A primer on Conditional Trades

Setting the curve or spread exposure as a function of market direction; different ways of achieving premium neutrality

- Conditional trades are an attractive way to express yield curve or yield spread exposure
- These trades are typically implemented by buying an option on one leg (receivers or payers swaption) and selling an option on the other leg
- The advantage of conditional trades relative to outright trades is that there is curve or spread exposure at option expiry only if the underlying yield moves in the specific direction
- Additionally, these trades become appealing if the *ex-ante* implied directionality is different from the *ex-post* delivered directionality
- Conditional trades are mostly implemented at zero cost at inception
- We present two ways of achieving premium neutrality: either by *1)* shifting OTM the strike of the option with the more expensive implied volatility (*Strike shift* strategy), or *2)* adjusting its notional proportionately to the implied volatility ratio (*Weighted curve* strategy)
- We discuss the advantages of one versus the other and find that typically in small moves the *Weighted curve* strategy outperforms the *Strike shift* strategy…
- …whereas the opposite is true in case of large sell off, provided delivered directionality outpaces implied directionality at inception
- As a limit case, we also prove that if the volatility of the two legs is identical, the two strategies converge
- We present mathematical expressions to calculate the strike shift necessary to obtain premium neutrality in the Strike shift methodology, assuming that the volatility surface is flat
- Although the analysis is mostly presented for yield curve or spread exposure it is possible to extend the framework to butterfly trades
- J.P.Morgan analytics on conditional curve and spread trades are available in our daily Derivatives Package here

Rates Strategy

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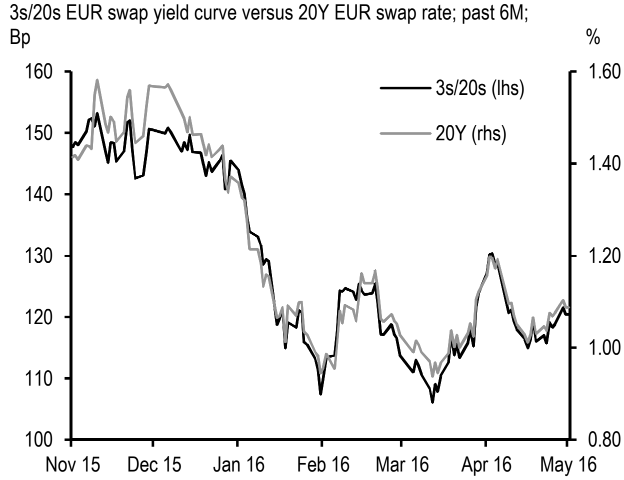
A primer on conditional trades

In addition to outright duration exposure, fixed income investors typically express views on either the slope of the yield curve or on the yield spread between different markets (US Treasury versus German Bund, swap yield vs. government bond yield etc). Yield curve or spread views are expressed by implementing simultaneously long and short positions at various points on the curve (yield curve view) or in various markets (cross market view). For instance, a 2s/10s swap curve steepening view is implemented by paying in 10Y swaps (short duration in 10Y) and receiving in 2Y swaps (long duration in 2Y). Irrespective of the direction of the movement of the underlying yields and ignoring carry considerations, this trade will be profitable if the absolute level of the 2s/10s curve is higher (or steeper) compared to inception. The same can be applied to a cross market positions between US Treasury and German Bunds.

As some of these yield spreads (curve, cross market or cross product) are often directional with the level of yields, investors may find it attractive to get exposure via conditional structures, i.e., via buying and selling options on the two legs of the trade in a way that the final curve exposure is realised only if the overall level of yields is higher (bearish exposure) or lower (bullish exposure) than inception levels. The primary advantage lies in the fact that **conditional trades** lets investors have an exposure in a yield curve or yield spread only if the underlying yield moves in the specific direction. For example, in the Euro area with policy rates firmly on hold, the yield curve has been strongly directional, steepening in a sell off and flattening in a rally (**Exhibit 1**).

Ideally investors sharing a view that this directionality is likely to persist should prefer to hold curve steepening (flattening) exposure only if rates are expected to drift higher (lower); i.e., for the yield curve to bull flatten/bear steepen). To achieve this, the **conditional strategy uses options** which fundamentally give directional exposure to the underlying. These trades are typically implemented using a long and a short positon in options. So, for example, investors wishing to get exposure to a steeper curve in a sell off could construct the trade by buying payer swaptions (which gives exposure to higher rates) on long end tails (20Y or 30Y) vs. selling payer swaptions on short end tails (2Y or 3Y tails).

Exhibit 1: The EUR yield curve has exhibited strong directionality to yields recently, steepening in a sell off and flattening in a rally
3s/20s EUR swap yield curve versus 20Y EUR swap rate; past 6M;



A key factor to consider before implementing conditional trades is how much directionality is priced in the options market versus what the market typically delivers. If implied volatility were flat across tails, for example, then with the yield curve exhibiting empirical directionality like shown in Exhibit 1, it would always be attractive to buy options on long tails versus short tails. However, the low volatility of front end rates is currently already priced in the curve, with volatility on short tails typically cheaper than volatility on long tails. However, the trades can still be attractive if the options market has not fully priced the recent delivered directionality (see below for more discussion).

In practice, how often do we get these opportunities? Historical analysis of the curve directionality shows that these opportunities arise very frequently and can be found across various markets. Exhibit 2 shows the subsequent delivered directionality versus *ex-ante* implied directionality (a rough measure of the success of the trade; the final trade has either 0 or positive P&L) across EUR, USD, and GBP over the past few years. As seen, that the options market has generally underpriced the subsequent delivered directionality. In this analysis we have assumed that the curve has been driven by the long-end of the curve. Such behaviour is expected when the central bank is perceived to keep its policy rates on hold. However, in an active central bank regime, we would expect the curve to be driven by the front-end of the curve and expect the curve to bear-flatten/bull-steepen. Of course, we can use options to pre-position for such an expected change in directionality.

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The most important feature of these trades are that they are **generally structured to be premium neutral at inception**. Thus, if the baseline view of higher yields is not realized, for example, and yield decline driving the curve flatter, then there is no exposure in the trade at expiry and a conditional bear steepener would exit at flat P&L. However, if the baseline view (yield selling off) is correct then the trade will have an exposure to steepeners and is expected to be profitable if the curve steepens in a sell-off more than was already implied by the relative level of volatility. In summary, conditional curve trades are an attractive way to position to express a directional view on the curve. Indeed, a bulk of our recent recommendations has focussed on expressing the curve or spread view conditionally with a solid success rate[1].

What about options on curves? Yield curve spread options are fairly popular to trade options on the underlying yield curves. Readers can learn more about this, including popular trading strategies involving YCSOs from our previously published primer on this.[2] Unlike conditional trades, payoff from YCSOs only depends on the final level of the yield curve versus the initial level. For example, buying an YCSO cap will be profitable if the underlying curve steepens, irrespective of whether the curve has steepened as the underlying yield has increased or decreased. So, if we are positioned for a *bear*-steepening of the yield curve and the yield curve *bull*-steepens (that is the curve has changed its recent directionality), then the YCSO will still be profitable whereas the conditional curve trade will likely expire worthless because the underlying view of higher yields was not realized (**Exhibit 3**).

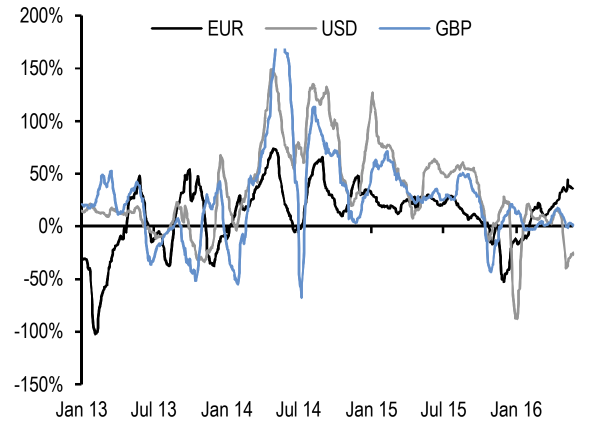
Thus, these are two different strategies with different baseline view – the first a conditional view while the second an outright. We prefer conditional trades when the underlying yield curve directionality is strong and is expected to hold, as has been the case recently.

