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DB FX Derivatives Strategy

Riding Volatility

Compendium

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Our popular report on market positioning in FX options and the likely impact of options market flows on FX spot.

Section 1: FX Derivatives Focus Reports

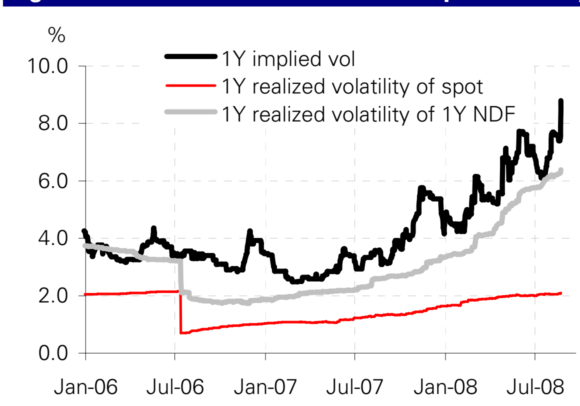
Model Trading EM Asian Volatility (18/09/08)

Introduction

Despite the restrictions imposed by capital controls, Emerging Asian currencies have become widely accessible to foreign investors as investable instruments via offshore NDF markets. Owing to growing liquidity in offshore forwards, FX derivative products have also flourished in recent years.

Much like derivatives on G10 currencies, implied vols on Asian currencies in offshore markets are driven by demand/supply dynamics. However there is a fundamental difference. Option strikes are based off NDF curves rather than onshore forwards, and due to capital controls, dealers can usually hedge their delta only in NDFs rather than onshore spot. As such, the oft-made comparisons of implied to realized volatility in G10 FX are redundant in EM Asia (except HKD and SGD which are deliverable currencies). Since the delta-hedging instrument here is an NDF contract, implied vols are not predicting future volatility of spot, but rather predicting future volatility of *market expectations* of spot (plus a risk-premium). This subtlety is highlighted in the first chart below, which should help understand why, for instance, 1Y USD/CNY vols can trade at 8% handle while spot volatility is barely 2%.

Figure 1: USD/CNY vols vs. NDF and spot volatility



Source: Deutsche Bank

The main participants in Asian FX vol markets include:

1. *Corporates* – usually for the purpose currency hedging, especially where a regular stream of cash flows is involved.

2. *Investment banks' structuring desks and dealing desks* – for the creation of yield enhancement products, and the provision of market liquidity.

3. *Foreign portfolio investors* – typical buyers of low delta risk as "disaster protection" on local market asset holdings.

4. *"Speculators"* – looking for directional exposure on the underlying currency pair.

The diverse nature of players, their motives, and the relative infancy of these markets suggest there might be inflated risk-premia or even outright market inefficiencies. But few, if any, have given much thought to finding and exploiting these systematically. In this paper, that is our main objective.

The bias in EM Asian volatility surfaces

Our first task is to identify the sources of market premium which can most efficiently be exploited by the volatility trader. In order to take market convention and (potential) execution issues into account, we concentrate on two conventional sources: straddle-implied ranges, and volatility term premium. We ask whether the future moves in USD/Asia spot, or FX volatilities, have been accurately predicted by the preceding market prices. A consistent failure to do so is a sign that opportunities can be exploited on a systematic basis. We conducted 2 specific tests:

- Do current straddle-implied spot ranges accurately estimate the future spot ranges?
- Do current forward implied volatilities accurately estimate the future (spot) implied volatilities[1]?

As a starting point to our bias tests, we ran OLS regressions[2] using spot and volatility data, which have been modified to meet general stationarity requirements. We checked the size and statistical significance of the coefficients that relate our dependent variables (changes in spot ranges, and implied volatilities) to our explanatory variables (lagged changes in straddle and FVA prices),

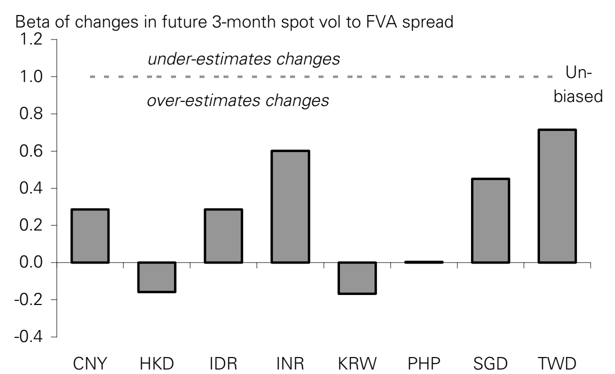
[1] We used implied volatilities as opposed to realized volatilities because forward volatility agreements are marked versus implied ATMF volatilities, as opposed to realized volatility.

[2] Bias tests can be specified in numerous ways. For simplicity and clarity, we employed significance tests on ordinary least squares coefficients

with the general guidance that "betas" closer to 1 imply greater accuracy and less bias[3].

The results suggest that EM Asian options prices are, on average, biased predictors of the price action in spot and volatilities. This bias is most strongly seen in forward volatilities, where FVAs have over-estimated future changes in 3-month implied vols by an average factor of 3. The bias was most consistent in currencies under strict regimes, though also in some of the higher yielders. In the case of USD/KRW, for instance, the beta has been mostly negative over the past year - that is, FVAs have on average predicted ATMF volatilities to fall when in fact they have risen. Beforehand, FVAs had often predicted volatilities to rise, when in fact they fell.

Figure 2: Do forward volatilities accurately predict future (spot) implied volatilities?

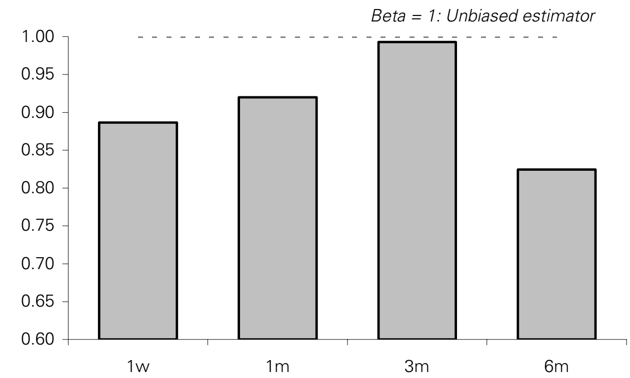


Note: data from Jan-04. Source: Deutsche Bank

As for the spot ranges, our bias tests for the performance of straddles in forecasting future spot ranges generated mixed results. Straddles are more liquid instruments, and hence we tested for bias in different tenors instead of just concentrating on the most liquid part of the curve. The differences are quite high: the predictive power of straddles rises up to the 3-month tenor, beyond which it falls aggressively. More interestingly, 1-week straddles consistently over-estimate future spot ranges well in excess of 3-month straddles despite the considerably shorter forecasting horizon. The over-estimation is most visible in USD/CNY (premia on revaluation risk), USD/IDR ("blow-up" insurance against carry trade unwind) and USD/INR (perhaps a reflection of frequent central bank "smoothing" intervention).

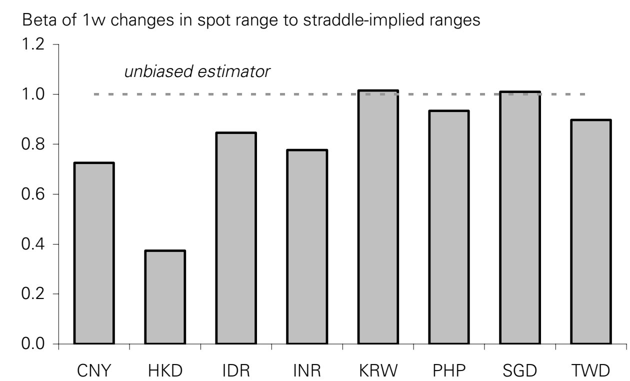
[3] A statistically-significant beta of 1, and a statistically insignificant alpha, would imply that the future changes in our dependent variables are accurately estimated by our explanatory bias, hence rejecting the hypothesis that market prices are a biased estimator of future price action. There is vast literature on bias tests, though for a concise and straight-forward procedure (conducted on agricultural commodities) we recommend Egelkraut and Garcia, 2005.

Figure 3: Which straddle tenors seem to best predict future spot ranges?



Note: data from Jan-04. Source: Deutsche Bank

Figure 4: Do 1-week straddle prices accurately predict spot ranges over the coming 1-week?



Note: data from Jan-04. Source: Deutsche Bank

Making sense of the bias – insurance premium, central banks and market memory

So why do these biases exist? We have the following explanations to offer:

- *Liquidity risk:* Instruments that are more liquid seem to carry less market bias. This statement is intuitively sound, as it draws from the general theory of market efficiency[4], and can be observed by the fact that third generation (volatility) products (most notably, FVAs) seem far more biased than 3-month vanilla straddles.

[4] For a more detailed discussion on the impact of liquidity on volatility bias, see FX Derivatives Focus, February 26th 2008.

- *Insurance premia:* Another key explanation of market bias is linked to the "insurance" value of FX options. The products analysed - straddles and FVAs - are long volatility in some form. Like most EM currencies, Asian FX tends to become more volatile when they depreciate compared to when they appreciate. Thus the cost of an option carries a particular "insurance premium" in excess of fair value in a risk-neutral world.

- *Preferred habitat:* Investors taking a view on spot direction tend to prefer the more liquid short-dated options, while hedgers – especially corporates hedging long-term contracts, tend to be more active in longer-dated options.

- *Central bank "smoothing":* The "managed" nature of regional exchange rate regimes means broader FX policy objectives matter for both the direction and volatility of spot. These objectives frequently relate to controlling/suppressing volatility, though the risk of policy flip-flops and capitulation increases tail risk for a bigger blow-up from time to time. From the point of view of a market maker, potential "fat tail" events can be a particular source of concern, as sudden regime shifts are typically followed by a "price discovery" period of scarce liquidity where hedging the trading book's exposure can be very challenging. That potential excess cost needs to be incorporated into the pricing of Asian options, and can be a key source of pricing bias.

- *Market memory:* Finally, general memory or expectations can also be a source of bias in the options market, especially in defining the bias in term premium [5]. Traders have a tendency to expect volatility to revert back to historical norms after gappy price action, hence inverting volatility curves when spot has recently become more volatile, and steepening curves when spot is more stable than usual.

- *Event risks:* Anticipated event risks may also affect term premia. Monetary policy meetings, elections, or shift in FX regimes can lead to higher, and longer-lasting, volatility, which pushes longer-dated volatility higher than short-dated volatilities[6].

Capitalizing from the options market bias – testing simple strategies

So we know there are biases in Asian FX vol markets, and why these might exist. But could these have been tapped as money-making strategies net of transaction costs?

We take a purely empirical approach to answer this question by back-testing various trading strategies. Given the endless set of potential trading rules, and the risk of "over-fitting", we stuck to simple strategies which intuitively captured each type of bias without resorting to complicated filters:

- *The straddle-implied bias:* we tested i) a strategy that is consistently short straddles and butterflies, ii) a strategy that trades straddles and butterflies using a valuation filter, and iii) a strategy that trades one-touch options with the same filter.
- *The forward volatility bias*: we tested a strategy that goes long and short forward volatility agreements depending on simple intra-regional valuations.

Trading the straddle-implied bias"

A short straddle position combines two trades: short a call and a put of the same strike (ATMF) and in the same notional. The position breaks-even if the underlying asset moves away from the current forward level by an amount equal to the premium earned. As we have shown earlier, straddle prices generally over-estimate the future ranges in FX spot which suggests that short straddle positions should be profitable over time as the terminal spot ranges are likely to stay within the break-even band.

We tested whether this is true by constructing a paper portfolio that consistently sold EM Asian straddles over time, taking all transaction costs into account. The straddles were of 1-week tenor, and rolled at maturity. The returns were strong, as predicted by the bias test, though they also highlighted a key issue with selling "insurance" products: occasionally, that insurance is needed. While the back-tested Sharpe ratio was in excess of 1.5, the largest draw-down was severe: a 2-week draw-down in May-06[7] wiped out an entire year's worth of returns.

An alternative to this strategy is to filter the trading signals to sell only if the spread between current straddle prices

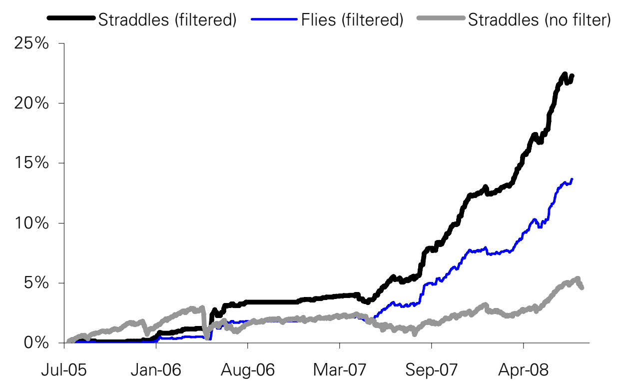
[5] In our FX Derivatives Focus piece from July 2008, we also discuss the impact of the anchored forwards in determining curve slope in USD/Asia. We do not address anchored forwards specifically in this piece given that our bias tests were conducted using (indicative) FVA strikes, which are adjusted for that.

[6] A good example of policy risk priced into volatility term premium is in the USD/HKD curve, where 2-year volatilities are consistently bid relative to 1-year volatilities. Market makers see the risk of a policy shift as the head of the HKMA is expected to retire next year.

