15.

Pricing a midcurve option: estimating fair value from vanilla swaptions

The midcurve volatility may be expressed in terms of two vanilla swaptions and the correlation between the underlying swap rates. For instance, if we consider a 1Yx2Y swap rate, its *variance* can be calculated using:

1) Variance of the underlying 1Y swap yield

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Exhibit 2: Midcurve options have become increasingly liquid over the past few years and can be used to set a variety of option based trades

Various midcurve structures and their current implied volatility, statistics on these implied volatilities, and 1M & 3M delivered volatility of the underlying forward swap

	Implied volatility					Delivered volatility		Imp - delivered volatility	
	Current	Avg	Max	Min	Zscore	1M	3M	1M	3M
3M expiry	**EUR**								
1Yx1Y	1.5	1.4	2.6	1.0	0.4	0.8	1.0	0.7	0.5
2Yx1Y	2.0	2.3	4.1	1.8	-0.5	1.3	1.5	0.7	0.6
2Yx2Y	2.3	2.5	4.2	2.0	-0.6	1.7	1.8	0.6	0.4
3Yx1Y	2.7	3.0	4.6	2.4	-0.5	2.1	2.3	0.7	0.5
3Yx2Y	2.9	3.2	4.7	2.6	-0.6	2.3	2.6	0.6	0.3
5Yx5Y	4.2	4.5	5.8	3.6	-0.7	2.8	4.2	1.4	0.1
10Yx10Y	5.4	4.7	7.0	3.1	0.8	2.8	4.3	2.6	1.2
20Yx10Y	5.2	4.5	7.4	2.9	0.7	3.2	4.3	2.0	0.9
	GBP								
1Yx1Y	5.0	4.7	5.5	3.9	1.0	2.9	3.6	2.0	1.4
2Yx1Y	6.3	5.8	7.8	4.7	0.8	4.1	4.7	2.2	1.6
2Yx2Y	6.4	5.8	7.7	4.7	0.9	4.7	5.1	1.7	1.3
3Yx1Y	6.9	6.2	8.1	5.0	0.9	5.3	5.6	1.6	1.3
3Yx2Y	6.8	6.0	7.8	4.8	0.9	5.8	5.8	1.0	0.9
5Yx5Y	6.1	5.2	6.9	4.1	1.1	5.6	6.0	0.5	0.1
10Yx10Y	5.9	4.7	7.5	3.0	1.0	4.3	5.1	1.6	0.9
20Yx10Y	6.4	5.0	8.6	2.7	0.9	4.3	4.9	2.1	1.5

2) Variance of the underlying 3Y swap yield (final maturity), and
3) A cross term that uses the correlation between these two swap rates.

These variances should be weighted by the duration of the underlying swaps (here, we use the PVBP – price value of a basis point change in yield). Arithmetically, including option expiry period of 3M, this can be written as:

$$\sigma^2_{M,3Mx1Yx2Y} = w_a^2 * \sigma^2_{3Mx1Y} + w_b^2 \sigma^2_{3Mx3Y} - 2 * w_a * w_b * \sigma_{3Mx1Y} * \sigma_{3Mx3Y} * \rho$$

where, $\sigma_{3Mx1Yx2Y}$ denotes the implied volatility of a 1Yx2Y midcurve that expires in 3M.
σ_{3Mx1Y} & σ_{3Mx3Y} denotes 3Mx1Y and 3Mx3Y swaption implied volatility.
w_a is defined as (PVBP of 3Mx1Y swap)/(PVBP of 3Mx3Y - PVBP of 3Mx1Y);
w_b is defined as (PVBP of 3Mx3Y swap)/(PVBP of 3Mx3Y - PVBP of 3Mx1Y);
ρ is the correlation between the 1Y and 3Y swap rate.