In this research note, we discuss the details of various types of conditional trades. We also **focus on two different ways of structuring premium neutral conditional trades**. Finally, **we present several usages of conditional trades and JPM analytics available for monitoring of these conditional trades**. For example, we can easily extend the theory and analysis described below for each of the following types of trades:

1) **Conditional yield curve** steepener or flattener (to express single currency yield curve directionality)
2) **Conditional swap spread** widener or narrower (to express swap spread directionality)
3) **Conditional cross market** widener or narrower (to express cross market yield spread directionality)
4) **Conditional butterfly** richener or cheapener (to express single currency butterfly directionality)

Exhibit 2: However, the options market does not always price this directionality correctly and hence provides opportunities to initiate "conditional curve trades" in which we position for the steepening (flattening) of the yield contingent on yield sell off (rally)

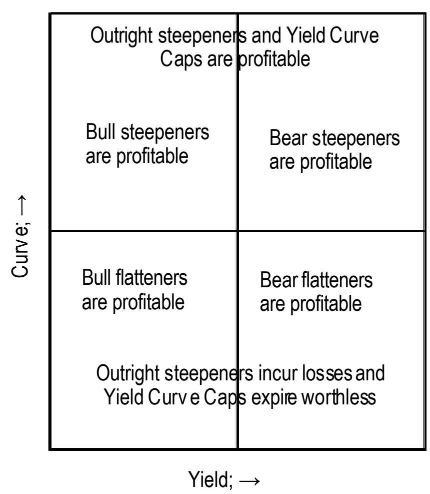
Subsequent realized directionality* – ex-ante implied directionality for the 3s/20s curve; since Jan 2013; %



Realized directionality calculated as 3M beta of 3s/20s curve of 10Y yield. Implied directionality calculated as (1 – ratio of 3Mx3Y implied vol to 3Mx20Y implied vol).

Exhibit 3: Stylized representation of when various types of curve trades are profitable

Regions for the outcome of various types of curve trades. The origin represents the starting point for a trade.



[1] See *Global Fixed Income Markets Weekly: Trade statistics*, published weekly for detailed trade P&L recommendations
[2] See *Yield Curve Spread Options: Mechanics, fair value analysis, typical trades, and JPM analytics*, by Khagendra Gupta, 3 November 2015

Details of conditional curve trades

As mentioned above, conditional curve trades uses options to gain exposure to the yield curve or yield spread. For example, use payers to gain exposure to curve steepeners in a sell-off. A 3s/20s *bear-steepener* (to express the fundamental view of the curve steepening in a sell-off) is structured by buying payers on 20Y tails and selling payers on 3Y tails. Both the options are exercised if underlying yields increase otherwise the trade expires worthless (excluding the case of curve twisting making one option in the money and the other out of the money at expiry). **If the yield curve has indeed steepened in a sell-off in excess of that is currently priced in the relative implied volatility** (as was the a-priori), then the payoff from long payers in 20Y would be higher than the losses from being short the payer on 3Y tails, resulting in overall profit in the trade. However, if the yield curve steepens in a sell off by an amount that is less than priced by the relative implied volatility, then the trade will become unprofitable. On the other hand, if the underlying yields have rallied and the curve has flattened, then both the options will likely expire worthless giving no exposure to the yield curve (**Exhibit 4**).

We make a few observations regarding conditional trades from the above example:

1) Bearish trades are implemented using payers while bullish trades are implemented using receivers. For example, a 3s/20s bull flatteners is structured by buying receivers on 20Y swaps and selling receivers on 3Y tails.
2) In the event we do not have a strong view on the directional movement of the underlying yield but still believe that yield curve directionality is likely to hold, we can then trade straddles versus straddles (both unhedged).
3) These trades are expected to perform only if the underlying yield curve directionality holds and they are attractive to implement only if the options market is not correctly pricing the recent realized directionality of the swap curve (implied directionality is cheap compared to delivered directionality.[3] In other word, the attractiveness of these strategies depend on the relative option implied volatilities across the curve. In **Exhibit 5** we show the recent delivered directionality of the 3s/20s curve and implied directionality measured using the options market. As seen that implied directionality is significantly cheap to delivered directionality indicating that conditional trades are currently attractive in EUR.
4) The yield curve directionality does not have to be "positive" as it is often driven by the monetary policy stance, with "positive" curve directionality when the central banks are on hold and "negative" curve directionality when central banks are active.

Exhibit 4: If the yield curve steepens in a sell-off, then the positive P&L from the long payer in a bear steepener will more than offset the losses from the short payer resulting in overall positive gains
Stylized representation of the performance of a bear steepener if the yield curve bear-steepens

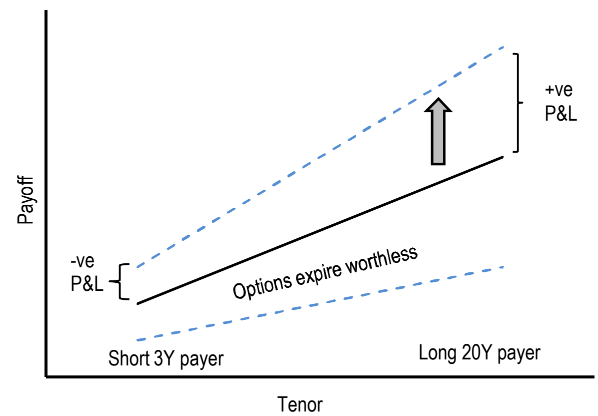
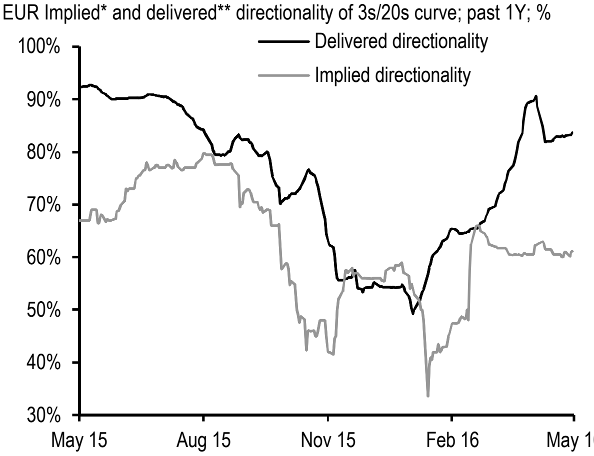


Exhibit 5: Conditional trades are attractive if the options market is not correctly pricing the recent delivered directionality
EUR Implied* and delivered** directionality of 3s/20s curve; past 1Y; %



* 1 – (3Mx3Y implied vol / 3Mx20Y implied vol)
** 1 – 3M beta of 3Y yield to 20Y yield.

[3] Implied directionality is defined as: 1 – (implied volatility of the short tail option/implied volatility of the long tail option). Thus, for a 3s/20s bear steepener, this would be calculated as 1 – (3Mx3Y/3Mx20Y). Delivered directionality is defined as 1 – 3M beta of short tail yield to long yield. In our example, this would be calculated as the 3M beta of 3Y yield to 20Y yield. In other words, 3M beta of the 3s/20s swap curve to 20Y yield.

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Bull-steepeners (or bear flatteners) can also be constructed using receivers (or payers) in which we buy receivers (payers) at the front-end of the curve and sell receivers (payers) at the long end of the curve. For instance, as we approach a central bank hiking cycle, the curve tends to bear-flatten. Similarly, the onset of an easing cycle leads to the bull-steepening of the curve (**Exhibit 6**).

5) The downside to these type trades is not limited; while the downside on the long leg is limited, the downside to the short leg is unlimited. This is typically the case if the yield curve directionality completely reverses.

6) The notionals on each leg is typically calculated according to the PVBP and risk weights on each leg (see below for more details).

7) **Exhibit 7** shows the P&L regions (including breakeven lines) for a 3s/20s EUR steepeners in a sell-off initiated at current levels. In this exhibit, we present adjusted 30Y yield on the y-axis, adjusted for the one-off impact of the ECB October 2015 meeting via a dummy variable[4]. If we assume that the recent curve directionality holds, then bear steepeners (or bull-flatteners for that matter) are likely to be profitable if the yields sell-off (flattens).