[7] The large draw-down was attributed to being short straddles in USD/IDR at the onset of the EM turmoil in May-06. Prior to that, the USD/IDR portion was the largest contributor to the positive returns in the portfolio.

and recent spot ranges is wide[8] - in other words, selling straddles only when the bias seems most apparent. This filtered strategy has the extra advantage of not being as exposed to draw-downs as the previous - it only invests when current spreads seem extreme. The results were significantly friendlier, as the draw-downs were contained and the hit ratio was far higher. The decoupling versus the unconstrained straddle strategy became even clearer in 2008, as the filtered strategy generated considerably less "sell" signals and hence was less exposed to the weakness in EM Asia.

Figure 5: Cumulative returns – straddle strategies

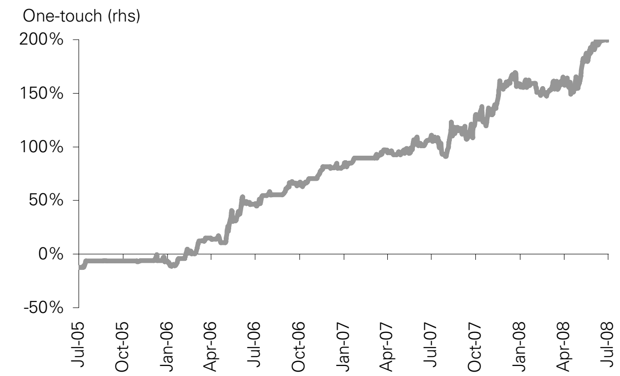


Source: Deutsche Bank

But while the signal filter improves the results considerably, it still leaves the portfolio with the uncomfortable reality that the maximum downside in a short straddle position is unlimited, and investors are typically wariest of selling straddles specifically when doing so looks most attractive from a bias perspective. The next adjustment in our exercise was to replace the straddles with the equivalent short volatility view via delta-neutral FX butterflies and one-touch options[9]; these are structures whose maximum downside is already known in advance[10].

The results are mixed. The extra "protection" from the low-delta strangles in the butterfly strategy was rarely needed in our back-test, and dampened the returns. The one-touch strategy[11], on the other hand, fared well, but still witnessed notable draw-downs compared to the level of returns.

Figure 6: One-touch strategy – using OT options* instead of straddles



** The unadjusted returns and volatility measures are not directly comparable to the others due to the nature of the one-touch strategy, due to the leveraged nature of the latter. See footnote for details.*
Source: Deutsche Bank

Figure 7: Straddle/OT strategies – return characteristics

	Straddles (unfiltered)	Straddles (filtered)	Butterflies (filtered)	OT* (filtered)
Annualised Returns	2.2%	6.9%	4.4%	44.3%
Volatility of Returns	1.4%	1.4%	1.1%	37.6%
Sharpe	1.6	4.9	4.1	1.2
Max Draw-down	2.5%	-0.8%	-0.7%	-23.3%
Draw-down / Returns	1.1	0.1	0.2	0.5

** The unadjusted returns and volatility measures are not directly comparable to the others due to the nature of the one-touch strategy, due to the leveraged nature of the latter. See footnote for details.*
Source: Deutsche Bank

A breakdown of the performance by currency shows that the performances of short straddles (with filter) appear to be correlated to the degree of control that authorities exert over their currencies. Generally speaking, the more "managed" currencies deliver the better Sharpe ratios, the highest being for HKD, CNY, INR and SGD.

Central banks in India and Singapore have a currency basket framework against which they run their FX policy. India's RBI has a loose 6-currency REER framework, but intervention in the form of "smoothing" is quite frequent. Singapore's MAS has a more rigid and disciplined NEER framework which requires intervention to enforce policy bands around the trade-weighted exchange rate target.

[8] We first define the historical average spread by calculating the (rolling) 2-year moving average of this spread. From there, we calculate the rolling 1-standard deviation band and set it as the threshold for signaling short straddle trades. We checked the sensitivity of results to wider and tighter bands, and the results were not significantly different

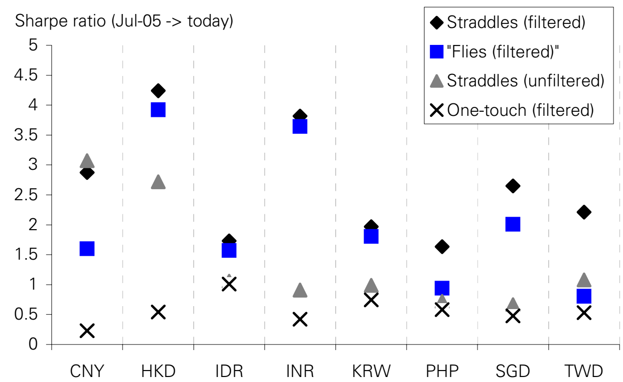
[9] The long butterfly position is long a 1-week 10-delta call and put versus short the straddle. The short one-touch position is short 1-week barriers struck at the same distance from spot as the straddle break-even levels.

[10] In the case of the butterflies, the maximum downside to the buyer is limited to the difference in adjacent strikes minus the net credit of the position. In the case of one-touch options, the maximum downside to the seller is limited to the option notional. We used 10-delta strikes for the butterfly positions.

[11] The one-touch strategy assumed selling barriers struck at levels equal to the upside and downside break-evens of the straddles, taking transaction costs into account. A $1 unit of capital was put at risk in every trade (maximum downside), and the upfront payoffs were normally between one-third and half of that.

China is still largely a crawling peg to the dollar, though the engineered pace of appreciation varies from time-to-time which in turn affects market expectations of future appreciation and corresponding price action in the NDF and volatility markets.

Figure 8: Sharpe ratio per currency pair, per type of strategy



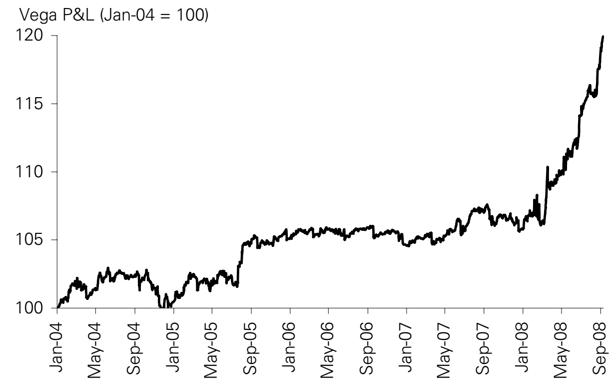
Source: Deutsche Bank

Trading the forward volatility bias through FVAs

A forward volatility agreement is a pure volatility product whose level is largely a function of short-dated and long-dated delta-neutral implied volatilities. Analogous to forward rate agreements (FRAs) in fixed income, FVAs capture current market expectations of future implied volatility; they are above spot volatilities in upward sloping curves, and below in downward sloping curves[12]. In the previous section, we showed that forward (implied) volatilities in EM Asia have a tendency to over-estimate the future changes in implied volatilities, hence suggesting that term premium trades involving the forward volatility bias should be profitable over time.

Our method for capitalizing on the bias in USD/Asia is straight forward - a paper portfolio that consistently sold FVAs in the steepest curves, and bought in the most inverted curves. The strategy evaluates the spread between FVAs and "spot" implied volatilities at every rebalancing date, sells FVAs in the 2 curves with the highest spread (most upward sloping), and buys 3-month, 3-month forward volatility agreements in the 2 curves with the lowest spread (most inverted or least upward sloping curves). The contracts are held until maturity (3 months), when the ranking and re-allocation process is repeated[13].

Figure 9: Historical returns – EM Asian FVA strategy



Source: Deutsche Bank

The results corroborate our previous findings on the forward volatility bias, and suggest that systematically trading FVAs in EM Asia can be a consistent source of positive returns.

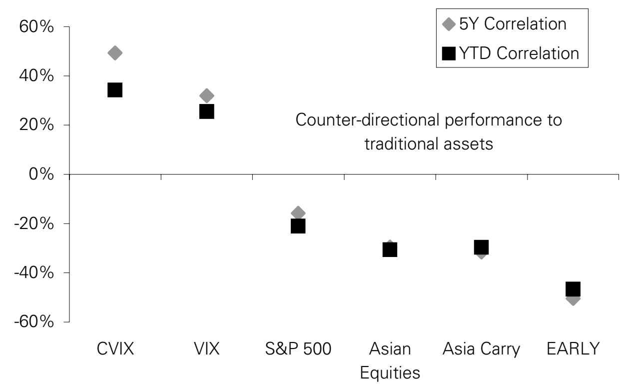
The back-test also suggests out-performance when traditional strategies - such as buying Asian FX carry or Asian equities - are underperforming. This is due to the very nature of the strategy: FVAs in inverted curves (which the portfolio is long) tend to rise quicker and more acutely than FVAs in upward sloping curves (which the portfolio is short). The performance of this vega-neutral, volatility-bullish[14] strategy was also slightly positive under risk-seeking conditions, as it benefits from the roll-down in the volatility term structure.

[12] We made adjustments for the FVA strikes from initial (mathematically-derived) forward volatility calculations as per market convention. For a detailed discussion on forward volatilities and FVAs, please refer to "Profiting From The Bias In Forward Volatility", FX Derivatives Focus, December 12th 2007.

[13] In the interest of minimizing liquidity and execution concerns, we stuck to 3m-3m FVA contracts. We also looked at other tenors and other portfolio compositions (aside from +2/-2) and the risk adjusted returns were not dramatically different.

[14] The strategy is vega neutral in that it is short as many FVAs as it is long, in equal amounts. However, it tends to be bullish volatility as the FVAs in which it is long (those of inverted curves) tend to be more volatile than those in which the strategy is short (upward slopping curves). Note: the maximum loss of a short FVA position is theoretically unlimited.

Figure 10: Correlation of returns to traditional assets



Source: Deutsche Bank

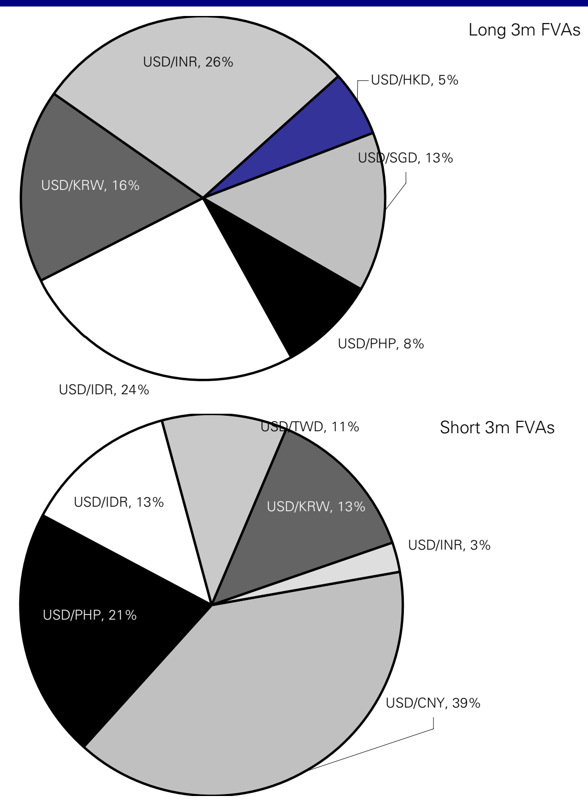
While the results are encouraging, a more careful analysis shows that much of the returns are attributed to consistent positioning short in USD/CNY FVAs, and long in USD/INR and USD/IDR FVAs. The exposure to IDR FVAs is intuitive – being the highest yielding and most volatile currency in EM Asia, its vol curve is typically flat or inverted. The short exposure to CNY FVAs reflect the strict nature of China's FX regime and market expectations that this may change in the future - a key source of curve bias as we discussed earlier. INR is somewhere in between, being heavily managed like CNY and also often used as a carry currency like IDR. Implied volatility remains subdued due to central bank intervention, which provides a stable anchor for FX spot, though the curve stays steep due to expectations that the FX regime may be loosened and allow for further spot volatility sometime in the future.

Are these strategies the same?

There are a few important links between the straddle and forward volatility strategies. For instance, USD/CNY and USD/INR generated consistently high risk-adjusted returns in both our back-tests. In the case of the renminbi, both strategies take the view that market expectations of a regime change are consistently overdone and hence take a bearish view on volatility. In the case of the rupee, the strategies often took differing views: forward volatilities can over-predict the future moves in INR spot, though often also over-estimate the pace of future falls in implied volatilities. This scenario occurs most often under periods of heavy INR weakness, where implied volatility rises well beyond its realised equivalent (which is anchored by central bank activity) and the volatility curve inverts.

Another important feature in our back-tested portfolios is the outperformance of the strategies over the past year, which results from rising volatility in the region. In the straddle strategy, this is analogous to the case of the rupee - volatility risk premium typically (though not always) rises as a function of the level of empirical volatility in EM Asia, and results in an even greater straddle-implied bias. In addition, the filtered strategies generated less trading signals during this year's weakness in EM Asia, hence becoming less exposed to some of the spikes in FX spot in the more volatile currency pairs. In the case of the forward volatility strategy, the portfolios effectively captured the rise in KRW and INR implied volatilities due to their consistently inverted volatility slopes. Therefore, the higher correlation between the returns of both strategies is not due to their similarity[15], but rather because both sources of bias are augmented under high volatility conditions.

Figure 11: Exposure (long / short FVAs) per currency pair



Source: Deutsche Bank

[15] In fact, the straddle trades are conceptually short (empirical) volatility while the FVA trades are long (implied) volatility.