Therefore, the fair value of a midcurve swaption implied volatility (and hence its premium) can be calculated using the volatilities of the underlying swaptions and the correlation between the two underlying swap rates. In practice, though, midcurve implied volatilities typically trade away from their estimated fair value (where the correlation is generally calculated on daily changes of the underlying swap yield). This difference is to account for the convexity arising due to changing swap annuity. In the fair value estimation, we assume that the swap annuity (denoted by the PVBP of the swap in the above formula) remains constant throughout the life of the option and as the underlying changes. However, in practice, the annuity itself changes leading to a convexity in the payoff and hence difference in implied volatility. If the yield curve is upward sloping and the longer maturity swap rate is higher compared to the shorter maturity swap rate, the fair value estimation acts as a lower bound for the traded midcurve implied volatility and vice versa (due to the higher annuity convexity effect of the longer maturity swap rate).

Exhibit 2 shows some of the typical midcurve structures including current implied volatility, statistics on these implied volatilities, and 1M & 3M delivered volatility of the underlying forward swap. All the underlying data is available via Dataquery®.

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Exhibit 3: Using midcurves to initiate directional view on market is extremely popular

Various bullish receiver structures with current cost, projected payoff at maturity if current carry is realized, and yield bounds for 1Yx(1Yx1Y) midcurve swaptions; bp

						Yield bounds (bp)	
Structure		Strike	Contract	Cost (bp)	Projected payoff (bp)	Lower	Upper
Outright	ATMF	0.33	+1	19.5	22.8	-	13.3
Spread	ATMF/ATMS	0.33/0.20	+1/-1	6.9	12.9	-	25.9
1x2	ATMF/ATMS	0.33/0.20	+1/-2	-5.8	3.0	14.1	38.6
Ladder	ATMF/ATMS/ATMS-1C	0.33/0.20/0.07	+1/-1/-1	-0.6	12.9	6.4	33.4
Butterfly	ATMF/ATMS/ATMS-1C	0.33/0.20/0.07	+1/-2/+1	1.7	3.0	8.7	31.1
Condor	ATMF/ATMS/ATMS-1C/ATMS-2C	0.33/0.20/0.07/-0.06	+1/-1/-1/+1	3.4	12.9	-2.5	29.4

Trading strategies using Midcurve options

What are the typical trades that investors implement using midcurve options? In this section, we present typical trading strategies amongst investors using midcurve options. In addition, we also discuss and present the J.PMorgan analytics which can be used to identify and analyse trades using midcurve options. Broadly, we categorise the types of trades into four categories:

1) **Delta-based trades**: these are trades which typically retain duration exposure and are implemented by investors taking an explicit or implicit outright view on the underlying rate. These include trades that are implemented for yield enhancement, earn carry and target a range of the underlying yield
2) **Conditional curve trades**: via these trades investors implement a curve view conditional on the market either rallying or selling off. The combination of swaption and midcurve options allows investors to take conditional curve exposure in both spot and forward space.
3) **Delta-hedged pure volatility trades**: these are trades that do not retain duration exposure and are structured to express views on implied and/or delivered volatility
4) **Relative value trades**: These are generally gamma trades that exploit any relative value between swaptions and midcurve options.

We discuss each of these in detail below.

Delta-based trades

Similar to a regular swaption, we can use midcurve options to express outright or leveraged duration views. For example, buying midcurve receiver swaptions would be an alternative way to express a bullish positions, which could also benefit from carry and positive slope in the curve – a long receiver midcurve options, have a positive payoff at the expiry if the underlying yield would be lower than the option strike by more than the premium paid to purchase the option (price expressed in yield terms). In **Exhibit 3**, we show a list of such directional trades (including outright receivers, receiver spreads, 1x2s, ladders, flies, and condors) along with their expected payoff at option expiry under various rate scenarios. We highlight that these structures have varying delta and gamma exposures; some of them have large long duration exposure whereas others have long duration exposure only locally. We produce daily analytics showing the current cost and expected P&L for a small sample of these trades which are available on www.jpmm.com.