Exhibit 6: Yield curve directionality continues to change depending on the central bank policy cycle and therefore appropriate type of conditional curve trade should be selected

3s/20s EUR swap curve (lhs) and 20Y swap yield (rhs); past 10Y

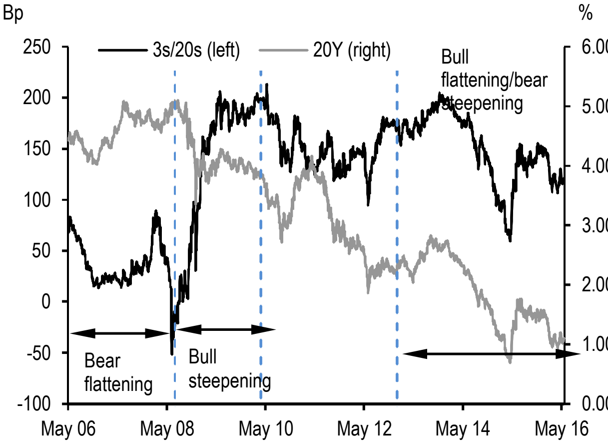
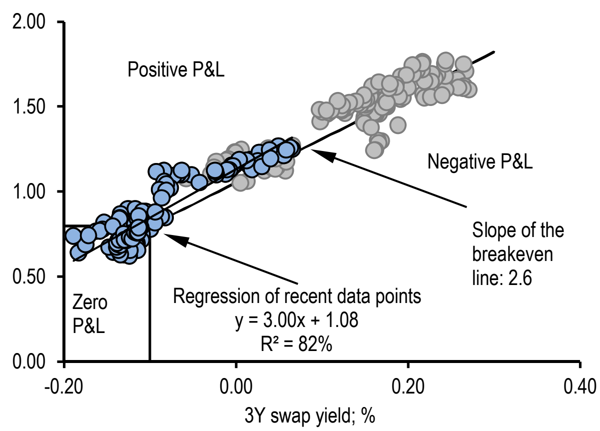


Exhibit 7: If recent relationships hold, then 3s/20s bear steepeners (or bull flatteners) are likely to be profitable

20Y yields versus 3Y yields and regions of positive, negative, and zero P&L for implied volatility weighted bear steepeners (initiated at zero cost); past 1Y; %



Two flavours of conditional trades

As investors usually prefer to hold conditional exposure and P&L only in the scenario where the market direction is in line with the option structures, quite often these conditional trades are implemented at zero-cost. Therefore, if the options expire worthless (for example we hold bear steepeners and market rallies), then the downside to the trade at expiry is limited.

As the option prices for ATMF options are linear in volatility, a PVBP curve weighted trade can be implemented as premium neutral trade, if and only if the volatilities on the two legs of the trade are exactly the same – an unlikely feature in an environment where implied volatility get priced somehow in line with historical volatility. Therefore we can achieve this premium neutrality by either *1)* shifting the strike of the options with higher implied volatility (option is traded out-of-the money), or *2*) reducing the notional on the leg with higher volatility (both legs are traded ATMF). We now discuss in details these two ways and compare them.

The notional exposure on each leg of a conditional trade is calculated using the swap PVBP and risk-weights on each leg. Thus, there are two popular variants come from the choice of risk weights on each leg:

A) Strike shift strategy (1:1 risk weight) – In this strategy, notionals are calculated assuming equal risk exposure on both the legs; in other words, the notionals are calculated as is done for a standard curve or yield spread trade. Using ATMF options would, therefore, not necessarily ensure premium neutrality (unless both the options are trading at identical volatility levels in which case the ATMF option premium would just be a ratio of the swap PVBP). Therefore, premium-neutrality is obtained by shifting the strikes on one (or both) the options; strikes are typically shifted so that the options

[4] ECB cut its depo rates to -30bp at this meeting and the curve steepened in a knee-jerk reaction. As seen, the overall curve directionality, adjusting for this move, however was intact.

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are out-of-money at inception, with a larger move OTM for the option with more expensive implied volatility. The trade is exposed to the movement of the underlying curve as the conditional curve exposure is 1:1, i.e., Long end yield – short end yield.

B) Weighted curve strategy (Implied volatility ratio risk weight) – In this strategy the premium neutrality is achieved by buying less of the more expensive option, and specifically by having the duration neutral notional adjusted by the ratio of implied volatility. The options themselves are initiated with ATMF strike. So, for example, if the volatility on long tail options were 50% higher than the volatility on short tail option, then the premium neutrality could be achieved by buying 50% of the notional risk in the more expensive volatility versus 100% of the notional risk in the cheaper option. The risk weights on each option leg is equal to the implied volatility ratio (1:*implied volatility ratio*). Adjusting the risk weights essentially means adjusting the notionals of options to attain premium neutrality while still trading in ATMF options[5]. Unlike the previous case, the exposure of the conditional trade here is to the movement of the weighted curve (weighted by the ratio of the implied volatility weights); i.e., *volatility ratio* * Long end yield – short end yield, where *volatility ratio* is the implied volatility on short tail divided by the implied volatility on long tail.

We illustrate the differences between the two strategies via a specific example. Let us consider a 3s/20s bear steepeners using 3M payers (expectation of yield curve steepening in a sell-off). **Exhibit 8** gives the option details, including swap PVBP, ATMF strikes, implied vol, delta, and gamma etc. As seen, using the weighted curve strategy is equivalent to a leveraged position in the trade and the exposure is to the underlying weighted curve and not to the actual 3s/20s swap curve.

We highlight the following: under the *Strike shift strategy*, 3Mx20Y payers will expire in the money only if at expiry the spot 20Y yield is above the ATMF strike (initiated 3M ago) + strike shift. In a scenario of unchanged yield curve, this differential is defined as (ATMF – ATMS) + strike shift (x). In other words, this is equal to the swap rate carry (C_L) + x. The 3Mx3Y payer will expire in the money if the spot 3Y yield is above the ex-ante ATMF yield (or at least more than the ex-ante carry (C_S)).

In the *Weighted curve* strategy, both the yields just need to increase by the corresponding *ex-ante* carry for the options to expire in the money, but this does not guarantee a positive outcome.

Exhibit 8: Example of how to structure the two types of conditional trades: *Strike shift* strategy and *Weighted curve* strategy

Option details for 3Mx3Y and 3Mx20Y payers. We also present the notionals and entry level for the two types of premium neutral strategies

	3Mx3Y	3Mx20Y
PVBP	301	1790
Implied vol (bp/day)	25.0	63.4
ATMF strike (%)	-0.10	1.10
Payer premium (bp of notional)	15	234
Strike shift strategy		
Risk weight	100%	100%
Notional (€mn)	595	100
Strike adj for premium neutrality (bp)	0	23
Option strikes (%)	-0.10	1.33
Total cost (bp of notional)	92	92
Entry level (bp)*	143	
Weighted curve strategy		
Risk weight	100%	39%
Notional (€mn)	595	39
Strike adj for premium neutrality (bp)	0	0
Option strikes (%)	-0.10	1.10
Total cost (bp of notional)	92	92
Entry level (bp)**	53	

*Defined as strike on 3Mx20Y (1.33%) – strike on 3Mx3Y (-0.10).
** Defined as ATMF 3Mx20Y yield (1.10%)*implied vol ratio (0.39) – ATMF strike on 3Mx3Y (-0.10).

Details of the two types of conditional trades

In this section we provide further intuition, including mathematical formulation, for these two types of strategies.

Strike shift strategy:

Here, we maintain duration-neutral exposure on the curve. Therefore, the notionals used on both the legs are:

Notional on long leg (longer tenor swaption) = 100

[5] Recall that ATMF options are linear in volatility.

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Notional on short leg (shorter tenor swaption) = 100* ($PVBP_L/PVBP_S$), where *PVBP* is the price value of a basis point move in yield of the underlying swap.

The underlying principle in this strategy is **attaining premium neutrality via shifting strikes of the options while maintaining net zero-risk exposure**. In theory, there are two degrees of freedom with just one constraint (premium neutrality): we can shift the strikes of one or both the options to calculate the zero-cost entry points. Therefore, there is an infinite set of solutions for this exercise (the set of points satisfying these conditions are what we typically call iso-premium lines, see below). However, if we choose ATMF strike for the option with lower implied volatility which would then leave us with only one degree of freedom, then we can devise, using some simplifying assumptions, **closed form solution for the shift in strike needed for the other leg** (trading OTM options) to achieve premium neutrality.

Assuming flat volatility surface for OTM options, if δ and Γ are the option delta and gamma, respectively (for the option with higher implied volatility), ΔP is the price adjustment needed for this option to attain premium neutrality (equal to the difference in ATMF premium of the two options), then x, the required shift in strike, is the solution to the quadratic equation below (see ***Appendix I*** for detailed derivation)[6]:

$$\delta * (-x) + 0.5 * (\Gamma) * (-x)^2 = -\Delta P \qquad (1)$$

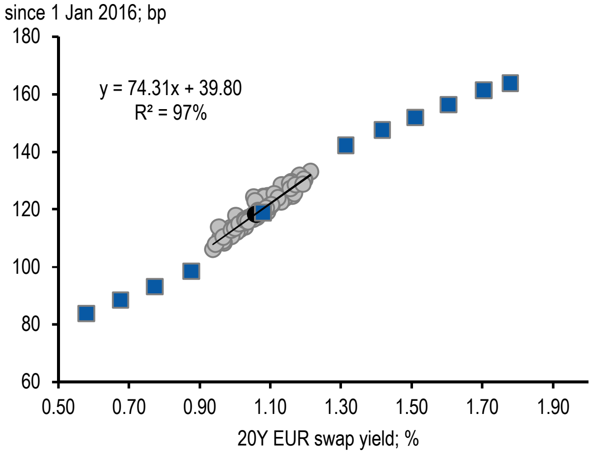
The solution of this equation is:

$$x = \frac{\delta \pm \sqrt{\delta^2 - 4*(0.5*\Gamma*\Delta P)}}{(2*0.5*\Gamma)} \qquad (2)$$

The above equation can also be used to identify strike shift needed if we started with choosing OTM strike for the lower implied volatility options. Using various starting points, we can then construct an "iso-premium" line for the conditional trade which basically show the zero cost entry points for the conditional trade (**Exhibit 9**). Intuitively, the slope of each iso-premium point is a reflection of the implied directionality. This iso-premium chart can also be used to see if using OTM options offer better entry levels relative to the historical directionality. We generate these iso-premium reports on a daily basis in our analytics packages to identify conditional trade opportunities.[7]

Exhibit 9: Iso-premium lines highlight the discrepancy between implied and delivered directionality indicating that conditional curve trades are potentially attractive

3s/20s EUR swap curve regressed against 20Y yield and iso-premium* line; since 1 Jan 2016; bp



* Defined as zero-cost entry point.