Conclusion – bias, intuition and back-tests

In sum, FX derivative trading strategies have a lot to offer. We have found evidence of a bias in straddle implied ranges, which we attribute to two underlying dynamics acting together on both implied and realized volatility. On the one hand, the presence of capital controls pushes out speculative trading activity to NDF markets where price action is more volatile. Since implied vols are quoted off NDFs, the ranges implied by offshore option straddles are wider. On the other hand, managed exchange rate regimes and "smoothing" intervention tend to dampen realized ranges in onshore spot.

We also find evidence that forward volatility markets inaccurately predict future implied vols. This, we feel reflects premia for potential regime changes and "jump risks", such as revaluation in CNY and HKD, and devaluations in the higher yielding currencies like IDR. In addition, a concentration of fast-moving directional players in the front-end and slower-moving hedgers/structurers at the back-end of the vol curve creates a bias in how term premia is priced.

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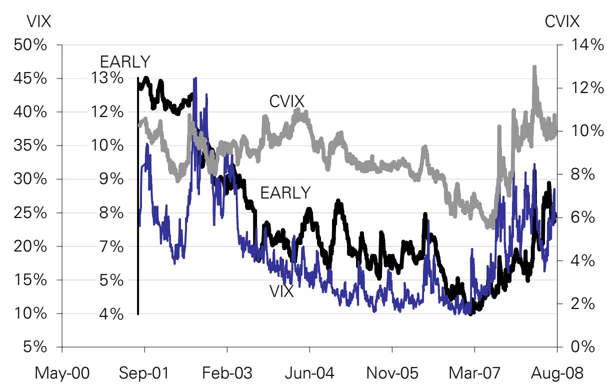
The Drivers of EM Asian Volatility: Past, Present, and Future (23/07/08)

Introduction

Asian currency markets are changing. Currency pairs have broken historical ranges, and intra-regional decoupling is occurring. At the same time that spot volatility is rising, liquidity is deepening and non-vanilla volatility products are increasingly traded.

Figure 12: SPX, CVIX and DB EARLY implied volatility



Source: Deutsche Bank, Bloomberg.

This study is the first in a series analyzing the region's volatility surfaces. In this report, we discuss the past and present drivers of the three main components of the surface: i) levels, ii) skew and convexity, and iii) term premium.

Our analysis suggests that *volatility levels* in USD/Asia are driven by a combination of external factors that reflect global economic conditions and risk appetite, as is the case with the rest of global FX, though idiosyncratic factors also play a significant role in most currency pairs in the region. We also discuss the role of "natural" buyers and sellers of *EM Asian skew*, the presence of revaluation risk and the impact of this structural behavior on the volatility smile. Finally, we look at the influence of expectations and interest rate volatility on *term premium* in USD/Asia, and how it compares to peers in G-10 and the rest of EMFX.

The drivers of volatility levels: two-thirds US economy and broad currency drivers, one-third risk appetite

We use principal component analysis (PCA) to identify forces that influence the realized volatility of USD/Asia[16]. Principal component analysis is a statistical technique whereby the common – as opposed to the idiosyncratic – variation in a set of correlated variables is extracted and used to form a new data series. In short, it is a statistical data reduction technique that explains variability among observed variables in terms of fewer, model-generated (not external) variables called "principal components". In this case, each principal component explains a portion of the variability of USD/Asia, and is uncorrelated to the other components by construction.

We find that two-thirds of the volatility of USD/Asia in the post-China revaluation period can be attributed to external factors[17]: economic indicators such as US business sentiment (ISM) and US unemployment, and broad currency drivers such as the DXY. These variables show the largest association with the model's first principal component, which currently explains two-thirds of the total variation in longer-term[18] FX volatilities in the region. The sign of the drivers is also intuitive – rising US unemployment and commodity prices, and falling

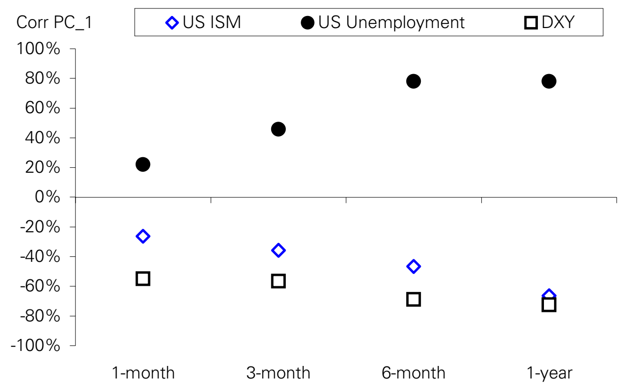
[16] Identifying the drivers of foreign exchange volatility is not straightforward due to the number of variables that influence the price of currencies - arguably the highest among the standard asset classes. Intuitively, currency volatility should be closely linked to variables associated with investor sentiment - either directly (as financial variables) or indirectly (through economic variables). This starting criterion, however, does not provide much filtering due to the diversity of potential explanatory factors, especially as one extends the analysis to an entire set of currency pairs. The task can be made even tougher due to the changing nature of the relationship between these potential explanatory variables, which may culminate in parameter estimation errors using a standard least squares analysis – all factors which argue for a more cross-sectional, aggregate technique such as principal component analysis.

[17] We derive those weights through analysing the coefficients of determinations (R-squared values), as opposed to sensitivity (beta) estimates.

[18] These results apply for one-year historical volatility (using 1-year forwards); shorter tenors give lower explanatory power to the first component (around 50%), similar explanatory power to the second component (30%) and more to lower components, which better capture currency-specific dynamics. In our view, this reflects the larger role of idiosyncratic factors in driving shorter-dated volatilities.

economic sentiment (ISM) or the dollar, are all bullish indicators for Asian realized volatility.

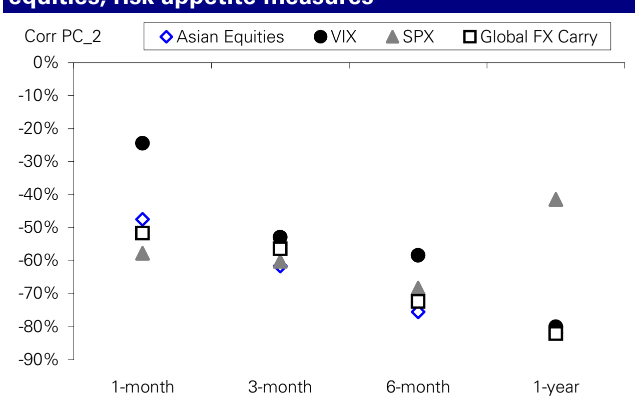
Figure 13: The first principal component – US economic indicators and broad currency drivers



Source: Deutsche Bank

The remaining one-third of the variability in USD/Asia volatility levels can be explained by factors that express risk appetite. The second principal component, which captures this variation, is most highly correlated with global and regional equities, the VIX and the performance of FX carry trades. An important distinction in this framework is the association between Asian FX volatility and *local* equity indices, as opposed to foreign equities, when looking at longer horizons. The correlations between the second principal component and Asian equity markets have averaged twice those of developed equity markets, which reflect a large degree of local factors. The correlation signs are also intuitive – volatility in USD/Asia rises when equity markets are falling (normally due to a rise in risk aversion).

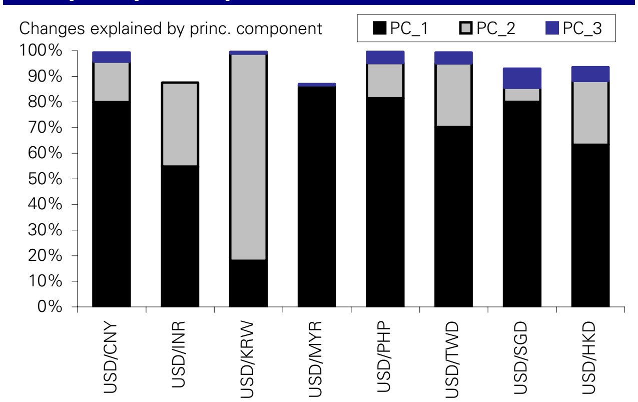
Figure 14: The second principal component – local equities, risk appetite measures



Note: we measure Global FX Carry through DB's Balanced Harvest Index. Source: Deutsche Bank

The results apply broadly for individual currency pairs. However, the volatilities of USD/CNY and USD/MYR, currencies which follow basket-type regimes, seem a lot more influenced by the first component (US economy and the USD) rather than the second. By contrast, USD/KRW, USD/HKD, USD/INR and USD/TWD volatilities are strongly influenced by the second component (equities, risk appetite, regional idiosyncrasy), although primarily influenced by the first principal component. In the case of USD/KRW, its dependency on this second component is even greater than that on the first.

Figure 15: Changes in each currency pair explained by each principal component

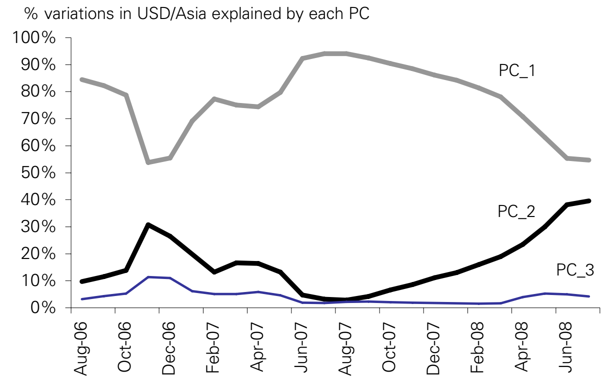


Source: Deutsche Bank

The factors are similar to those driving Asian FX forward returns, though distinguishing between the first two principal components is less clear. Another difference is that idiosyncratic drivers seem more evident when running the PCA for FX forward returns, as shown in the significance of lower-order principal components in explaining the variations of some of the currency pairs. This was largely evident in USD/KRW, USD/TWD and USD/HKD to a lesser extent.

We also note the changing relevance of the different components as drivers of USD/Asia volatility. The growing link between FX and other asset classes has led to a rise in the influence of the second principal component. It is more evident in the higher yielding currency pairs, but also visible in USD/TWD, USD/KRW and USD/HKD. Overall, the gap in explanatory power of the first two components has shrunk over recent periods.

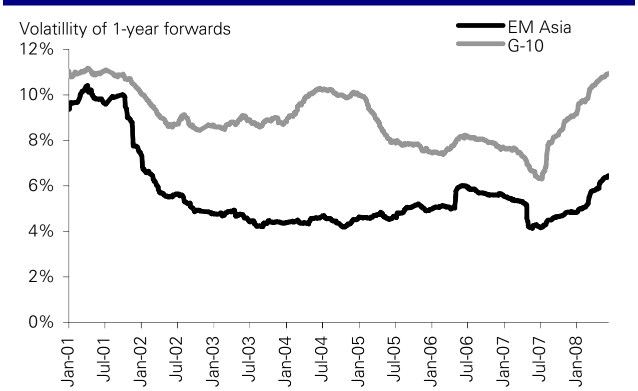
Figure 16: Principal components and explanatory power for USD/Asia volatility



Note: we use 2-year rolling intervals for the rolling PCA analysis. Source: Deutsche Bank

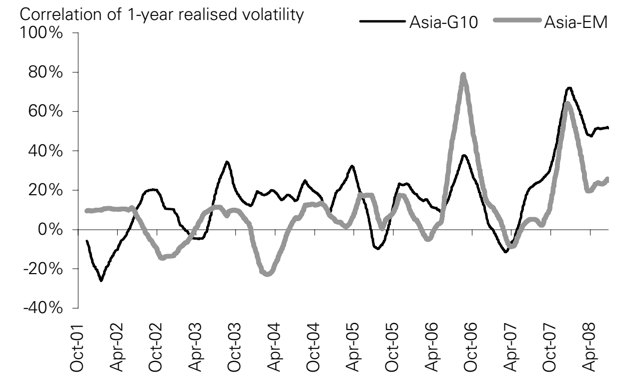
Looking ahead, the low volatility era is most likely over. As US growth concerns mount, the USD turns once more, and global risk appetite shrinks, currency volatility in EM Asia is likely to rise. The analysis also suggests that the correlation between Asian volatility and their respective EM counterparts will continue to rise, as is already becoming evident, due to the influence of the second principal component as driver of volatility in both cases. As we show below, the empirical volatility of 1-year forwards in EM Asia is well below that seen at the start of the decade – a time when a similar environment was in place. In addition, the correlation of these volatilities to that of the peers is also on the rise – with notable spikes during episodes of global risk aversion.

Figure 17: EM Asian volatilities – still well below levels from earlier in the decade



Note: we use equal weights for TWD, HKD, CNY, PHP, MYR, SGD, KRW, INR and IDR in USD/Asia, the main USD and EUR crosses in G-10, and MXN, BRL, ZAR, TRY, EUR/HUF and EUR/PLN in the rest of EM. Source: Deutsche Bank

Figure 18: Correlation of realized volatilities - EM Asia vs EM, and vs G-10 FX



Note: we use a 3-month correlation of daily changes in the volatility of 1-year forwards. We also smooth it in order to better capture the trend. Source: Deutsche Bank

Asian skew and kurtosis – drivers and practices

Volatility skew is normally defined as the price difference, measured in units of implied volatility, between a call and a put of equal deltas in the same underlying asset. Of the three main components of FX volatility surfaces – levels, term premium, and skew - the latter is most affected by structural issues such as the presence of "natural" buyers and sellers. Demand for low delta put options typically arises from their characteristic as cheap(er) insurance against potential currency depreciation, especially in markets where foreigners own a considerable amount of local currency assets. The less liquid the local asset is likely to be during periods of risk aversion, the more likely asset holders will seek proxy protection. This will tend to drive up the price of lower delta (cheaper) puts relative to that of higher delta (more expensive) other options.