Conditional curve trades

Investors can express conditional views on the curve using midcurves (both OTC and listed) or a combination of midcurves and swaptions. By construction, these conditional trades will turn into a delta-1 trade only if the underlying market direction is realized at expiry. For instance, if recent yield curve directionality holds, then the swap curve is expected to steepen in a sell-off and flatten in a rally. A curve steepening view, under such circumstances, would be better expressed by conditional payers, which would expire worthless if yields decline and the curve flattens (if recent directionality holds). These trades can be structured to be premium neutral at inception (by either shifting more OTM the strike of the relative more expensive option, or by trading a premium neutral ratio combination) which gives the added advantage that if market moves in the opposite direction and the options expire worthless, then the trade does not suffer any loss at expiry. Of course, to initiate such premium neutral trades, the entry level for the trades are generally worse then the forward levels, if the volatility on the “long” leg is higher than the volatility on the “short” leg.

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We produce analytics on a daily basis to identify zero-cost entry points for such conditional trades using swaptions and midcurves (or even midcurve vs. swaptions) (**Exhibit 4**). In these reports, we also show the current swap rate carry and volatility for the individual trade legs. Together, we can infer the overall carry cost in implementing these conditional trades. In **Exhibit 5** we compare the implied directionality and delivered directionality of a variety of trades to identify the relative advantage in initiating conditional trades. For instance, if the options market prices the swap curve directionality cheaper compared to that observed from movements in the swap curve, then option based structures appear attractive as they would allow investors to benefit from persistent curve directionality. For example, **Exhibit 6** shows the breakeven lines for a greens/10Yx10Y bear steepener initiated at current levels. As seen, the options market is underpricing the recent observed directionality as the breakeven line appears to be below to the regression of the observed data points. If the recent delivered directionality holds conditional bearish structures are attractive.

We generate analytics to identify zero-cost entry points for the following three combinations:

i. Swaption versus swaption (buying 3Mx30Y payers versus 3Mx3Y payers)
ii. Midcurve versus swaption (buying 3Mx(5Yx5Y)

Exhibit 4: The midcurve conditional report can be used to identify zero-cost entry points for various curve trades using midcurves. We can also infer the total cost of carry for such trades

Spot and forward curves and zero cost entry level using payers and receivers using 3M options; bp

				Strike*		ATMF implied vol; bp/day	
Trade using 3M options	Spot	Carry	Fwd	Payer	Rec	Short leg	Long leg
1Yx1Y/2Yx1Y	12.6	2.1	14.7	19.0	11.0	1.5	2.1
1Yx1Y/3Yx1Y	29.9	2.0	31.9	44.0	23.0	1.5	2.8
1Yx1Y/2Yx2Y	21.2	2.1	23.3	31.0	17.0	1.5	2.5
1Yx1Y/3Yx2Y	38.3	1.9	40.2	54.0	29.0	1.5	3
1Yx1Y/5Yx5Y	86.0	0.5	86.5	116.0	64.0	1.5	4.3
1Yx1Y/10Yx10Y	115.6	-2.2	113.4	155.0	77.0	1.5	5.6
1Yx1Y/10Yx20Y	109.5	-2.2	107.3	145.0	71.0	1.5	5.5
2Yx1Y/3Yx1Y	17.3	-0.1	17.2	23.0	13.0	2.1	2.8
2Yx1Y/2Yx2Y	8.7	-0.1	8.6	12.0	6.0	2.1	2.5
2Yx1Y/3Yx2Y	25.8	-0.3	25.5	33.0	19.0	2.1	3
2Yx1Y/5Yx5Y	73.5	-1.7	71.8	92.0	56.0	2.1	4.3
2Yx1Y/10Yx10Y	103.0	-4.3	98.7	130.0	71.0	2.1	5.6
2Yx1Y/20Yx10Y	90.2	-4.4	85.8	109.0	61.0	2.1	5.4

* Strike represents the zero-cost entry level using payers and receivers.