We highlight that the difference in volatility on both the legs can also play a significant role in deciding the entry point of the final trade (or give up versus forwards). For instance, in the case of 3s/20s bear steepeners (buying payers on 20Y versus selling payers on 3Y), the spot and forward levels are both around 120bp (in other words the rate curve carry for an outright steepener is 0bp). However, as seen in Exhibit 8, the give up in terms of entry point for a bear steepener is around 23bp on the back of significant volatility difference as the zero cost entry point is around 143bp. This means that for the bear steepener strike-shift strategy to be profitable it is necessary that at expiry the curve is at least 23bp steeper than spot with yields moving higher. Of course, if we were to position for a bear-*flattening* of the yield curve (not our baseline view and against the current directionality), then this volatility disadvantage would turn into a significant advantage as we would now be buying a cheaper option (payers on 3Y tails) funded via selling a more expensive option (payer on 20Y tails). In other terms the 23bp give-up versus forwards in a bear steepening trade would be a pick up versus forward in a bear flattening trade.

Weighted curve strategy:

[6] In the above example, we have assumed that we are dealing with payers and strikes need to be shifted upwards. The equation shows the underlying shift in swap yield needed to attain the change in premium and hence has a negative sign. If we deal with receivers, then the signs of x need to be reversed. We highlight that these strike shifts are exact in cases where the volatility surface across strikes is flat (or vol skew is zero). In cases where OTM vols are different than ATM vols, then these expressions are an approximation to the actual solution.

[7] See *Euro interest rate derivatives package* published daily

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Here, we achieve the premium neutrality by buying less of the options with higher implied volatility. Instead of having notionals on the two legs consistent with the PVBP ratio of a curve trade we reduce the notional on the leg with higher implied volatility by the ratio of implieds on short tail to that of long tail vol (see equations below). As ATMF premium is linear in volatility, after the adjustment described above, the premium on both the legs will be identical making the trade premium neutral. The curve exposure in this conditional trade is to the *weighted* yield spread which is then defined as:

W*(longer tenor swap yield (L)) – (shorter tenor swap yield (S))

Where, W is the ratio of implied volatility (σ_S/σ_L).

The actual trade notionals can be calculated as follow:

Notional on leg L: 100*W

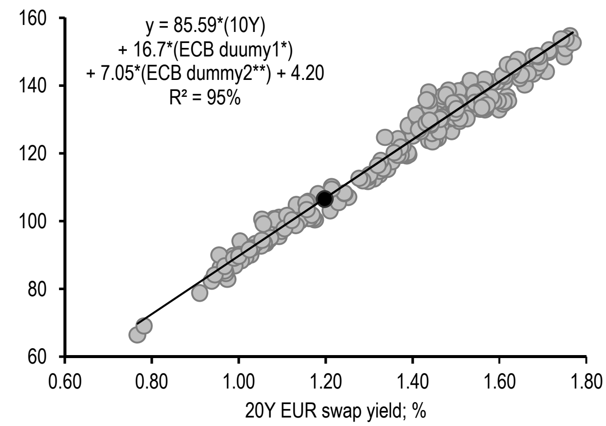
Notional on leg S: 100*($PVBP_L/PVBP_S$).

In the previous strategy, we generally use the iso-premium lines to identify attractive opportunities. In this case, we exploit the fact that if the option market is properly priced, then the curve weighted by the ratio of implied volatility should be non-directional to yield levels. For example if implied volatility on 3Y tails is 50% of the implied volatility on 20Y tails and the market moves with a ratio of delivered volatility consistent with implied then the weighted curve will be non directional. In the example for a 20bp sell off in 20Y yields, 3Y yields would move 10bp (in line with the implied ratio) and the weighted curve (defined as 50% *20Y – 3Y will be unchanged). In this strategy, we use the directionality of the weighted curve to underlying yield to identify attractive opportunities.

To review, **conditional trades are generally preferred under the following two conditions: *1)* the swap curve exhibits a strong directionality to yields (Exhibit 10) and *2)* implied directionality is cheap to delivered directionality**. In Exhibit 5 we had compared the delivered directionality of the 1:1 curve with the implied directionality. For the *Weighted curve* strategy, **we look at the strength of the relationship between the weighted curve and the underlying yield** (both in terms of regression beta and r-squared) **to determine the attractiveness of the trade (Exhibit 11)** – the higher the regression beta, the larger the mispricing.

Exhibit 10: In general, conditional trades are favourable when swap curve exhibits a strong directionality to the underlying yield…

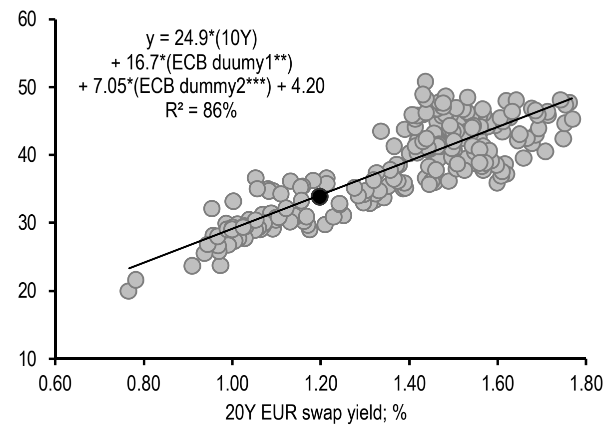
3s/20s EUR swap curve regressed against 1) 20Y EUR swap yield; 2) ECB Oct15 rate cut dummy1*; and 3) ECB Jan16 dummy2**; past 1Y; bp



* Defined as 1 for dates after 22 Oct 2015 and 0 before that.
** Defined as 1 for dates after 21 Jan 2016 and 0 before that.

Exhibit 11: …and attractive if the options market is not fully pricing the recent delivered directionality. We use the directionality of the weighted curve to yields to identify attractive conditional curve trades

3s/20s EUR weighted* swap curve regressed against 1) 20Y EUR swap yield; 2) ECB Oct15 rate cut dummy1**; and 3) ECB Jan16 dummy2***; past 1Y; bp



* Defined as 20Y*(3Mx3Y/3Mx20Y implied vol ratio) – 3Y.
** Defined as 1 for dates after 22 Oct 2015 and 0 before that.
*** Defined as 1 for dates after 21 Jan 2016 and 0 before that.

We have developed analytics to analyse these trades on a daily basis. **Exhibit 12** show a snapshot of our implied/delivered directionality report. In addition to the implied/delivered directionality, we also show the zero-cost entry point for the *Strike shift strategy* and the *Weighted curve strategy*. We make the following points. **First**, as discussed above, the entry point of the weighted curve strategy is equal to the forward weighted spread. **Second**, the give up (or offset from ATMF forward) in the Strike shift strategy is commensurate with the difference in implied volatility.