In terms of volatility skew, USD/Asia divides up neatly into three main categories:

- Currencies of export-oriented countries, whose options markets have been highly influenced by resident supply of low delta USD calls. Historically, most of this selling of low delta options has been done by institutions that are structurally short their own currency - exporters whose sales values rise if the US dollar appreciates. An eventual move higher in USD/Asia is less likely to hurt their business compared to a move lower in USD/Asia, hence the bias to sell USD calls. These include USD/KRW, USD/TWD, USD/SGD and USD/TWD[19].

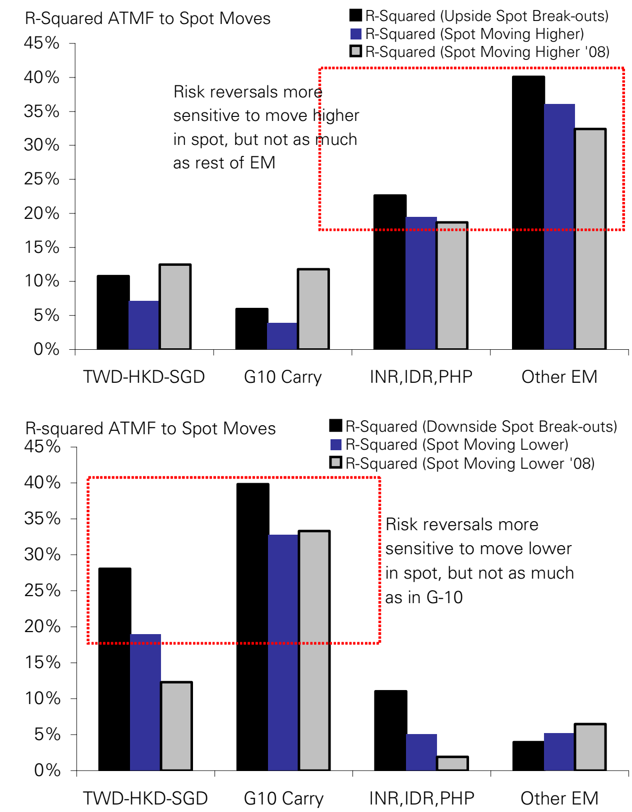
[19] Other currency pairs do not exhibit this pattern as much, either due to a preference to extract premium from the cash market (as opposed to via FX options), or due to idiosyncratic factors. The most notable case is USD/HKD, where the opposite behaviour has been dominant over more recent years - resident institutions have sold low delta USD puts, not calls.

- Currencies that are more driven by the country's domestic story, and whose skew (implied and empirical) more closely resembles that of their EM peers. These higher-yielding currencies include USD/IDR, USD/PHP and USD/INR.
- Currencies that are heavily managed by the respective monetary authorities, whose volatility surface bears little relationship with spot activity, and whose skew consistently over-estimates future currency appreciation. These include USD/CNY and USD/HKD.

Thus, a key differentiating aspect of EM Asia lies in the nature of the FX regimes. Central bank influence on the price action in USD/Asia spot is a lot greater than that seen in its G-10 and EM peers, and spot is "artificially" made to follow a path that is in line with their foreign exchange policy. The resulting impact on the volatility smile has been two-fold: i) implied volatility has been less sensitive to moves in spot, and ii) the distribution of empirical returns has largely differed from the surface-implied distribution - most notably the skew and kurtosis.

The sensitivity of implied volatilities to moves in spot is generally an important driver of FX skew, as it provides traders with an indication of the proxy break-even levels for the simple vega P&L of lower-delta options[20]. That sensitivity is generally strong in G-10 and most EM currency pairs, but in USD/Asia, the relationship has been weaker prior to 2008 due to the nature of FX regimes. In the case of the export-oriented countries mentioned above, the historical central bank "smoothing" of spot encouraged the supply of low-delta options, which in turn reduced the hedging requirement of trading desks if spot moved higher. This has resulted because market makers have already been supplied with options struck at levels that imply USD upside[21]. In the case of higher yielding currencies, the smaller impact (compared to the EM peers) is likely due to central bank intervention.

Figure 19: Changes in implied volatility explained by moves in FX spot



Note: we define Spot Break-outs as a move higher or lower in FX spot, that is in excess of 2 standard deviations above the 2-year-year average. We use EUR/USD, USD/JPY, EUR/JPY, EUR/CHF, AUD/USD, NZD/USD, and GBP/USD in G-10, such that the terms currency is consistently the one with the lower interest rates. The opposite applies in the EM case: the terms currency is normally the higher yielder.
Source: Deutsche Bank.

The skew and kurtosis of FX returns are also affected by central bank activity in EM Asia. In terms of the skew, the more tightly managed the currency pair, the higher the market-implied probability of currency appreciation has been. As shown in the chart below, volatility surfaces have consistently implied future depreciation of higher yielding Asian currencies, which is in line with the rest of EMFX, and out of line with empirical behaviour in recent years[22]. But as rate differentials fall, the more managed the currency pair has been, and the more future currency appreciation tended to be priced – as seen in CNY and HKD. In this case, options markets appear to have consistently over-estimated potential currency appreciation, opposite to the case of Asian high yielders.

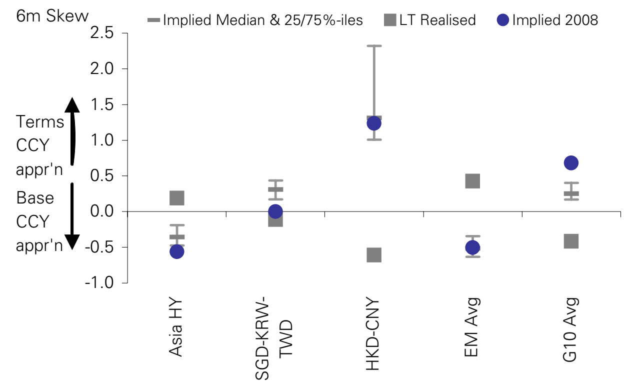
We believe the rationale is a function of both the excess premium (lower delta USD puts are more expensive than calls), and the consensual view that policymakers will ensure that the current currency regime will be in place over the horizon of the option (typically less than 1 year).

[20] For example, say the trader buys a 25-delta option struck at a level 5% above spot, with an implied volatility reference of 11%, and where the ATMF implied volatility is at 10%. If the beta of changes in ATMF volatility to changes in spot is 0.2, a 5% move in spot will lead to a 1% move in ATMF volatility, and will mean that the vega P&L of the option bought is zero, as the implied volatility of that option is now also 11% (an ATMF option). This example is shown for illustration purposes only – the (non-hedged) option position can lose 100% of the initial capital invested (premium paid) if it expires out-of-the-money.

[21] If looking to stay market-neutral, trading desks will then sell spot (to offset their rising delta exposure) and sell vanilla options (to offset their rising vega exposure) as spot moves higher and closer to the strikes of options previously sold to them. In practice, market makers do not hedge fully, due to the risk of upward moves in spot being accentuated.

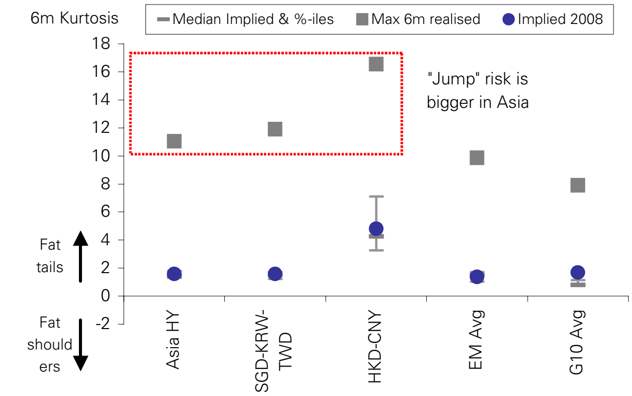
[22] Higher yielding currencies have tended to appreciate over the historical sample (5-years) across the globe, as evidenced by the 11.5% annualised returns of the FX carry trade (DB Global Harvest).

Figure 20: Options-implied versus empirical skew over time



Note: we use 5 years worth of data. The implied skew is calculated from 6-month options on a rolling basis. Source: Deutsche Bank

Figure 21: Options-implied versus empirical kurtosis over time

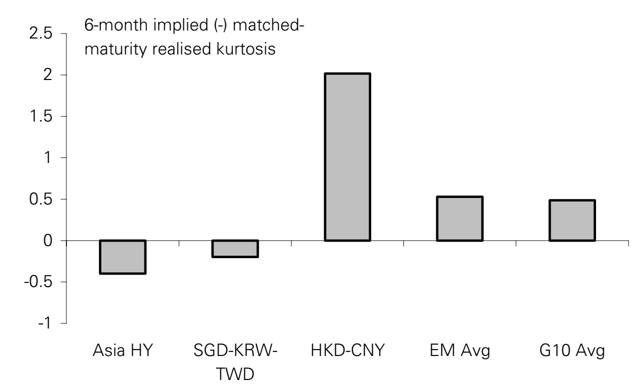


Note: we use 5 years worth of data. The implied skew is calculated from 6-month options on a rolling basis. Source: Deutsche Bank

The discrepancy between the market-pricing of "fat tails" (kurtosis[23]) and what's been empirically verified through history in USD/Asia has also been heavily influenced by the region's FX regimes. Asian currencies hold the highest empirical kurtosis among global FX - that is, the distribution of currency returns has the highest peak and "fattest" tails among all currency blocks. Such evidence should be no surprise; the "high peaks" reflect the stability of returns resulting from currency management policies by monetary authorities, while the "fat tails" reflect the prospects for structural changes in FX regimes, or range break-outs.

However, such empirical evidence has not been fully consistent with market pricing. In the case of USD/CNY and USD/HKD, surface-implied kurtosis has tended to under-estimate the magnitude of range breaks (or structural regime changes) once they come, though it over-estimates the actual changes in spot during the interim period. This does not necessarily indicate mis-pricing, as fat-tailed events are rare by definition[24]. In addition, as the charts show, this dynamic is not uniform across USD/Asia. Options-implied kurtosis is consistently below near-term realised kurtosis in the high-yielding Asian crosses, and also to a smaller extent in USD/SGD, USD/KRW and USD/TWD.

Figure 22: "Kurtosis risk premium" – short term implied minus empirical kurtosis over time



Source: Deutsche Bank

This year, however, a few changes have occurred with respect to EM Asian skew, which we attribute to the rising volatility of FX spot. The sensitivity of implied volatilities to spot have risen via the move higher in USD/Asia, while the ensuing risk aversion has reduced the local supply of low delta USD calls, and ignited considerable demand for Asian currency puts from offshore investors - such that sensitivities now better resemble broader EMFX and G-10 FX. In addition, higher yielding currencies in the region have generally depreciated, vindicating some of the (historically) expensive skew. As this new environment is unlikely to end anytime soon, the lack of local supply of low delta USD calls should continue to provide upward pressure on risk reversals, despite the historically high levels currently witnessed.

[23] We capture implied skew and implied kurtosis using an approach defined in Jurczenko et al, "Multi-moment Approximate Option Pricing Models: A General Comparison", 2002.

[24] Measuring kurtosis over time is challenging as fat tail events are rare by definition. Our dataset suffers from being too small (5 years), and hence unable to capture the "true" kurtosis of empirical and implied returns. However, it provides a reasonable indication of the behavior of high sigma events in recent history, as it encompasses a series of market shocks such as regime changes, global contagion events and significant market corrections.

Term premium in USD/Asia – expectations and interest rate volatility

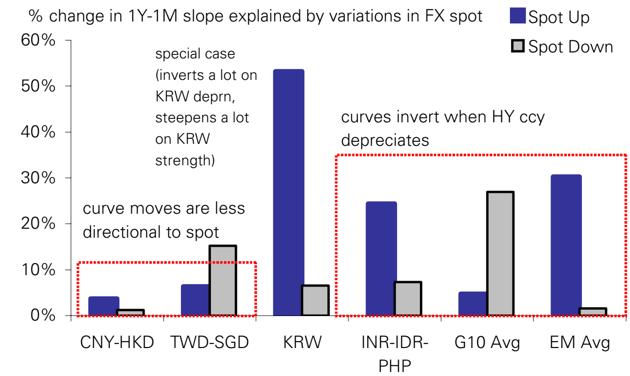
Term premium is defined as the difference between long-dated and short-dated implied volatilities, and in foreign exchange it is typically measured as the difference between 1-year and 1-month ATMF volatilities. This is normally driven by two factors: market expectations (and uncertainty) of the future variability of spot, and the expected[25] volatility of the forward to maturity.

Expectations can be driven by a variety of factors. Among G-10 currencies, this is usually a product of market memory. That is, market makers generally believe that volatility will revert to a certain historical level (the average in the cycle), and quote longer dated volatilities accordingly. Expectations are also affected by events such as data releases in G-10 and political developments in EM, as the uncertainty around these can lead to demand for options contracts which encompass those particular dates.