Exhibit 5: Implied/delivered directionality report can be used to identify attractive opportunity to implement conditional trades

Implied and delivered directionality for various midcurve trades and 3M regression statistics from regressing the weighted curve** against the longer maturity swap leg; all options have 3M expiries;

			Directionality*; %											
	Implied volatility; bp/day		Implied		Delivered	Implied - delivered	Implied weights; %		Weighted curve**; bp			3M regression stats***	
Trades	Short	Long	Current	3M Lagged	Levels	Levels	Short	Long	3M Fwd	Spot	3M Carry	Beta	Rsqr
1Yx1Y/2Yx1Y	1.5	2.1	28%	38%	27%	1%	100%	72%	7	7	1	-1%	0%
1Yx1Y/3Yx1Y	1.5	2.8	47%	55%	51%	-5%	100%	53%	12	12	0	5%	2%
1Yx1Y/2Yx2Y	1.5	2.5	39%	46%	41%	-1%	100%	61%	10	9	0	1%	0%
1Yx1Y/3Yx2Y	1.5	3	50%	59%	60%	-10%	100%	50%	14	14	0	10%	11%
1Yx1Y/5Yx5Y	1.5	4.3	65%	76%	84%	-19%	100%	35%	23	24	-1	19%	73%
1Yx1Y/10Yx10Y	1.5	5.6	73%	77%	90%	-17%	100%	27%	22	24	-2	17%	85%
1Yx1Y/10Yx20Y	1.5	5.5	73%	76%	91%	-18%	100%	27%	21	23	-2	18%	88%
2Yx1Y/3Yx1Y	2.1	2.8	26%	28%	28%	-2%	100%	74%	6	7	-1	2%	1%
2Yx1Y/2Yx2Y	2.1	2.5	16%	13%	15%	1%	100%	84%	3	4	-1	-1%	1%
2Yx1Y/3Yx2Y	2.1	3	31%	34%	41%	-10%	100%	69%	9	11	-2	10%	31%
2Yx1Y/5Yx5Y	2.1	4.3	52%	61%	79%	-27%	100%	48%	21	24	-3	27%	83%
2Yx1Y/10Yx10Y	2.1	5.6	63%	64%	88%	-25%	100%	37%	20	24	-4	25%	88%
2Yx1Y/10Yx20Y	2.1	5.5	62%	62%	88%	-26%	100%	38%	19	23	-4	26%	90%

* Implied directionality defined as: 1 – (Short maturity implied vol)/(long maturity implied vol). Delivered directionality defined as: 1 – 3M beta of short maturity swap regressed against long maturity swap.
** Weighted curve defined as: (Short maturity implied vol/Long maturity implied vol)*Long maturity yield – Short maturity yield. 3M carry defined for curve flatteners.
*** Weighted curve regressed against long maturity swap.

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midcurve payers versus 3Mx(2Yx1Y) midcurve payers, and

iii. Midcurve versus swaption (buying 3Mx30Y swaption payers versus 3Mx(2Yx1Y) midcurve payers.

Delta-hedged trades

We can use midcurve options (listed and OTC) to express gamma views on the swap curve and on money market futures. Exhibit 2 shows the current implied volatility, 1M and 3M delivered volatility, and gamma carry for short gamma positions (implied volatility *minus* delivered volatility) for various 3M expiry midcurve swaptions. In Dataquery® we have available time series implied volatility for several tails and for several maturities for OTC midcurve options. We have been routinely recommending delta-hedged trades using midcurve swaptions in our *Global Fixed Income Markets Weekly* publication to express a gamma view on the swap curve.

The gamma (adjusted for the theta) and the vega are the main source of P&L for these delta-hedged trades. While gamma P&L depends on the difference between inception implied volatility and subsequent delivered volatility, the vega P&L depends on the evolution of implied volatility. This has implication on the optimal choice of trade to be implemented with a preference for short date (higher gamma) options if the underlying view is that of a divergence between implied and delivered volatility and a preference for longer dated (higher vega) option to position for a repricing in implied volatility. **We produce a daily report that shows a snap shot of various midcurve structures along with recent delivered volatility of the underlying forward yield** (**Exhibit 7**). We also show a volatility cone (statistics on current delivered volatility versus empirical distribution of delivered volatility calculated on overlapping period with the same number of days to expiry month) and empirical frequency of delivered volatility being higher than current level of implied volatility.