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Exhibit 12: J.P.Morgan analytics on implied/delivered directionality for various curve trades available on www.jpmm.com on a daily basis
Implied and delivered directionality of various curve trades using 3M payers; %

Curve	Current implied vol; bp/day		Implied directionality*	1Y delivered directionality**	1:1 strike shift strategy; bp			Weighted curve***; bp			1Y regression statistics after adjustng for ECB Oct15 & Jan16 meetings††		
	Short maturity	Long maturity			3M fwd	Spot	Zero cost entry point†	3M fwd	Spot	Zero cost entry point†	Beta	R-squared	Residual; bp
1s/5s	1.1	2.2	51%	67%	20	17	32	18	16	18	16%	64%	-1.7
1s/10s	1.1	3.3	67%	81%	75	70	99	35	33	35	14%	78%	-1.6
2s/10s	1.3	3.3	61%	72%	74	70	94	38	36	38	11%	79%	-2.3
2s/20s	1.3	4.0	68%	81%	123	121	151	49	49	49	13%	83%	-1.5
3s/10s	1.6	3.3	52%	60%	70	67	86	39	38	39	8%	79%	-1.8
3s/20s	1.6	4.0	61%	72%	119	118	143	53	54	53	11%	82%	-0.6
3s/30s	1.6	4.2	63%	74%	122	123	148	52	53	52	11%	82%	-0.5
5s/30s	2.2	4.2	48%	50%	107	109	125	53	56	53	2%	78%	1.8
10s/30s	3.3	4.2	23%	18%	53	56	61	27	30	27	-5%	71%	3.0

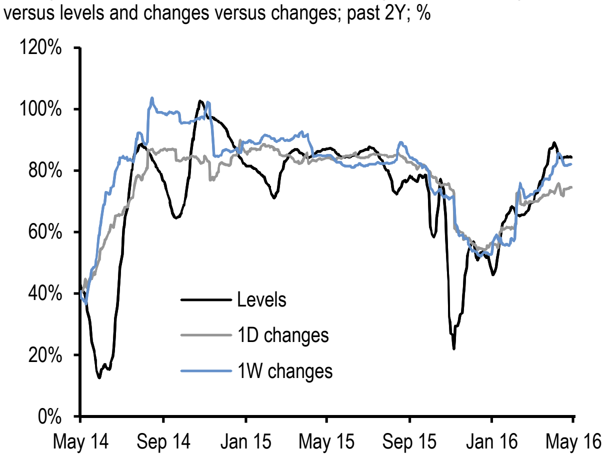
* Defined as 1 – (Short maturity implied vol)/(long maturity implied vol)
** Defined as 1 – 3M beta of short maturity swap regressed against long maturity swap.
*** Weighted curve defined as: (Short maturity implied vol/Long maturity implied vol)*Long maturity yield – Short maturity yield.
† Zero cost entry points for bear steepeners.
†† Weighted curve regressed against long maturity swap.

Third, the difference between the implied and delivered directionality shows the mispricing between the implied options market and that realized. It is no coincidence that the regression beta of the weighted curve to underlying yield is identical to (delivered directionality minus implied directionality). We present the arithmetic equivalence between these two in ***Appendix 2***.

Fourth, the measure of delivered directionality and its stability can have some impact on evaluating the attractiveness of these trades. We measure delivered directionality as the regression between the curve and yield levels. While this seems appropriate, we could also use regression beta of curve changes and yield changes (daily, weekly, etc). **Exhibit 13** shows the evolution of the 3s/20s EUR swap curve directionality when measured using different ways. As seen, these estimates can be significantly different and hence impact the decision in initiating a trade. The other dimension that we have not explored in the exhibit is time – as in over what period should one estimate the yield curve directionality. We acknowledge that there is no correct way of doing this. We generally use levels and a regression period of three months.

Overall, the main conclusion from this analysis is that both the above mentioned methods of setting conditional trades are fundamentally similar and exploit the discrepancy between implied and delivered directionality.

Exhibit 13: The methodology used to calculate the delivered directionality can have a significant impact in identifying potential opportunities. We prefer using a regression of levels versus levels as opposed to regression of changes
Rolling 3M beta of the 3s/20s EUR swap curve against 20Y; we regress levels versus levels and changes versus changes; past 2Y; %



Which is better?

Despite the initial mathematical equivalence in terms of the attractiveness metric, the performance of these strategies is indeed different as yields evolve simply because the overall P&L depends on the evolution in one case the *unweighted* swap curve and in the other case the *weighted* curve. **Exhibit 14** compares the payoff at maturity of these two strategies (using a 3s/20s bear steepener) versus shift in the spot 20Y yield curve (the longer tenor swap yield). In this analysis, we have assumed that *a)* both trades are structured to be premium

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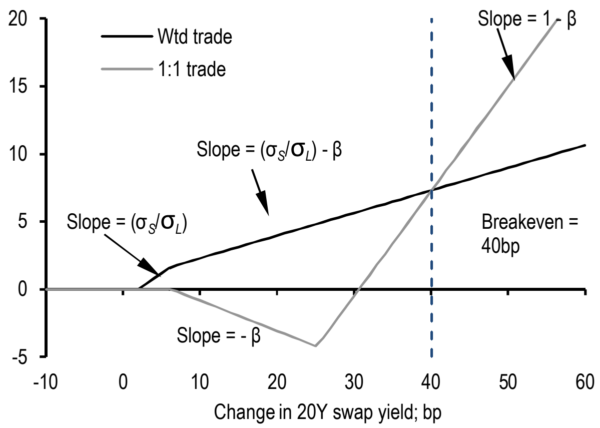
Exhibit 14: The *Weighted curve* strategy will outperform the *Strike shift* strategy if the underlying yield movement is small

Payoff from the two variants of 3s/20s EUR bear steepeners at option expiry under various 20Y yield shift scenarios. We assume that the realized curve beta is in line with the recent historical beta; bp of yield



neutral at inception (long 3Mx20Y payer and short 3Mx3Y payer) and *b)* the shorter maturity swap yield moves in line with its recent *historical* beta to longer maturity yield (we denote this beta by β). We make the following observations:

1) The *Strike shift* strategy is likely to incur losses for small upward change in yield. Under such a scenario, the option that we are short expires in the money whereas the long option expires worthless (or not enough in the money to overcome the losses) as this option is struck OTM. **The inflection point in the payoff for this strategy occurs when the yield shift equals to the strike offset plus the rate carry on this leg (x+ C_L).** The payoff then increases with a slope of (1-β).

2) The *Weighted curve* strategy is going to be profitable if β is less than the ratio of implieds (σ_S/σ_L- around 40% in our example; delivered directionality is defined as 1- β). **Exhibits 15** and **16** show the payoffs of these two strategies making different assumptions about the evolution of β. The yield shift needed for the options to expire in the money, should also account for *ex-ante* carry (C_L and C_S) as well.

First, β < (σ_S/σ_L), for example purposes, we make this is equal to the recent delivered volatility, 22% (beta between the weighted curve and 20Y swap). In this scenario, the trade will not incur any loss. This is because given the small β, the long option will always be

Exhibit 15: The P&L for the weighted trade will saturate if the realized curve movement is in line with the initial implied volatility ratio (weighted curve is unchanged)

Payoff from the two variants of 3s/20s EUR bear steepeners at option expiry under various 20Y yield shift scenarios. We assume that the realized curve beta is equal to the initial implied vol ratio; bp of yield

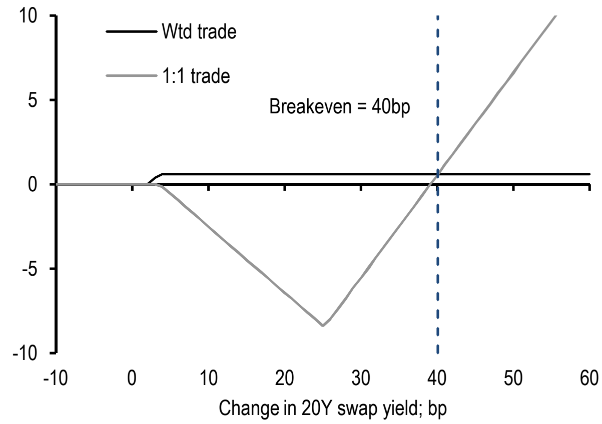
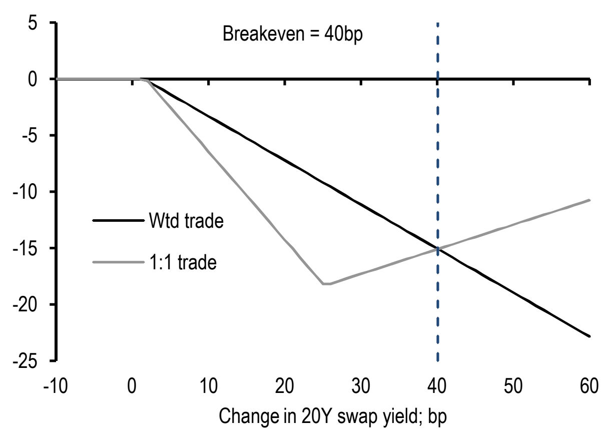


Exhibit 16: In the scenario where the weighted curve flattens whereas the 1:1 curve still steepens, the weighted curve will incur losses while still dominating the strike shift strategy for small movement in yields

Payoff from the two variants of 3s/20s EUR bear steepeners at option expiry under various 20Y yield shift scenarios. We assume that the realized curve beta is twice the initial implied vol ratio; bp of yield



relatively more in the money compared to short option as the front-end yield is moving less than is implied by the options market (or, our measure of implied directionality, which is defined as (1 –(σ_S/σ_L)) is cheap to subsequent delivered directionality (1 - β)). See above for discussion on the Strike shift strategy.