The volatility term premium also reflects the volatility of the FX forward rate. The implied volatility quoted in a vanilla options contract expresses the market estimate of the future volatility of the underlying instrument used for hedging the delta of the option - in other words, the anchored forward[26]. The longer the expiry of the contract, the more interest rate differentials become a key driver, and the greater the influence of interest rate volatility becomes.

We find that volatility term premium in USD/Asia is a function of both these factors. In the higher yielding currency pairs, FX spot is more volatile, so interest rate volatility has a smaller impact (compared to the volatility of spot) in defining the volatility of the anchored forward. The "expectations" component holds greater influence and volatility curves invert with higher spot volatility (typically associated with the depreciation of the higher yielding currencies). Such tendency is in line with G-10 currencies, and (on average) broader EMFX markets.

Figure 23: Changes in term premium explained by movements in spot over time



Note: we use data from mid-05 onwards. Source: Deutsche Bank

The term premium in CNY, HKD and TWD, however, has historically been less sensitive to FX spot, which we attribute to the fact that the variations in spot don't necessarily reflect the view of the market - they are highly influenced by central bank activity. In such cases, market sentiment is better reflected in the behaviour of the forward rates, which tends to increase interest rate volatility and heightens its impact (compared to spot volatility) on the volatility of the anchored forward[27]. Term structures steepen as a result.

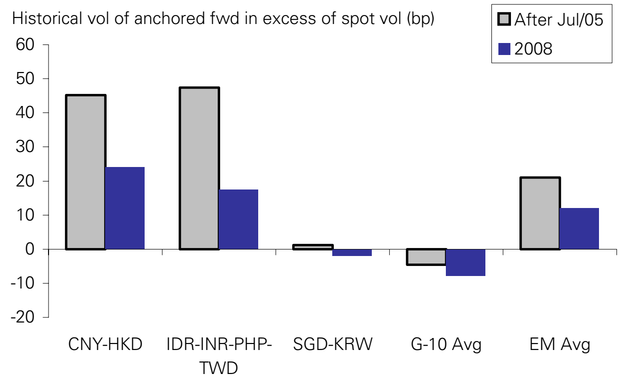
Overall, the volatility of FX forwards has contributed more to term premium in USD/Asia than in most of its G-10 and EM peers over time. In the case of CNY and HKD, the term premium of anchored forward historical volatility exceeds that of spot volatilities, as shown in the charts below. Nevertheless, the attributions have changed this year with the excess contribution of the forwards to volatility term premium in EM Asia converging towards what is seen among its peers – in line with the other key aspects of Asian volatility surfaces.

[25] The expected behaviour of the forwards is normally driven by history.

[26] The anchored forward is a forward FX rate whose maturity is anchored at a particular date (the expiry of the option contract). It is different from spot in that it includes interest rate differentials, and different from a constant maturity forward in that it has a decay component.

[27] For a more detailed review on the volatility of forward points in EMFX, see "Sleep Well With EM - Understand FX forward risk to size positions and find value in vol", *FX Mini-Blueprint for Summer 08*.

Figure 24: Volatility term premium – anchored forwards versus spot



Source: Deutsche Bank

Conclusion – are Asian surfaces converging to their peers?

Our analysis suggests that volatility surfaces in USD/Asia are converging back to their G-10 and EM peers. Obviously, such process will not happen overnight and there is still a long way to go, especially among currency pairs under strictly managed FX regimes. But as the new environment progresses, volatility levels are likely to rise further due to their sensitivity to US economy factors, the strength of the USD and the erosion of global risk appetite. Skew is likely to be more responsive to shifts in risk appetite (and to spot) due to the eroding supply of low delta options by residents. Finally, term premium will also become more dependent on spot behaviour, as opposed to simply the volatility of forward points.

Volatility Drivers Part 2: The Cyclical Factors (15/04/08)

Introduction

As global FX continues to move into a new environment of higher volatility, we concentrate this second report on volatility drivers on the cyclical components of FX volatility. Our analysis focuses on two major areas: i) identifying the cyclical drivers and their respective impact on FX volatility, and ii) assessing the typical behaviour of FX volatility cycles, so as to compare it with the most recent developments in currency markets.

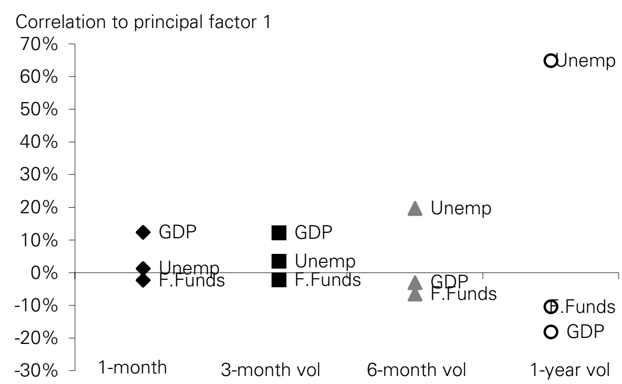
Through applying standard statistical techniques and empirical analysis, our work shows that the historical volatility European currency pairs tend to be more strongly influenced by US economic indicators, while the dollar block and JPY-cross volatilities see greater influence from financial market variables. Our analysis also shows that, based on historical cyclicality patterns and the progression of FX volatilities since the start of H2'07, historical volatilities in most European crosses have further "catch-up" to do when compared to most dollar-block and JPY crosses.

The cyclical drivers – US economy, financial markets, and risk appetite

In order to deal with most statistical deficiencies of a standard least squares fitting model[28], we apply principal component analysis (PCA) to identify the forces that influence the volatility of G-10 exchange rates. Principal component analysis is a statistical technique whereby the common - as opposed to idiosyncratic - variation in a set of correlated variables is extracted and used to form a new data series. In short, it is a statistical data reduction technique that explains variability among observed variables in terms of fewer, model-generated (not external) variables called "principal components". In this case, each principal component explains a portion of the variability of G-10 FX volatilities, and is uncorrelated to the other components by construction.

In our view, realised volatility in USD/G-10 currency pairs can be grouped into three main components; together, they explain between 80% and 90% of the variations in the full data set, depending on the volatility tenor. The first factor explains 40-50% of the variations in the total data set, and is associated, in our view, to variables directly related to the overall state of the US economy[29]. This association becomes increasingly evident as a function of the volatility tenor; the correlation between the first principal component and US unemployment, for instance, rises as the tenor of G-10 FX volatilities rise. This first component, which we'll call the "US economy" factor, is also considerably more related to the volatility of European currency pairs - that is, the factor loadings are most heavily contributed by EUR/USD, GBP/USD, USD/CHF, EUR/GBP, EUR/CHF and the Scandinavian crosses.

Figure 25: The first principal component – the "US economy" factor

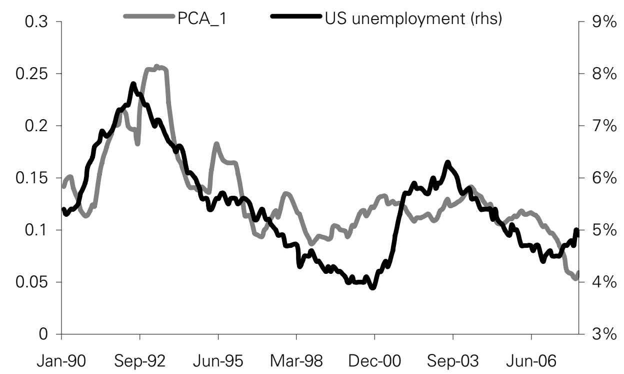


Source: Deutsche Bank

[28] Identifying the drivers of foreign exchange volatility is not straight forward due to the amount of variables that influence the price of currencies - arguably the highest among the standard asset classes. Intuitively, currency volatility should be closely linked to variables associated with investor sentiment - either directly (as financial variables) or indirectly (through economic variables). This starting criteria, however, does not provide much filtering due to the diversity of potential explanatory factors, especially as one extends the analysis to an entire set of G-10 currency pairs. The task can be made even tougher due to the changing nature of the relationship between these potential explanatory variables, which may culminate in parameter estimation errors using a standard least squares analysis – all factors which argue for a more cross-sectional, aggregate technique such as principal component analysis.

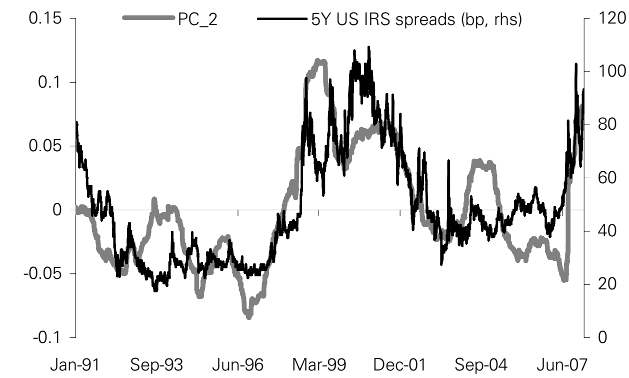
[29] We looked at a series of economic, financial, and risk appetite variables in the analysis and the first set was by far more strongly correlated with the first component. Of the economic variables, US GDP has also been a relevant measure at times in the past, especially earlier in the decade, but not with the same magnitude or consistency as US unemployment and the US current account (as a % of GDP). We also used Eurozone economic variables (and differentials between US-Eurozone variables), in our analysis, though they showed much less association with the principal components, especially the first.

Figure 26: Principal component 1 and US unemployment over time



Note: we use the PC_1 derived from the analysis of 1-year volatilities. Source: Deutsche Bank

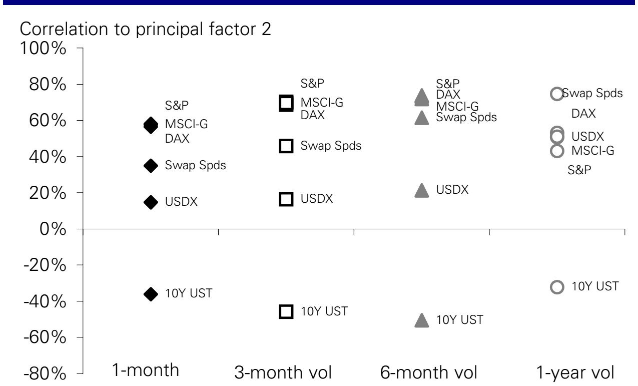
Figure 28: US swap spreads and second principal component over time



Note: we use the PC_2 derived from the analysis of 1-year volatilities. Source: Deutsche Bank

The second principal component also carries a considerable weight in explaining the variations in G-10 FX volatility, between 25% and 35% depending on the tenor of the volatilities analysed. This factor has been much more closely associated with financial variables, most notably equity markets (S&P 500, DAX, MSCI Global), USD swap spreads and US high grade credit. Interestingly, this second component, the "market" factor, is not as influenced by the tenor of the FX realised volatilities observed; global equities, for instance, affect all tenors in similar magnitude (especially the 3-month to 1-year bucket).

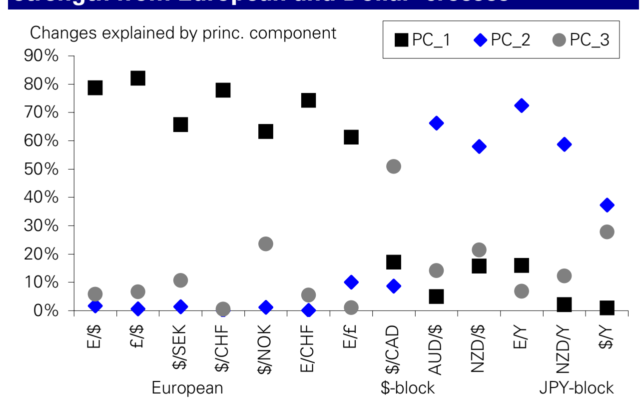
Figure 27: The second principal component – the "financial market" factor



Source: Deutsche Bank

This second principal component has a couple of important characteristics, especially when viewed in comparison to the first. Firstly, it is more strongly associated with the behaviour of the historical volatility in dollar-block and JPY crosses, as opposed to the European crosses, which are much more closely linked to the first factor (the US economy). In our view, this can be intuitively explained by the behaviour of the US dollar as a general driver of these currency pairs; previous work[30] has shown that US economy-specific factors have been more influential in explaining the performance of European crosses compared to those of the dollar block, and our results suggest that similar conclusions can be drawn for FX volatility. In addition, the non-European crosses have generally boasted higher interest rate differentials compared to the European crosses over time, thus generating a greater association with financial variables.

Figure 29: Principal factor loadings – relationship strength from European and Dollar crosses



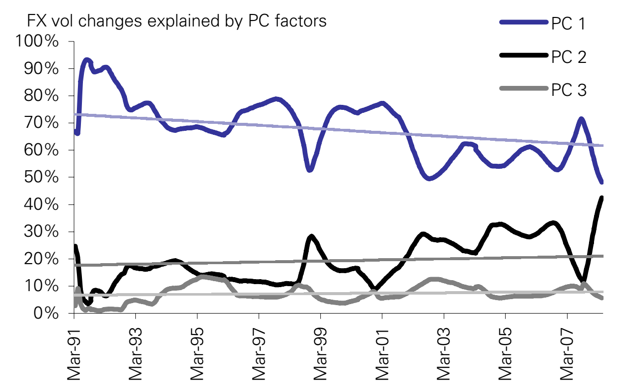
Source: Deutsche Bank

Another important relationship between the first and second components is in their changing influence, over

[30] See *Exchange Rate Perspectives*, February 2006.

time, in driving the variations in G-10 FX volatility. The behaviour of economic variables has become less influential to FX volatilities over time, while financial market variables have consistently grown as drivers of FX volatilities. In our view, this may well be linked by the increasing integration of financial assets over time, a dynamic evident in the growing correlation between currencies and other asset classes[31].