Volatility relative value trades

In theory, midcurves can be synthetically replicated using standard swaptions. However, this requires an assumption of the correlation between two swap rates (see above). Using the relationship in the above equation, we can infer the correlation that the midcurve market is pricing between the underlying swaption. Comparing this implied correlation with realized correlation gives a measure of relative value and can be used to evaluate the richness/cheapness of midcurve swaptions. **Exhibit 8** shows a snap shot of a report that

Exhibit 6: Currently, options market do not appear to be pricing the recent delivered directionality making conditional curve trades attractive

10Yx10Y yields versus 2Yx1Y yields and regions of positive, negative, and zero P&L for implied volatility weighted bear steepeners (initiated at zero cost); past 1Y; %

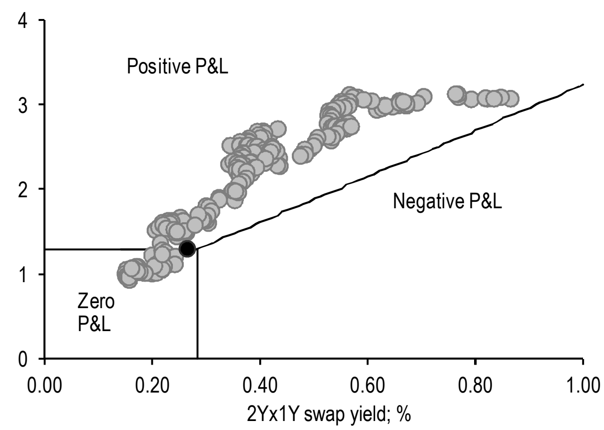

Exhibit 7: A snapshot of the midcurve gamma report

Current implied volatility and statistics on implied volatility, delivered volatility on various look back, and 3Y delivered volatility cone; bp/day;

	Imp vol (bp/day)			Deliv vol (bp/day)			Deliv vol 3Y cone; bp/day			
Exp	Curr	1M Chg	6M Zscore	10D	1M	3M	Max	Min	Avg	% Hist > Imp
1Yx1Y EUR midcurve options										
1M	1.5	0.0	0.5	1.2	1.0	1.0	6.0	0.5	2.4	73%
3M	1.5	0.0	0.8	1.4	1.1	1.0	4.7	0.9	2.6	72%
6M	1.7	0.1	1.3	1.7	1.3	1.2	4.6	1.1	2.9	77%
1Y	2.0	0.1	1.4	2.1	1.8	1.5	4.5	1.7	3.5	92%
2Yx1Y EUR midcurve options										
1M	2.1	0.1	-0.2	2.1	1.8	1.6	7.5	0.9	3.2	73%
3M	2.1	0.1	0.0	2.3	2.0	1.8	5.8	1.4	3.5	74%
6M	2.3	0.2	1.1	2.6	2.3	2.1	5.6	1.9	3.7	84%
1Y	2.5	0.2	2.1	3.2	2.7	2.4	5.0	2.8	4.3	100%

we produce on a daily basis highlighting this differential (implied correlation minus realized correlation). We also present statistics on the differential on the actual minus theoretical value of the midcurve swaption (calculated using actual realized correlations).

<u>Forward volatility</u>: One of the applications of midcurve is to replicate *forward volatility* in combination with swaptions. Specifically, forward volatility can be decomposed into an equivalent midcurve option and a longer dated swaption. For illustrative purpose we present our most recent recommendation in the forward volatility space. For instance, a 1Yx2Yx5Y forward volatility can be synthetically replicated using a

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Exhibit 8: Comparing actual realized correlation versus that implied by the midcurve price gives a measure of richness/cheapness of the midcurves versus fair value

Realized and implied correlation (implied from midcurve prices) and statistics on the difference between these two correlations for various structures; %