Second, β = (σ_S/σ_L) (around 40%). In other words, the weighted curve remains unchanged and hence the net P&L saturates when the yield move is enough for the shorter maturity option to expire in the money (this shift

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in long end yield is equal to *carry on the longer maturity swap* * (σ_S/σ_L) – see above for discussion on this). With an increase in beta compared to the previous case, the overall loss is larger. However, the inflection point remains the same as above but the subsequent P&L increases at a slower pace.

Third, $\beta > (\sigma_S/\sigma_L)$ (we use 2* σ_S/σ_L or around 80% - this is consistent with an increase in the beta of the front-end yield versus the long end yield). The weighted curve has *flattened* in this scenario and thus the weighted trade results in net loss.

Fourth, the breakeven point between these two strategies is independent of the realized directionality β. The weighted trade strategy dominates the Strike shift strategy if the underlying yield change is small. The range over which the weighted trade strategy dominates is a function of *(a)* the strike shift necessary in this strategy to make the trade zero cost (δ) (**Exhibit 17**), *(b)* the implied volatility ratio (σ_S/σ_L), and *(c)* the carry on the longer maturity swap (C_L). The breakeven point between these two strategies can be calculated as (see ***Appendix 3***)[8]:

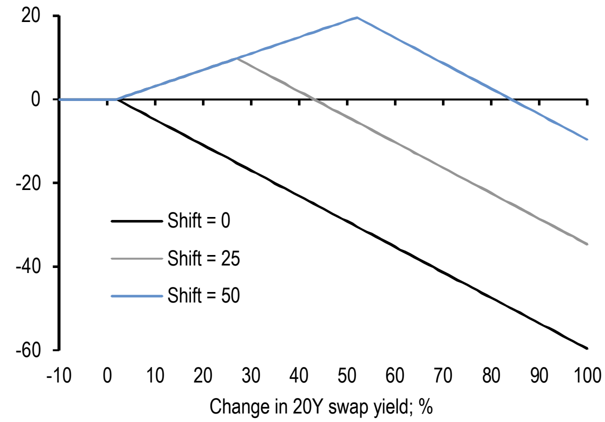
$$\Delta x = \frac{\delta}{1 - \frac{\sigma_S}{\sigma_L}} + C_L$$

3) The relative attractiveness between the two strategies is also a function of the volatility difference between the two legs. If the volatility difference is large, then the strike shift needed to gain zero cost in the first strategy is large and hence breakeven change in yield is large. Under such a situation, we would prefer expressing the conditional view using the weighted curve strategy. In the **limiting case where the volatility surface is flat ($\sigma_S = \sigma_L$), the two alternatives converge**; the volatility ratio is 1 and premium for ATMF options are equal, after adjusting for the PVBPs. Thus, no strike shift is needed making the two alternatives identical.

In conclusion, **the performance of the two alternatives depends on how large the realized move in yields is. For small change in underlying yields** (such as smaller than the strike shift necessary for zero cost) the weighted trade will dominate. However, for large shocks in yield (for example the Bund VaR shock), the *Strike shift* strategy will outperform.

Exhibit 17: The range over which the *Weighted curve* strategy outperforms the *Strike shift* strategy is a largely a function of the initial shift in strike needed to attain premium neutrality

Payoff from the two variants of 3s/20s EUR bear steepeners at option expiry under various 20Y yield shift scenarios. We assume that the realized curve beta is in line with the recent historical beta; bp of yield



Other applications of conditional curve strategies

This research note has, until this point, focussed entirely, at least in terms of examples, on conditional curve trades – we position for the movement of a curve (steepening/flattening) using payers/receivers. However, the underlying principles can also be extended to a variety of other curve trades. We highlight few such options:

1) **Cross market curve trades**: In this type of trade, we position for the relative outperformance (or underperformance) of swap yield in one currency versus another. For instance, the USD curve is currently pricing a very benign trajectory of the Fed hike compared to the "Fed dots" and our own forecast; the USD OIS curve is pricing the next 25bp hike by end-2016 and then the second 25bp hike by end-2017. Our own forecast calls for two hikes in 2016 and four in 2017. In contrast, the EONIA curve is pricing a modest cut in ECB repo rate and then ECB staying on hold for an extended period of time, in line with our own expectations. However, we cannot completely exclude the risk of another 10bp cut in depo rates (not our baseline call). If our forecast is realized, then at least in a sell-off, the USD yields are expected to underperform EUR yields. The 1Yx1Y volatility in EUR is about 40% of the implied volatility on similar USD options.

[8] If we substitute the expression for δ from equation (2) above and further assume that the impact of gamma is small and hence negligible, hen we can prove that the breakeven point is essentially a function of volatility on the long option and rate carry on the underlying swap.

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Exhibit 18: J.P.Morgan produces analytics to identify attractive opportunities on cross-market spreads on a daily basis
Implied and delivered directionality and zero-cost entry point using payers; bp

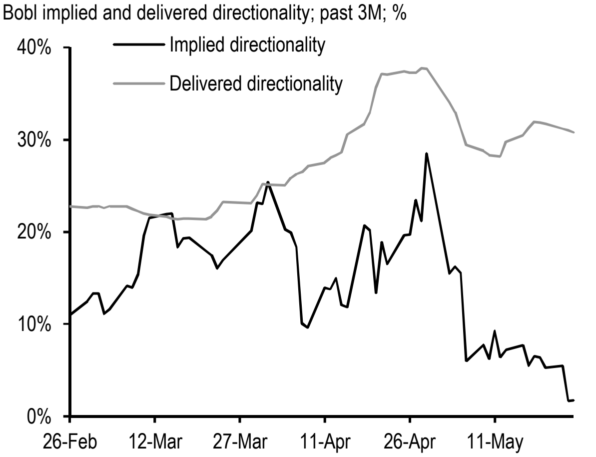
		Implied vol; bp/day		Directionality; %		Entry levels for zero cost structure: 1:1 strategy; bp			Entry levels for zero cost structure: Implied vol weighted strategy; bp			6M regression statistics***; %	
	Structure	EUR	USD	Implied*	3M delivered**	Spot	1Y fwd	Zero cost entry point	Spot	1Y fwd	Zero cost entry point	Beta	R-squared
Vanilla payers	1Yx1Y	1.6	3.7	57%	68%	108.9	137.9	173.5	55.3	67.5	67.5	24%	69%
	1Yx2Y	1.9	4.3	57%	65%	124.4	143.8	184.5	62.0	68.0	68.0	25%	45%
	1Yx7Y	3.3	5.1	36%	38%	131.2	130.5	157.8	74.8	68.4	68.4	25%	30%
	1Yx10Y	3.8	5.1	26%	27%	118.1	116.2	135.0	73.4	68.0	68.0	20%	22%
	1Yx20Y	4.3	4.9	12%	1%	103.1	103.9	113.3	78.3	78.1	78.1	12%	27%
	1Yx30Y	4.4	4.8	8%	-2%	108.6	109.8	117.5	90.2	90.9	90.9	11%	21%
Midcurve payers	1Yx(1Yx1Y)	2.2	5.6	60%	73%	137.9	142.9	213.6	64.3	65.5	65.5	24%	46%
	1Yx(2Yx1Y)	2.9	6.7	57%	66%	150.0	150.2	221.3	68.7	66.8	66.8	26%	44%
	1Yx(3Yx1Y)	3.7	10.2	64%	46%	148.0	146.4	266.8	47.3	43.5	43.5	3%	56%
	1Yx(5Yx5Y)	5.2	5.7	8%	11%	102.8	100.1	107.1	86.6	83.7	83.7	17%	15%

* Implied directionality defined as 1 – (EUR implied vol / USD implied vol)
** Delivered directionality defined as 1 – 6M beta of EUR swaps regressed against USD swaps
*** Regression statistics of implied volatility weighted curve versus GBP swap leg. Weighted curve defined as (EUR implied/USD implied)* USD yield – EUR yield. We adjust for the ECB QE dummies: *1)* defined as 1 for dates after 22 October 2015 and 0 before that and *2)* defined as 1 for dates after 21 Jan 2016 and 0 before that

The cross market weighted spread constructed with the ratio of implied volatility (i.e., 40%*1Yx1Y USD rate – 1Yx1Y EUR rate) remains strongly directional to USD rates and has widened in a sell-off (in other words, widening more than implied by the ratio of the implied volatility) with an empirical beta of about 20%. Thus, we are currently recommending a cross-market bear-widening of the 1Yx1Y (USD – EUR). We have developed analytics, similar to that in Exhibit 12 above, to identify attractive opportunities in cross market space (**Exhibit 18**). Our analytics contains USD/EUR, USD/GBP, and EUR/GBP crosses and are available on www.jpmm.com.