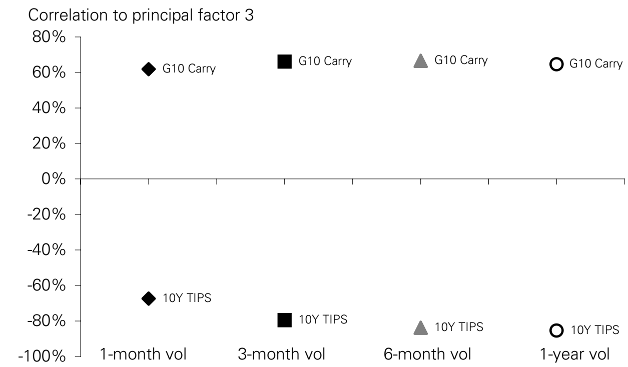
Figure 30: The explanatory power of principal components over time



Source: Deutsche Bank

The remaining 15-25% of the variations (depending on the tenor) is explained by a series of smaller factors, each seeming more associated with the behaviour of a smaller group of currencies – sometimes one specific currency pair. This separation suggests that some other factors, including idiosyncrasy and block-specific drivers, may also play a role in driving G-10 FX volatilities. The third principal component, which explains circa 10-15% of the variations, is a good example of that. This component, whose relevance is constant over time as shown in Figure 7, captures the influence from specific barometers of market risk sentiment – such as US real yields and the performance of FX carry trades. This is a key distinction from the second principal component, which encompasses a greater variety of market risk measures (such as growth expectations and credit risk). As shown in Figure 6, this third, "residual" component has the smallest influence overall, but is also more influential than the first component in currencies with higher interest rate differentials due to its link to risk appetite variables[32].

Figure 31: The third principal component – the "carry trade" factor



Source: Deutsche Bank

Duration and intensity – the anatomy of FX volatility cycles

Having discussed the cyclical drivers of FX volatility cycles, we now provide a careful look at the cycle itself; in other words, an "anatomy" of the cycles in 3-month FX realised volatility.

Since 1980, G-10 FX volatility cycles have had a tendency to last around 3 years, including both the standard and the less liquid crosses. This dynamic is seen irrespective of the region, although a few dollar-block and European currencies have a tendency to see slightly shorter (2.5-year) cycles. These can be divided into two portions: the rise from trough to peak (approximately 45% of the full cycle), and the peak to subsequent trough (the remaining 55%). As before, such dynamic occurs irrespective of the region. Finally, G-10 FX volatilities have tended to move, on average, by 9.0% from their trough to subsequent peak, with historically higher yielding currency pairs (such as AUD/USD and GBP/USD) moving the most in percentage points, and lower yielding crosses (such as USD/NOK and USD/CHF) moving the most in z-score terms.

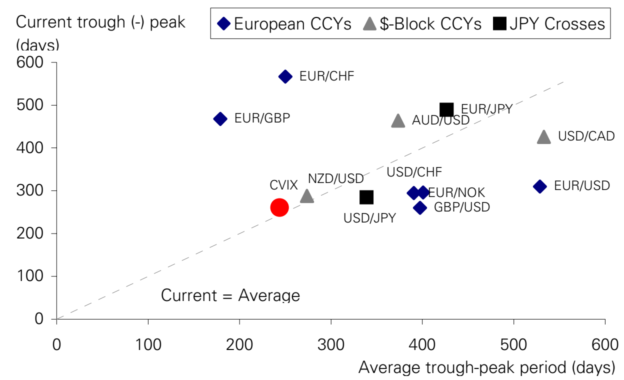
But contrary to what seems apparent, the current volatility cycle doesn't look unanimously nascent. The sense of "youth" is seen more evidently in the Europe, where two-

[31] See, for instance, "FX Exposure in International Equity Portfolios" for a more detailed discussion on the changing nature of FX-equity correlations over time. One may be tempted to argue that the progressive improvement in US macroeconomic stability (the "great moderation") is also behind the fall in its impact on FX volatilities, though, as pointed out in the November 2006 edition of our *Exchange Rate Perspectives*, the argument would be be applicable to the 1990s since the decline in the volatility of macro fundamentals ended in the mid 1980s.

[32] A distinctive characteristic of the third principal component is seen on how it affects each currency pair through the PCA coefficients. The factor loadings derived from the analysis are almost symmetrically opposite between the JPY and dollar-block crosses, suggesting that exposure to this factor can be almost fully offset by running opposite volatility positions between the two. Indeed, some of this relationship can be observed when looking at the correlation between historical volatilities of currency pairs such as USD/CAD and JPY crosses such as NZD/JPY. Over time, these have been low (often negative), especially when compared to that of the European crosses. While a careful overview of such volatility-correlation dynamics is best left to a separate report, we note that a similar relationship is also witnessed in the behaviour of spot returns of USD/CAD and JPY-block currency pairs.

thirds of the currency pairs are 50-70% of the way into the average trough-peak time period. Interestingly, on the other hand, EUR/GBP and EUR/CHF (also European crosses) have already gone far beyond their average peak-trough time, mostly due to their volatility cycles being typically shorter than the rest. Elsewhere – in the CVIX[33], JPY and dollar-block crosses ex-CAD – the time period from the last trough to today is well comparable to the average historical trough-peak period.

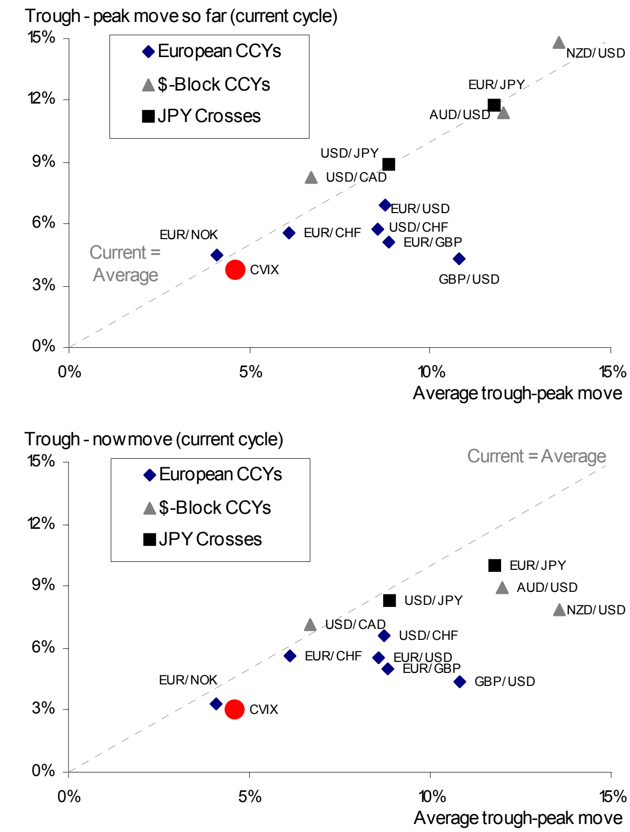
Figure 32: The duration of volatility cycles – trough to peak



Source: Deutsche Bank

More importantly, however, is how the current move in volatilities compares with history from the past 3 decades. As Figure 10 shows, 3-month realized volatilities have jumped by an amount similar to the historical average in over one third of the currency pairs analysed, and more than half of them exceeded, earlier in March, the average historical jump. This characteristic clearly distinguishes the current volatility jump from the historical counterparts - *FX volatilities in quite a few G-10 crosses moved from their trough to peak level well before the expected time, and many of them are now in the process of easing again.* This picture is most clearly evident in the Dollar and JPY-block currency pairs, which have already been at the history-expected peaks earlier this year, and which are near (or past) the average trough-peak time period.

Figure 33: The intensity of volatility moves – current and historical cycles



Source: Deutsche Bank.

Implications –European crosses look more vulnerable to volatility spikes than the USD and JPY blocks

The analysis of volatility drivers and the characteristics of a cycle allow us to reach the following conclusions: *i) the historical volatility in European crosses are more driven by US economic variables, ii) the volatility of the dollar-block and JPY currency pairs are more strongly influenced by financial market variables, and iii) the European volatiities (ex- EUR/GBP and EUR/CHF) are lagging the dollar-block and JPY crosses in terms of where they stand in the volatility cycle.*

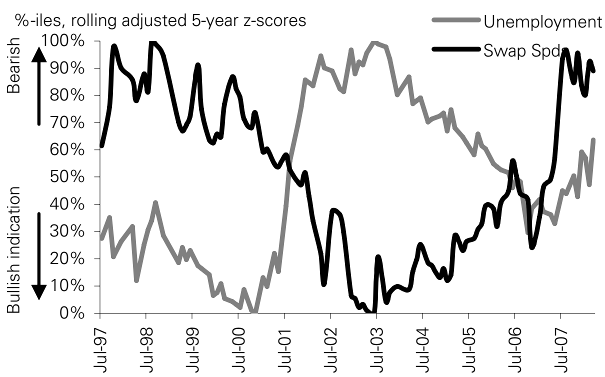
The implications as to the future behaviour of realised volatilities depend, therefore, greatly on these economic and financial market variables. A quick assessment of market stress [34] levels shows that, of the two most

[33] The CVIX is Deutsche Bank's Currency Volatility Index. For further information, please refer to *Deutsche Bank Guide To Currency Indices*, October 2007. This report uses the historical volatility version of the CVIX.

[34] We assess "market stress" by comparing the current level of the two variables against their historical behaviour, using a 5-year rolling window. We choose 5 years so as to better link it with the average duration of FX volatility cycles.

relevant PCA-associated variables, US unemployment seems to be in less extreme levels than swap spreads currently are. While this measure, which is shown in Figure 11, may be too simplistic when analysed on its own, it also corroborates our earlier argument that the European currency pairs[35] (which are more influenced by factors such as US unemployment) are lagging the dollar-block and JPY crosses (more influenced by swap spreads) in reaching the average peak in volatility, and that some form of conversion (either with the former rising, or the latter falling) should take place.

Figure 34: US economy and financial market indicators – "stress" levels



Source: Deutsche Bank

Figure 35: Summary of findings

CCY Pair	Most Influential Drivers	Trough => current (peak) vs average period	Trough => current vs average jump
EUR/USD	US economy factors	Below average duration	Below average jump
GBP/USD	US economy factors	Below average duration	Below average jump
USD/CHF	US economy factors	Below average duration	Below average jump
NOK	vs EUR,USD: US economy factors	Below average duration	At average jump
EUR/CHF	US economy factors	Above average duration	At average jump
EUR/GBP	US economy factors	Above average duration	Below average jump
USD/CAD	Financial market, risk appetite factors	Below average duration	At average jump, having gone beyond
AUD/USD	Financial market factors	At average duration	Below average jump, having reached earlier
NZD/USD	Financial market factors	At average duration	Below average jump, having reached earlier
EUR/JPY	Financial market, risk appetite factors	At average duration	Below average jump, having reached earlier
NZD/JPY	Financial market, risk appetite factors	At average duration	At average jump
USD/JPY	Financial market, risk appetite factors	Below average duration	At average jump

Source: Deutsche Bank

35 Except for EUR/CHF and EUR/GBP.

Volatility Drivers Part 1: Does Liquidity Affect Volatility? (26/02/08)

Addressing the non-cyclical drivers of volatility

Recent history suggests G-10 foreign exchange markets have entered into a new volatility regime. This regime seems clearly associated with higher volatility levels, marking what seems to be a return of the volatility cycles from earlier in the decade. This article is the first in a series aimed at addressing the different factors which we believe have affected volatility both over time and during the most recent period.

In this article, we discuss the impact of rising market liquidity on volatility, through channels of risk dispersion and improved price discovery. We first identify the presence of these factors through the analysis of the changing patterns in realized FX volatility through history, followed by a discussion of the key differences attributed to the previous cycle, where volatility was unusually low. We then assess other impacts associated with rising liquidity, an conclude that they are felt more through falling mean reversion (of volatility), erosion and less directionality of risk premium, and more efficient price discovery over multiple regime periods in time, as opposed to simply dampening FX volatility.

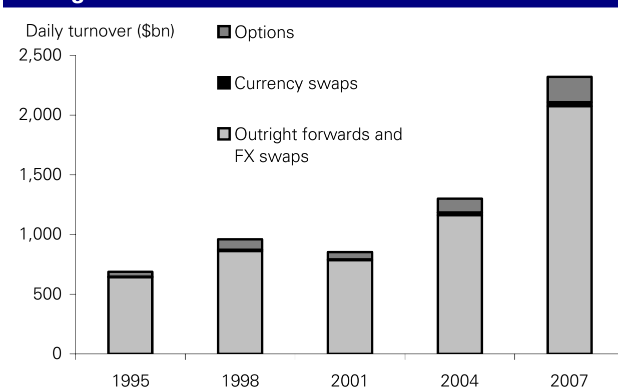
The drivers of volatility - it's not only about business cycles

It is widely argued that the volatility of financial asset prices is widely linked to business cycles in countercyclical form, and previous work by our colleagues has suggested this is also evident in foreign exchange[36]. Nevertheless, there has been growing evidence over the decade that liquidity also bears a growing role in defining the behavior of volatility. According to BIS data, the daily turnover in FX markets (spot and derivatives) has risen by an average of 40% every 3 years since 1995, with the growth in non-spot instruments marking a 69% over the past 3 years alone[37]. Such rise in turnover activity over the years has gradually brought along two key factors which we believe have had a growing role in defining the price action (and hence volatility) in the main currency pairs:

- *Greater dispersion of risk:* the growing liquidity in instruments used for risk-transferring purposes (such as financial derivatives) has provided investors (of a pre-defined risk profile) with the ability to execute transactions in line with their appetite without generating as much market impact. For instance, investors looking to neutralize their exposure to a particular currency may be able to do so (relatively quickly) without having to resort to the FX spot market. The transferal of risk is then done in a more gradual fashion throughout the growing number of market participants[38].