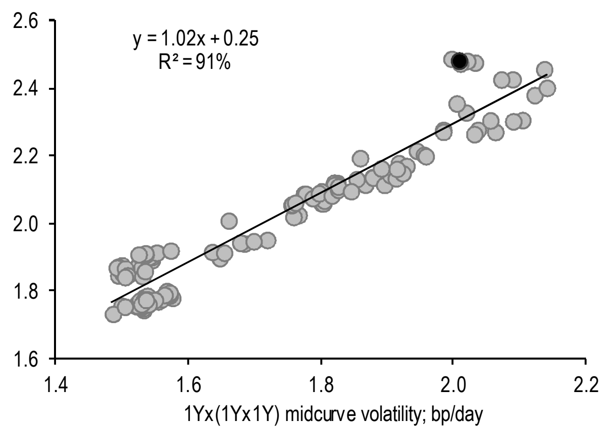
			Implied volatility; bp/day											
	Replicating swaptions		Swaption		Midcurve		Correlation			Midcurve - replicating port; 1Y stats				
Midcurve	Short	Long	Short	Long	Actual	Theoretical	Implied	Realized	Imp - realized	Current	Zscore	Max	Min	Average
3Mx(1Yx1Y)	3Mx1Y	3Mx2Y	1.5	1.5	1.5	1.7	97	91	7	-0.2	-3.2	0	-0.2	-0.1
3Mx(2Yx1Y)	3Mx2Y	3Mx3Y	1.5	1.6	2.1	2.4	98	94	4	-0.3	-0.6	0	-0.5	-0.2
3Mx(3Yx1Y)	3Mx3Y	3Mx4Y	1.6	1.8	3.0	2.7	96	98	-2	0.3	2.5	0.3	-0.4	-0.1
3Mx(4Yx1Y)	3Mx4Y	3Mx5Y	1.8	2.0	3.2	3.2	99	99	0	0	0.4	0.3	-0.3	-0.1
3Mx(1Yx2Y)	3Mx1Y	3Mx3Y	1.5	1.6	1.8	1.9	90	77	13	-0.1	-1.6	0	-0.2	0
3Mx(2Yx2Y)	3Mx2Y	3Mx4Y	1.5	1.8	2.5	2.5	84	86	-2	0	2.2	0	-0.5	-0.2
3Mx(3Yx2Y)	3Mx3Y	3Mx5Y	1.6	2.0	3.1	3.0	90	95	-4	0.2	1.7	0.3	-0.3	-0.1
3Mx(4Yx2Y)	3Mx4Y	3Mx6Y	1.8	2.3	3.4	3.5	98	97	1	-0.1	0.2	0.2	-0.4	-0.1
3Mx(5Yx5Y)	3Mx5Y	3Mx10Y	2.0	3.2	4.6	4.6	92	92	0	0	0.1	0.3	-0.4	0
3Mx(5Yx10Y)	3Mx5Y	3Mx15Y	2.0	3.8	5.1	4.9	73	87	-14	0.2	0	0.5	-0.1	0.2
3Mx(5Yx25Y)	3Mx5Y	3Mx30Y	2.0	4.5	5.4	5.2	32	79	-47	0.2	-0.3	0.5	0.1	0.3
3Mx(10Yx10Y)	3Mx10Y	3Mx20Y	3.2	4.2	6.0	5.6	89	96	-6	0.3	0.3	0.5	0.1	0.3
3Mx(10Yx20Y)	3Mx10Y	3Mx30Y	3.2	4.5	5.9	5.5	78	92	-14	0.3	0.1	0.4	0.2	0.3
3Mx(15Yx15Y)	3Mx15Y	3Mx30Y	3.8	4.5	6.0	5.6	92	98	-6	0.4	0.6	0.6	0.1	0.4
3Mx(20Yx10Y)	3Mx20Y	3Mx30Y	4.2	4.5	5.7	5.5	98	99	-1	0.3	0	0.6	0.1	0.3

1Yx2Yx5Y midcurve swaption and a 3Yx5Y vanilla swaption. This gives exposure to the 2Yx5Y rate, 1Y forward. For more details on this, please refer *Trading synthetic EUR forward volatility: JPM analytics for valuing forward volatility using swaptions* by Khagendra Gupta, 8 April 2015. Therefore, any relative value between midcurve and swaptions can result in opportunities for trading forward. For instance, currently 2Yx1Y swaption implieds are trading rich versus 1Yx1Yx1Y midcurve implieds on a regression basis (**Exhibit 9**). Consequently, 1Yx1Yx1Y forward volatility is trading close to its recent highs (**Exhibit 10**) and we have been recommending fading the richness of this forward volatility via selling 2Yx1Y swaption and buying an equi-notional amount of 1Yx1Yx1Y midcurve volatility. In **Exhibit 11** we present snapshot of a daily report that we produce to price forward volatility using vanilla swaptions and midcurve swaptions.