2) **Swap spread conditional trades**: We routinely recommend trading swap spreads conditionally as the options market are sometimes not pricing or overpricing the directionality of swap spreads. These trades are generally based to express swap spread view conditional on the underlying yield view. For example, Bobl swap spreads exhibit a strong correlation to Bobl yields. However, this directionality is currently not fully priced into the options market (**Exhibit 19**). Additionally, we would expect this directionality to remain strong or exacerbate in the event the ECB removes the depo rate as a floor for its QE purchases. The discussion in this research would apply completely to this category of conditional trades as well. In **Exhibit 20** (we present analytics that we produce on a daily basis to identify attractive conditional swap spread trades.

Exhibit 19: Conditional swap spread trades are also attractive as implied directionality is cheap to delivered directionality
Bobl implied and delivered directionality; past 3M; %



3) We also have daily analytics analyzing conditional curve opportunities implemented using *a)* midcurve versus midcurves – for example bear steepening of the reds/blues EUR swap curve and *b)* midcurves versus swaptions – for example, bear steepening/bull

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flattening of the greens/10Y swap curve. These are available on www.jpmm.com

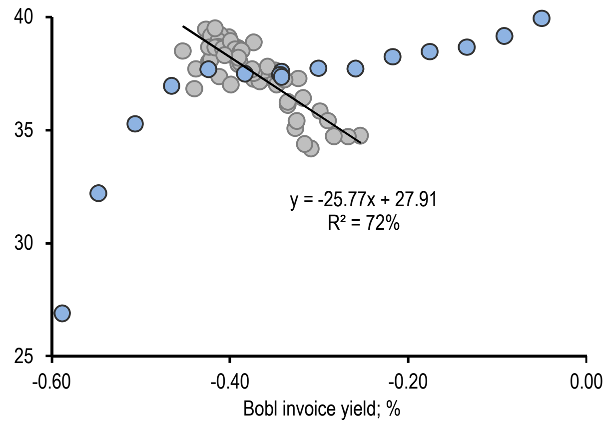
What about conditional flies?

As is the case for conditional curve trades, conditional butterflies are considered when the 50:50 swap fly exhibits a strong directionality to the underlying yield and we are interested in the richening/cheapening of the fly if our fundamental yield view is realized. These trades are attractive when the implied directionality of the fly is cheap to the delivered directionality[9] , which means that the options market is not correctly pricing the current curvature of the swap curve. Finally, similar to conditional curve trades, these trades are also generally structured to be zero cost at inception; both the zero cost strategies discussed for conditional curve trades are applicable for flies as well.

Similar to curve trades, we can structure flies using the "Strike shift strategy" in which we keep the wings at ATMF and shift the strike on the body so that the overall trade is premium neutral; the notionals on each leg is such that the risk distribution is done on a 50/100/50 basis. We can still use equation (2) above with the modification that ΔP now denotes the price adjustment needed on the belly to offset the total cost of the wings. **Exhibit 21** shows the zero-cost entry point for flies; we assume that the wings are traded at ATMF.

Exhibit 20: We produce analytics to identify attractive conditional swap spread trades. For example, Bobl bull wideners are currently attractive on directionality mismatch and also as a good hedge against the ECB removing the depo floor on QE purchases

Bobl swap spread regressed against Bobl invoice yield and iso-premium line; past 3M; bp



To implement the "Weighted curve" strategy, the risk weights necessary to achieve premium neutrality are calculated to be as follows:

Exhibit 21: The J.P.Morgan conditional butterfly report can be used to identify attractive conditional fly report

Implied and delivered directionality report for conditional flies; %

							Strike shift strategy	Weighted curve strategy							
	Implied volatility; bp/day			Directionality*; %			Shift in body strike; bp	Risk weights for zero cost; %			Weighted curve**; bp			3M regression stats****	
	Left	Body	Right	Implied	Delivered	Deliv - imp		Body	Left wing	Right wing	Spot	Fwd	3M carry***	Beta	Rsqr
1s/2s/3s	1.1	1.3	1.6	-3%	10%	13%	0.3	103%	50%	50%	-3.8	-3.9	-0.1	13%	31%
1s/3s/5s	1.1	1.6	2.2	-4%	8%	13%	0.5	104%	50%	50%	-11.6	-11.5	0.0	13%	12%
2s/5s/7s	1.3	2.2	2.7	9%	16%	6%	-1.1	91%	50%	50%	-4.5	-3.9	0.6	6%	6%
2s/5s/10s	1.3	2.2	3.3	-4%	5%	9%	0.7	104%	50%	50%	-36.8	-35.8	1.0	9%	4%
2s/7s/12s	1.3	2.7	3.5	12%	16%	4%	-1.8	88%	50%	50%	-18.8	-17.3	1.5	4%	1%
2s/10s/30s	1.3	3.3	4.2	16%	21%	5%	-2.5	84%	50%	50%	-3.0	-0.4	2.6	5%	1%
3s/7s/15s	1.6	2.7	3.7	3%	5%	2%	0.2	97%	50%	50%	-36.3	-34.6	1.7	2%	0%
5s/10s/30s	2.2	3.3	4.2	1%	3%	2%	1.0	99%	50%	50%	-4.1	-2.3	1.8	2%	0%
10s/20s/30s	3.3	4.0	4.2	6%	12%	6%	0.7	94%	50%	50%	34.9	34.1	-0.8	6%	14%

* Implied directionality defined as 1 – (0.5*(left wing implied + right wing implied))/body implied volatility. Delivered directionality defined as 3M beta of the 50:50 swap fly versus the body
** Weighted curve defined as Body weight*Body yield – 0.5*(left wing yield + right wing yield).
*** Carry for belly richening flies.
*** Regression statistics of weighted fly versus the body.

9 Implied directionality defined as 1 – (0.5*(left wing implied + right wing implied))/body implied volatility.
Delivered directionality defined as 3M beta of the 50:50 swap fly versus the body

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Left wing: 50%

Body: $(\sigma_{Left} + \sigma_{Right})/(2^* \sigma_{Body})$

Right wing: 50%

Indeed, as was the case in conditional curve trade, (delivered directionality – implied directionality) of the 50:50 fly is equal to the regression beta of the weighted curve versus body of the fly. Exhibit 21 also gives details about risk weights and this regression beta.

In the discussion above for the Strike shift strategy, we assumed that we trade ATMF options on the wing and shift the strike on the body to get zero cost. In principle, we could do the reverse as well – hold the body at ATMF and move the strikes on the wings. In this methodology, however, we encounter the issue of infinite solutions again: we have two degrees of freedom (strike shift for the options on the two wings) and just a single constraint of zero cost. We generally handle this issue by imposing a second constraint which restricts the movements in yields. For example, we can impose the constraint that the yields in the wings are allowed to move in parallel or only in their ratio of implied volatility (or delivered volatility). So, if the ratio of implieds (or delivered volatility) of the left and right wing is 1:2, then we search for the solution such that the strike shift in the right wing is twice as large as the left wing – so the strike shift is higher for the option exhibiting higher volatility. We then use an iterative method to solve for these strike shifts. Our report showing the "iso-premium" lines uses this methodology in identifying the zero-cost entry points for flies.

Market neutral conditional flies

The flies obtained above (either the 50:50 or the weighted curve) retain market exposure; i.e., the flies exhibit directionality to the underlying yield and our methodologies above exploit the difference between the delivered and implied directionality. **We can also construct market-neutral (level- and/or curve-neutral flies) conditional flies in which the risk-weights are calculated based on empirical regressions which satisfy the market neutrality component and then premium neutrality is obtained by shifting the strikes on either the body or the wings**. In a separate note our colleagues have presented a framework for trading such conditional flies[10]. The main highlights of this analysis are the following. **First**, there are periods when the options market pricing is generally such that the belly option can be struck ATMF while those in the wings can be struck OTM. This results in a carry advantage and makes the belly option more likely to be exercises than the wings. **Second**, our back testing of both belly cheapening and belly richening strategies for USD flies shows that the volatility advantage offered by options markets can be monetized by these conditional structures and results in lower loss rates, higher returns for wins, and smaller losses for losers. **Third,** we provide closed form solutions to find strikes that yield premium neutrality.

Conclusion

Conditional trades are an attractive way to express yield curve or yield spread exposure. The advantage of conditional trades relative to outright trades is that there is curve or spread exposure at option expiry only if the market moves in a specific direction. We present two ways of achieving premium neutrality: *Weighted curve* and *Strike shift* and discuss the advantages of one versus the other. Typically in small moves *Weighted curve* strategies outperform *Strike shift* strategies whereas the opposite is true in case of large sell off, provided delivered directionality outpaces implied directionality at inception. J.P.Morgan provides a set of analytics on conditional curve, cross-market spreads and butterflies in our daily Derivatives Package.