- *Improved price discovery capacity:* the proliferation of better pricing availability (through electronic brokering) and better pricing technology (through the presence of leveraged players) has brought along more continuous pricing and better assessment of risks, ultimately improving the price discovery process[39].

Figure 36: Foreign exchange derivatives turnover through time



Source: Bank for International Settlements, 2007.

Evidence #1 – the changing patterns of realized volatility

[36] See "When and what will turn vol around?", *Exchange Rate Perspectives*, November 2006.

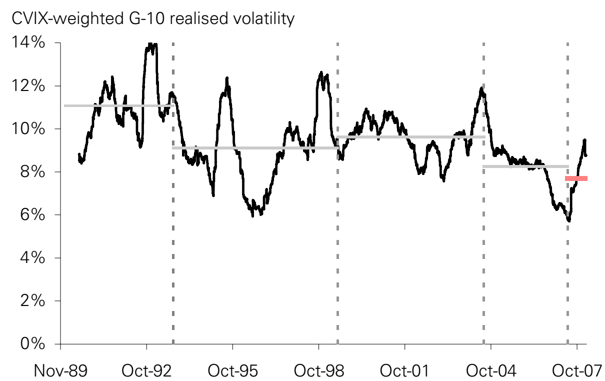
[37] *Triennial Central Bank Survey – Foreign exchange and derivatives market activity*, Bank for International Settlements, December 2007

[38] More an expanded discussion on risk dispersion and the impact on volatility, please refer to "The recent behaviour of financial market volatility", *BIS Papers*, August 2006.

[39] For a more detailed discussion, please refer to Kos, "Recent Volatility Trends in the Foreign Exchange Market", March 2006, and Hendershott et al, "Does Algorithmic Trading Improve Liquidity/", September 2007.

While these arguments can be verified anecdotally, assessing their impact on volatility over time is not very straight forward. It requires an analysis that removes factors driven purely by the business cycle, or in other words, results that show patterns not too dependent on the level of volatility alone. In other to address this issue, we have fitted GARCH processes to the regimes of historical volatility over the past 20 years in the 3 most liquid currency pairs - EUR/USD, USD,JPY, and GBP/USD. GARCH regressions aim to estimate and forecast realised volatility within a given regime through assessing its relationship to recent shocks (the alpha), to previous volatility readings (the beta), and to the speed with which volatility reverts to a given historical average (the memory)[40]. A key advantage of the GARCH technique is that it assesses patterns which are not necessarily dependent upon the level of volatility itself; if these patterns, expressed as GARCH parameters, are changing over time, there is good indication that business cycle-driven factors are not the sole drivers of FX volatility.

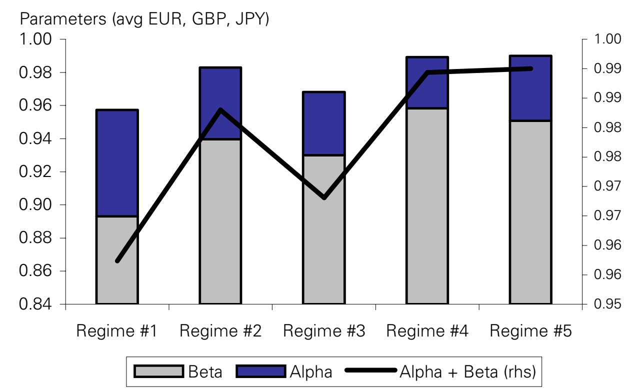
Figure 37: G-10 FX volatility regimes over time



Note: we use a 6-month rolling period. The CVIX weights are: EUR/USD 35.9%, USD/JPY 21.79%, GBP/USD 17.95%, USD/CAD 5.13%, EUR/CHF 1.28%, EUR/GBP 2.56%, EUR/JPY 3.85%, AUD/USD 6.41%, and USD/CHF 5.13%. Source: Deutsche Bank

Our analysis suggests that this is indeed the case; other market factors (liquidity driven, in our view) have been playing a growing role in defining the behaviour of FX volatility in the 3 currency pairs. As the chart shows, the parameters associated with the previous shock, and the most recent set of volatility readings, are growing increasingly integrated when looking at the 3 currency pairs as a whole. Higher integration can be interpreted as memory loss for the model, as the third parameter - the reversion component - is becoming less and less significant by model construction[41]. In other words, the multi-decade behaviour of the 3 main currency pairs suggests FX spot volatilities are becoming less "mean reverting" over time, irrespective of whether the currency pair is in a high or low volatility regime. In our view, this trend of integration and lack of mean reversion can be associated with growing market efficiency and a wider range of active participants - which lead to less predictability from standard modeling techniques over time.

Figure 38: GARCH parameters – progression over time



Source: Deutsche Bank

Figure 39: Fitting GARCH regimes in EUR/USD, USD/JPY and GBP/USD – results over time

Characteristics	Regime #1	Regime #2	Regime #3	Regime #4	Regime #5
Start Date	Mar-89	Nov-93	Jul-99	Aug-04	Jul-07
End Date	Oct-93	Jun-99	Jul-04	Jun-07	Feb-08
			EUR/USD		
Half-Life (memory - days)	13	46	50	693	27
Volatility Regime	Higher Vol	Lower Vol	Higher Vol	Lower Vol	Higher Vol
Best GARCH Fit	GARCH(1,1)	GARCH(1,1)	Threshold GARCH	I-GARCH	GARCH(1,1)
Alpha + Beta	0.947	0.985	0.986	0.999	0.988
			GBP/USD		
Half-Life (memory – days)	15	34	19	693	40

[40] GARCH regressions can take many forms. The concept was initially introduced in Bollerslev, "Generalised Autoregressive Conditional Heteroskedasticity", Journal of Econometrics, Vol. 31, 1986.

[41] According to a GARCH (1,1) fit, variance follows the equation: $\sigma_t^2 = \gamma\sigma_{LT}^2 + \alpha u_{t-1}^2 + \beta\sigma_{t-1}^2$, where γ is the weight assigned to long term variance (σ_{LT}^2), α is the weight assigned to the previous forecast error or "shock" (u_{t-1}^2), and β is the weight assigned to the previous variance reading σ_{t-1}^2. In order for the model forecasts not to become explosive, the constraint $\alpha + \beta + \gamma = 1$ is applied. This condition is largely followed in other, more complex types of GARCH regressions.

Volatility Regime	Higher Vol	Lower Vol	Higher Vol	Lower Vol	Lower Vol
Best GARCH Fit	GARCH(1,1)	GARCH(1,1)	GARCH(1,1)	I-GARCH	GARCH(1,1)
Alpha + Beta	0.955	0.980	0.965	0.999	0.983
USD/JPY					
Half-Life (memory – days)	23	43	14	23	693
Volatility Regime	Lower Vol	Higher Vol	Lower Vol	Lower Vol	Higher Vol
Best GARCH Fit	GARCH(1,1)	GARCH(1,1)	GARCH(1,1)	GARCH(1,1)	I-GARCH
Alpha + Beta	0.970	0.984	0.953	0.970	0.999

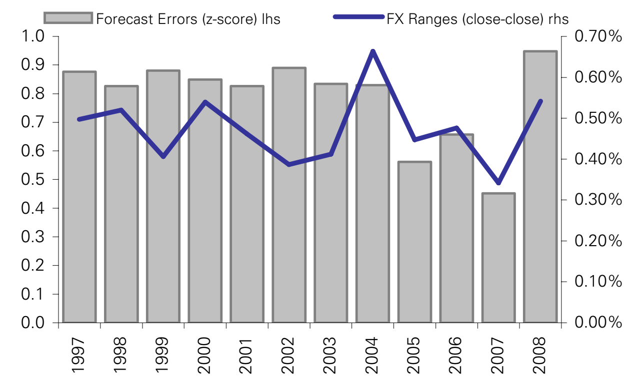
Note: I-GARCH stands for Integrated GARCH. I-GARCH and Threshold GARCH fits were modeled using first autoregressive order (1,1), as that gave the best fit results compared to other lags. We chose to use Half-Life as opposed to a regression coefficient for memory as the results are easier to interpret – the longer the expected reversion of volatility, the more integrated (less reverting) is the model. Source: Deutsche Bank

While the results show a multi-decade integration trend, there are differences in the progression between the 3 currency pairs. More notably, EUR/USD and GBP/USD volatilities have become *less* integrated since the middle of last year compared to the mid-04 to mid-07 period. In our view, this switch does not question the validity of the earlier findings[42]; it rather questions the behaviour of realised volatility over the mid-04 to mid-07 period. While the low volatility environment is largely explained by the behaviour of cyclical (business-cycle) factors and the global savings glut, we believe that some patterns – unusually low volatility levels and lack of mean reversion – can also be attributed to the lack of new information shocks to the market, or in other words, the lack of "new news".

External shocks to FX markets, such as hurricane Katrina and abrupt spikes in energy prices, occurred in abundance between mid-04 and mid-07, likely just as much as during previous volatility regimes. The key difference is that these external shocks did not translate into meaningful surprises in the behaviour of many US macroeconomic data - especially those variables seen as key cyclical drivers of FX volatility over time[43]. In other words, external shocks may have impacted macro-economic trends, but they did in a way that was quite well anticipated by economic analysts.

As the chart below presents, the amount of "new news" with regards to broad macroecomic variables has been relatively limited over that regime, as economic variables were trending and analysts were better at estimating the behaviour of key data. Better analyst predictive power allowed for the impact of data trends to be more smoothly translated into currency prices, hence helping take FX volatility to unusually low levels and making it (excessively) mean-*diverting*. Such trend is corroborated by how the recent spike in forecast errors - the rise in surprises - has been in line with the start of a new volatility regime in late 2007.

Figure 40: Analyst forecast errors (US economic data) and EUR, JPY and GBP daily FX ranges



Note: the z-score values were calculated using a long-term sample of absolute deviations. We use US activity, trade and price data in our analysis. Source: Deutsche Bank

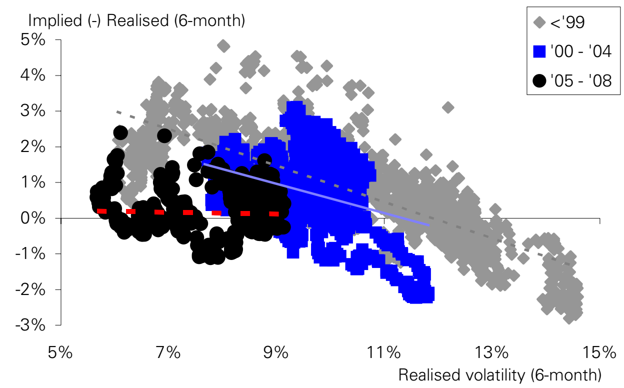
Evidence #2 – the changing nature of volatility risk premium and better reaction to "new news"

The argument of rising liquidity can also be evidenced by the changing behaviour of FX volatility risk premium over the years. As the chart below shows, the volatility risk premium in EUR/USD, USD/JPY and GBP/USD has progressively fallen over time, and more importantly, also became much less directional to the actual level of realized volatility. In our view, this is likely a function of the growth in the number of participants who extract risk premium across the asset class, with better pricing systems and forecasting frameworks, therefore less sensitive to the outright level of market volatility. As the chart below also shows, current risk premium levels are low compared to other periods of lower realized volatility.

[42] The trend from the early '90s would still be up even if one excludes regime 4 from the analysis; also, in the case of USD/JPY, the most recent sample shows even more integration than the previous. A better way of interpreting the relative *de-integration* is that volatilities in EUR/USD and GBP/USD may follow more similar clustering and reversion patterns now compared to "regime 4", though still less similar than seen in the '90s.

[43] Here we look specifically at activity, price and trade data. We will discuss these cyclical drivers in greater detail in future articles.

Figure 41: EUR, JPY and GBP volatility risk premium over time

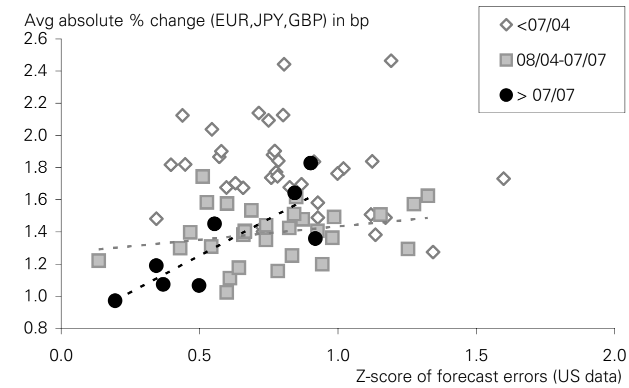


Note: we use data since 1990 in our analysis. We use an arithmetic average between USD/JPY, GBP/USD and EUR/USD (USD/DEM before 1999). Source: Deutsche Bank

Aside from falling risk premium, rising liquidity can also be evidenced through signs of better price discovery over time among investors in the marketplace. Our evidence is based on the price action of EUR/USD, GBP/USD and USD/JPY around the release of new data. The chart below shows the average variation of the 3 currency pairs within a 5-minute period after the release of key US economic data (displayed in terms of a scaled surprise, of "new news" factor) at different points in time.