The reports mentioned throughout this research note are produced on a daily basis and are a part of European Derivatives research package or EUR/UK interest rate volatility package. These reports are published on www.jpmm.com on a daily basis. Interested clients can request access to receive these packs via email on a daily basis.

Exhibit 9: 2Yx1Y swaption is trading rich to 1Yx(1Yx1Y) midcurve volatility resulting in high 1Yx1Yx1Y forward volatility

2Yx1Y swaption implied volatility regressed against 1Yx(1Yx1Y) midcurve volatility; past 6M; bp/day



Appendix - some definitions for OTC midcurve swaptions

We discuss some of the terminologies associated with midcurve swaptions. Let us consider the following trade executed on 30 April 2015.

Position: Long €100mn notional of 6Mx(1Yx2Y) midcurve receiver swaption, strike = 0.20%, at-the-money forward rate = 0.246%, premium is 36.7bp of notional.

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Notification date: 30 October 2015 (6M from trade date). This is the date on which the option may be exercised by the buyer.

Start date: 03 November 2016 (1Y from notification date, adjusted for holidays and settlement days).

Term/maturity date: 03 November 2018 (2Y from the start date, adjusted for holidays and settlement days).

Strike: 0.20%. This is the annual coupon on the underlying swap (the frequency of the fixed coupon depends on the underlying currency). The default frequency of the EUR swap is annual while that for USD midcurves is semi-annual.

Premium: 36.7bp of notional. This is the "spot premium", or the market value of the option in basis point of notional. Thus, a €100mn position will cost €367,000. The premium can also be expressed in "running yield", which is expressing the premium in yield terms by adjusting for the underlying swap dollar duration (premium / swap dollar duration). Also typical of the options market is to quote the option premium as "forward premium" and is payable at option expiry.

Exhibit 10: 1Yx1Yx1Y forward volatility is trading at its recent highs and appears an attractive sell

1Yx1Yx1Y forward volatility replicated synthetically using a triangle of swaptions and assuming that correlation between the underlying swaps is 100%; past 1Y; bp/day

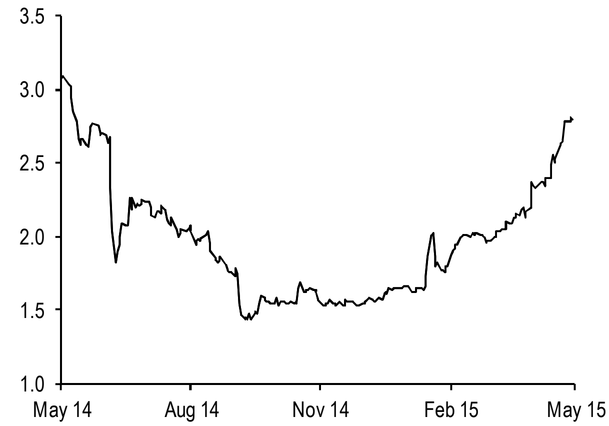

Exhibit 11: Replicating forward volatility using vanilla swaptions and midcurve swaptions

Statistics on forward volatility replicated using vanilla swaptions and midcurve volatility; bp/day