Appendix I: Some nomenclature:

σ denotes the option implied volatility

PVBP is the underlying swap PVBP

T is time to option expiry. If σ is expressed in annualized basis point volatility, then *T* is expressed as year fraction.

The subscripts *S* and *L* indicate the options that we are short and long, respectively.

Price of option that we are short (P_S) is:

$$\sigma_S * PVBP_S * \sqrt{T/(2*\pi)}$$

Price of option that we are long (P_L) is:

$$\sigma_L * PVBP_L * \sqrt{T/(2*\pi)}$$

These option prices are expressed in % of notional.

[10] See *Optimal Construction of conditional butterflies: A framework for managing underlying exposures and monetizing carry advantage*, by Alberto Iglesisas, 24 June 2015.

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These trades are structured only in a PVBP weighted amount. Therefore, notional required for the short maturity option is: ($PVBP_L/PVBP_S$), assuming notional on the long maturity option of 1.

Total cost of the short option after adjusting for notional is:

$$\sigma_S * (\frac{PVBP_L}{PVBP_S}) * PVBP_S * \sqrt{T/(2*\pi)}$$

We then need to shift the strike on the long leg which would reduce the premium by $\sigma_s * PVBP_L * \sqrt{T/(2*\pi)}$ to have net zero cost structure

Thus, ΔP_x =

$$(\sigma_L * PVBP_L * \sqrt{T/(2*\pi)}) - (\sigma_s * PVBP_L * \sqrt{T/(2*\pi)}).$$

If δ and Γ are the option delta and gamma, then the shift in strike necessary so that the option premium changes by ΔP_x is essentially a solution to the following equation:

$$\delta * (-x) + 0.5 * (\Gamma) * (-x)^2 = -\Delta\text{P}$$

The solution to this equation is:

$$x = \frac{\delta \pm \sqrt{\delta^2 - 4 * (0.5 * \Gamma * \Delta\text{P})}}{(2 * 0.5 * \Gamma)}$$

Appendix 2: Theoretical equivalence between the two strategies

In this appendix we demonstrate that the parameters used to identify the attractiveness of the *Strike Shift* strategy (difference between implied and delivered directionality) and the *Weighted curve* strategy (regression beta of the weighted curve versus yield) are mathematically equivalent.

Let σ_L^i and σ_S^i denote the implied volatility of the option on the longer tenor swap shorter tenor swap, respectively.
Let σ_L^r and σ_S^r denote the delivered volatility of the longer tenor swap shorter tenor swap, respectively.
Let Y_L and Y_S denote the underlying swap yields.

For the Strike shift strategy:

Implied directionality is defined as: $1 - (\sigma_S^i / \sigma_L^i)$ (1)

Delivered directionality is defined as: $1 - \beta(Y_S, Y_L)$. (2)

Replacing the regression beta with its closed form solution, we can rewrite (2) as:

$$1 - \rho(Y_S, Y_L) * (\sigma_S^r / \sigma_L^r) \quad (3)$$

where $\rho(Y_S, Y_L)$ denotes the correlation between Y_L and Y_S.

Thus, delivered – implied directionality is: (3) – (1)

$$1 - \rho(Y_S, Y_L) * \sigma_S^r / \sigma_L^r - (1 - \sigma_S^i / \sigma_L^i)$$

$$= \sigma_S^i / \sigma_L^i - \rho(Y_S, Y_L) * \sigma_S^r / \sigma_L^r \quad (4)$$

For Weighted strike shift strategy, the regression beta is between the weighted yield curve and Y_L.

The weighted curve can be expressed as:

$$\text{Wtd curve} = \sigma_S^i / \sigma_L^i * (Y_L) - (Y_S)$$

The regression beta is thus: $\beta((\sigma_S / \sigma_L) * (Y_L) - (Y_S), Y_L)$

We now note that the regression beta is an associative function. In other words,

$$\beta(Y_1 - Y_2, X) = \beta(Y_1, X) - \beta(Y_2, X)$$

Using this property on the regression beta of the weighted curve, we get:

$$\text{Beta} = \beta(\sigma_S^i / \sigma_L^i * (Y_L) - (Y_S), Y_L)$$

$$= \beta(\sigma_S^i / \sigma_L^i * (Y_L), Y_L) - \beta(Y_S, Y_L)$$

$$= (\sigma_S^i / \sigma_L^i) - \rho(Y_S, Y_L) * \sigma_S^r / \sigma_L^r \quad (5)$$

As seen, (4) and (5) are mathematically identical.

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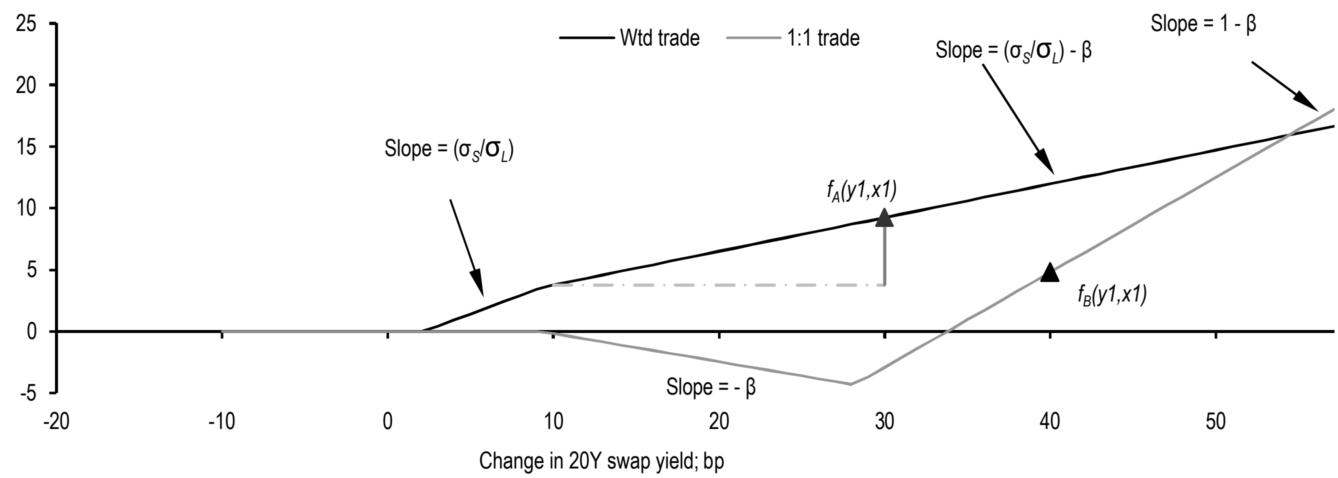
Exhibit A1: Stylized representation of the evolution of the payoff from the two strategies at expiry

Payoff of the *Strike Shift* and *Weighted curve* strategy versus change in 20Y yield; bp



Appendix 3: Calculating the breakeven between the two trading strategies

In addition to the nomenclature used above, we introduce the following. We also use Exhibit A1 for a graphical representation of the evolution of the payoff from both the strategies.

Let C_S and C_L denote the rate carry component of the shorter maturity and longer maturity swap, respectively

Let $F_A(y_1,x_1)$ and $F_B(y_2,x_2)$ denote two generic points on the payoff profile from both the maturities; *1* denotes the Wtd trade strategy and *2* denotes the Strike shift strategy. For simplicity, we assume that these points are on the part of payoff lines when both the options are expiring in the money; slopes ($\sigma_S/\sigma_L - \beta$) and ($1 - \beta$), respectively (as shown in **Exhibit A1**.

For the Weighted trade strategy, the inflection point (smallest value of "x" when both the options can be exercised at expiry) is given as: ($C_S / \beta - C_L$), where C_S / β is the level of "x" when the shorter tail option expires in the money and C_L is when the longer tail option expires in the money.

Thus,

$$F_A(y_1,x_1) = \left(\frac{C_S}{\beta} - C_L\right) * \left(\frac{\sigma_S}{\sigma_L}\right) + \left(x - \frac{C_S}{\beta}\right) * \left(\frac{\sigma_S}{\sigma_L} - \beta\right) \quad (6)$$

Similarly, for the Strike shift strategy,

$$F_B(y_2,x_2) = ((\delta + C_L) - \frac{C_S}{\beta}) * (-\beta) + ((x - ((\delta + C_L)) * (1 - \beta))$$

This simplifies to:

$$F_B(y_2,x_2) = (C_S - (\delta + C_L) + x * (1 - \beta) \quad (7)$$

To find the breakeven, we solve for the value of "x" that equates (6) and (7).

We can now easily prove that:

$$x = \frac{\delta}{1 - \frac{\sigma_S}{\sigma_L}} + C_L$$

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