Fwd vol structure	Vanilla swaption		Midcurve swaption		1Y stats on forward vol					Fwd vol	Spot vol			1Y regression stats*** Spot vol			1Y regression stats*** Vanilla swaption vol		
	Structure	Value	Structure	Value	Current	Min	Avg	Max	Zscore	1M hvol*	Structure	Value	1M hvol**	Beta	Residual	R^2	Beta	Residual	R^2
1Mx1Yx1Y	13Mx1Y	2.0	1Mx1Yx1Y	1.6	2.0	1.1	1.5	2.1	2.0	1.2	1Yx1Y	2.0	1.1	1.0	0.0	99%	1.0	0.0	99%
3Mx1Yx1Y	15Mx1Y	2.1	3Mx1Yx1Y	1.5	2.2	1.1	1.6	2.3	2.1	1.3	1Yx1Y	2.0	1.1	1.1	0.1	97%	1.0	0.1	98%
6Mx1Yx1Y	18Mx1Y	2.2	6Mx1Yx1Y	1.7	2.4	1.4	1.8	2.7	2.0	1.5	1Yx1Y	2.0	1.1	1.1	0.1	88%	1.0	0.1	96%
1Yx1Yx1Y	24Mx1Y	2.5	1Yx1Yx1Y	2.0	2.9	1.8	2.3	3.5	1.6	1.9	1Yx1Y	2.0	1.1	0.8	0.1	37%	1.0	0.2	98%
1Mx2Yx1Y	25Mx1Y	2.5	1Mx2Yx1Y	2.3	2.6	1.6	2.2	3.5	1.1	2.0	2Yx1Y	2.5	1.9	1.0	0.0	99%	1.0	0.0	100%
3Mx2Yx1Y	27Mx1Y	2.6	3Mx2Yx1Y	2.1	2.7	1.7	2.3	3.6	1.0	2.2	2Yx1Y	2.5	1.9	1.1	0.0	96%	1.0	0.0	99%
6Mx2Yx1Y	30Mx1Y	2.8	6Mx2Yx1Y	2.3	2.9	2.0	2.6	3.9	0.8	2.4	2Yx1Y	2.5	1.9	1.1	-0.1	86%	1.0	0.1	99%
1Yx2Yx1Y	36Mx1Y	3.1	1Yx2Yx1Y	2.6	3.3	2.6	3.1	4.2	0.5	2.9	2Yx1Y	2.5	1.9	1.0	-0.2	63%	1.0	0.1	99%
1Mx5Yx5Y	61Mx5Y	4.0	1Mx5Yx5Y	4.6	4.0	3.7	4.2	4.8	-0.4	4.7	5Yx5Y	4.0	4.7	1.0	0.0	100%	1.0	0.0	100%
3Mx5Yx5Y	63Mx5Y	4.1	3Mx5Yx5Y	4.6	4.0	3.7	4.2	4.8	-0.4	4.7	5Yx5Y	4.0	4.7	1.1	0.0	100%	1.1	0.0	100%
6Mx5Yx5Y	66Mx5Y	4.1	6Mx5Yx5Y	4.7	4.0	3.7	4.2	4.9	-0.4	4.7	5Yx5Y	4.0	4.7	1.1	0.0	99%	1.2	0.0	99%
1Yx5Yx5Y	72Mx5Y	4.2	1Yx5Yx5Y	4.9	4.0	3.7	4.1	4.8	-0.4	4.7	5Yx5Y	4.0	4.7	1.1	0.0	97%	1.4	0.0	96%
1Yx10Yx10Y	132Mx10Y	4.3	1Yx10Yx10Y	5.4	4.2	4.0	4.2	4.5	-0.3	4.7	10Yx10Y	4.3	4.7	0.9	-0.1	77%	0.9	-0.1	68%
1Yx20Yx10Y	252Mx10Y	3.8	1Yx20Yx10Y	5.2	3.7	3.2	3.5	3.9	2.2	4.8	20Yx10Y	3.9	4.8	0.9	0.0	94%	0.9	0.0	94%

* 1M delivered volatility of the forward swap rate. For example, in the case of 1Yx1Yx1Y, this represents 1M delivered volatility of 2Yx1Y swaps.
** 1M delivered volatility of the spot swap rate. For example, in the case of 1Yx1Yx1Y, this represents 1M delivered volatility of 1Yx1Y swaps.
*** 1Y statistics from regressing synthetic forward volatility against spot swaption volatility and the vanilla swaption volatility (used in the replication of the forward vol).

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