As the chart shows, prior to mid-04 the 3 currency pairs tended to react much more strongly, and would not necessarily follow a direct relationship to the size of the surprise. The mid-04 to mid-07 period, however, was accompanied by a somewhat more coordinated reaction to the release of "new news", as the size of the shock in FX fell in magnitude (a more integrated market), and became more directional to the size of the analyst forecast error (better price discovery). Finally, the most recent volatility regime - from mid-07 onwards - has witnessed an even stronger "improvement" in how the 3 currency pairs react to new data releases, that is, much more directional to the size (and relevance) of the surprise being introduced to the market. In our view, this reiterates the argument that FX markets are becoming more integrated over time, and that price discovery has also improved, both brought by better market liquidity and depth.

Figure 42: FX ranges (5-minute period) and analyst forecast errors over time



Note: the z-scores of forecast errors were calculated using a long-term sample of absolute deviations. We use US activity, trade and price data in our analysis. Source: Deutsche Bank k

Conclusion

Micro-structure factors brought by the improvement in liquidity are also notable drivers of the performance of the 3 main currency markets. Their impact, however, is more likely felt by the falling mean reversion of volatility, the erosion and less directionality of risk premium, and more efficient price discovery over multi-regime periods, as opposed to dampening FX volatility.

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Profiting from the bias in forward volatility (07/12/07)

Exploring the forward volatility bias

The discussion of whether market-implied estimates of future asset prices are accurate reflections of future spot prices has been present is almost every asset class. The topic, formalised as the bias of forward rates, has also given birth to one of the most profitable strategies in global forward exchange over the past decade - the "carry" trade.

In this article, we extend the analysis of forward rate bias to foreign exchange implied volatility; the forward volatility bias. We first define forward volatility, then discuss its drivers and its ability to predict future "spot" implied volatility. Having defined that forward volatilities over-estimate future moves in spot volatility, we introduce a strategy that consistently sells and buys 3-month, 3-month forward FVAs in G-10 currency pairs depending on whether they are too high or low compared to current implied volatility. This strategy performs well during periods of risk aversion and is mostly uncorrelated to regimes of implied volatility, and we believe it will be a key performer during 2008. As of the last rebalancing date (early September), the strategy recommends being long 3-month, 3-month FVAs in USD/JPY, EUR/JPY and USD/CAD and short FVAs in GBP/USD, EUR/GBP, and EUR/USD.

Defining forward volatility, and the forward volatility agreement

Prior to addressing the bias of forward implied volatility, it is important to define it first. In global foreign exchange, forward-starting implied volatility is typically defined by forward volatility agreements (FVAs). In similar fashion to forward rate agreements in fixed income, FVAs provide the price of a financial contract (in this case, the implied volatility of an FX option straddle) which starts at a future date. The calculation of forward volatility can be proxied by a mathematical formula which assumes that the relationship between FX implied variance and time is linear, as shown below. By classifying $\sigma_{t0\rightarrow T1}$ and $\sigma_{t0\rightarrow T2}$ as (annualised) ATMF implied volatilities from intervals $t0$ to $T1$ and $T2$ ($T2 > T1$), and the year-fractions as $D_{t0\rightarrow T1}$ and $D_{t0\rightarrow T2}$, the implied forward volatility between the two dates ($\sigma_{t1\rightarrow t2}$) can be proxied as

$$\sigma_{t1\rightarrow t2} = \sqrt{\frac{\sigma^2_{t0\rightarrow T2}\times D_{t0\rightarrow T2} - \sigma^2_{t0\rightarrow T1}\times D_{t0\rightarrow T1}}{D_{T1\rightarrow T2}}}$$

While the formula above accurately captures forward volatility, the value of an FVA contract (the "strike") requires a few adjustments regarding the skew of the volatility surface and the volatility of volatility. This typically leads the FVA to trade at a different level to the forward volatility, especially in surfaces with more acute skew and higher volatility of implied volatility, and relates to the hedging of the FVA contract. In this article, we use standard forward volatility calculations (the formula above) for testing the bias of forward volatility, though we also adjust for FVA differentials (through assumptions on the rolling cost) in the section where we describe an FVA trading strategy.

The drivers of forward volatility

The tradable level of forward volatility, as defined by the formula described above, is mostly a function of the shape of the term premium of implied volatility. It will be higher than "spot" implied volatility in upward sloping curves, and lower in downward or inverted curves. Changes in the volatility curve – whether parallel or in the slope – therefore define the behaviour of FVAs. Another important consideration relates to the impact of non-parallel shifts in the curve compared to parallel shifts: while parallel bumps lead to an almost symmetrical bump in the forward volatility level, the impact of non-parallel shifts on forward volatility is quite different.

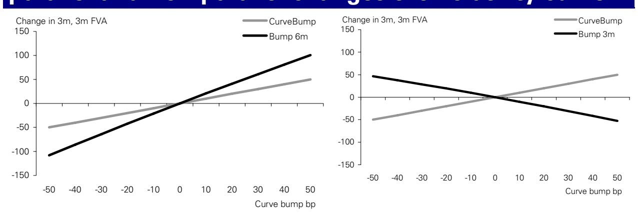
Take the example of a 3-month, 3-month FVA quoted at 7.92%, and derived from volatilities of 8.63% (3-month) and 8.28% (6-month)[44]. As the charts below show, a 10bp (parallel) upward bump in both 3-month and 6-moth tenors will lead to a rise of approximately 10bp in the FVA. However, a 10bp rise in the 6-month tenor compared to the 3-month tenor will lead to an approximate 20bp rise in the FVA. This is due to the fact that the 6-month point has roughly twice the weight of the 3-month point in defining

[44] For simplicity, we assume no required adjustment from skew and stochastic volatility.

changes in the FVA, as previously shown by the mathematical approximation formula.

A 10bp rise in the 3-month implied volatility compared to the 6-month tenor, however, will lead to a fall in the forward volatility by the equivalent 10bp; as per formula, the smaller magnitude of change is due to the smaller weight of the 3-month, and the direction is due to the impact on the 3m-6m spread. As the charts show, the impact on forward volatility is symmetric for both upward and downward moves in the 3-month and 6-month tenors. In other words, if long dated volatility is anchored, forward volatility moves in the opposite direction to that of short term "spot" volatility.

Figure 43: Changes in forward vol as a function of parallel and non-parallel changes the volatility curve



Source: Deutsche Bank

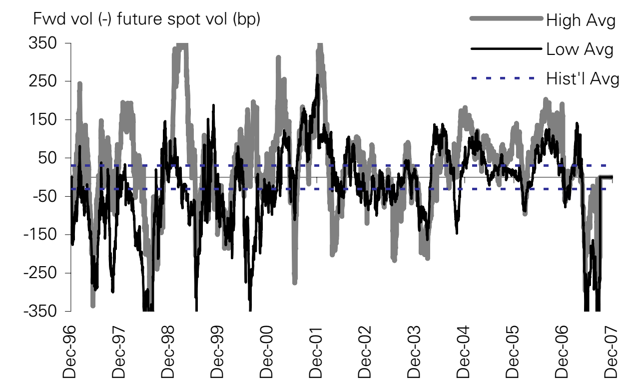
This is quite important in the context of what actually drives the term premium of FX implied volatility. In our view, this term premium is driven chiefly by market expectations of reversion to some future level of volatility; the dominance of speculative flows relative to other flow types[45] prompts the anchoring of longer dated tenors (i.e. 1-year) at the level where participants see the long-term average of short-dated volatility to be. Shorter dated tenors, however, are more strongly influenced by the volatility of spot FX as it defines the attractiveness of trading option "gamma" – which is much higher in shorter tenors. Forward volatilities, therefore, are a proxy[46] for the required level of future short-term implied volatility such that the long-term average predicted by the market turns out to be correct.

Onto the key question: is forward volatility a good predictor of future volatility?

Given that longer dated volatilities tend to be anchored, the key question is then how good is the market at predicting the behaviour of short-term implied volatility in the future; in other words, is forward volatility biased?

An initial analysis of curve behaviour suggests that there is an over-estimation bias. There is a consistent spread between 3-month, 3-month forward implied volatilities and empirical, matched-maturity (3-month) implied volatilities over time in the main G-10 currency pairs. Over the past 10 years, 3-month forward volatilities have over-estimated spot implied volatilities (of matched maturity) by an average of 30bp, the same amount by which forward volatilities in the flattest (or most inverted) forward curves have under-estimated future "spot" volatilities.

Figure 44: FVAs vs matched-maturity implied volatilities over time



Source: Deutsche Bank

A more robust test[47] of estimator bias confirms what the spread differential suggests. As shown in the chart below, the spread between forward volatilities and "spot" volatilities generally *over-states* the future moves (higher or lower) in the latter for G-10 currency pairs as the coefficients are significantly below 1. According to the data, this is despite the fact that, on average, the forward volatility spread [48] is the most (statistically) significant

[45] For instance, relative to hedging flows by investors who are naturally long or short the asset class. Structural forces play an important role on longer dated volatility tenors, especially in the JPY crosses (see FX Derivatives Focus, September 20th 2007), but are much less relevant in tenors up to 1-year.

[46] We say "proxy" given that this is not, strictly speaking, an arbitrage condition as for FRAs in fixed income (hence the adjustment described earlier in this article).

[47] Formally, we define the regression as

$$\sigma_{3m,6m}|_{3m} - \sigma_{0m,3m}|_{0m} = \alpha + \beta_{FVA}\left(\sigma_{FVA3m,6m}|_{0m} - \sigma_{0m,3m}|_{0m}\right) + \\ + \beta_{VIX}\left(VIX|_{3m} - VIX|_{0m}\right) + \beta_{Spot}\left(\Delta S_{0m,3m}|_{3m}\right) + \varepsilon$$

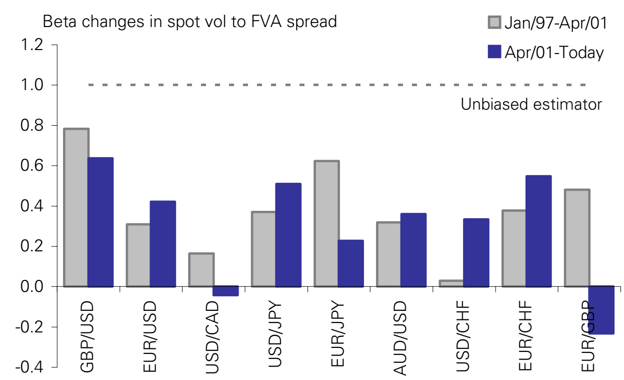
where the dependent variable is the spread between the 3-month "spot" implied volatility measured in 3-months time and the spot implied volatility measured now, and the explanatory variables are a combination of FVA-"spot" implied volatility spread, changes in the VIX, CVIX, and FX spot. It is argued that the "true" test of estimation bias has the forward volatility spread as the sole explanatory variable in regressing for changes in implied volatility (i.e. a simple regression). We have tried that approach and reached similar beta coefficients, though the residuals were not normally distributed over time. Our choice to include the VIX and changes in FX spot is based on trying to extract further information on the drivers of changes in implied volatility in addition to the FVA spread.

[48] We define the forward volatility spread as the difference between the 3-month, 3-month forward implied volatility minus the 3-month "spot" implied volatility.

estimator of future moves in implied volatility when compared to either the behaviour of FX spot or the VIX[49].

As shown in the chart below, the extent to which the forward volatility spread overstates future moves in "spot" implied volatility is most acute in some of the higher yielding currency pairs, such as the EUR/JPY and AUD/USD. The data also suggests that the forward volatility spread has shown no predictive power in forecasting future "spot" volatility moves in USD/CAD and EUR/GBP during the most recent volatility cycle, currency pairs where the changes in spot FX (and secondly, the VIX) have played a stronger role in defining future changes in implied volatility.

Figure 45: beta of changes in "spot" implied volatility to changes in the spread between FVAs and spot implied volatility



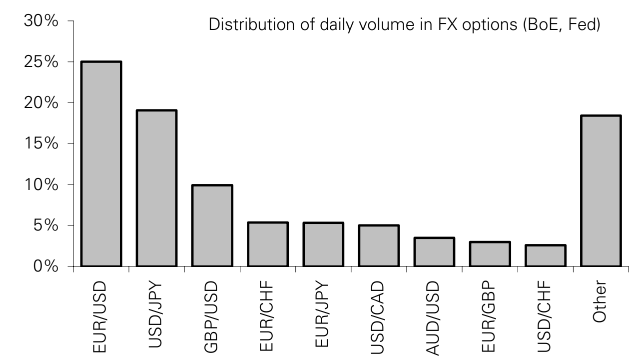
Note: we separate the results into 2 different volatility cycles – upward ('97 – '01) and downward ('01 – '07). We gather comparable betas when using a simple regression of changes in volatility against the FVA spread – see footnote on page 3 for further details. Source: Deutsche Bank

Profiting from the forward volatility bias – buying and selling FVAs according to the FVA spread

By defining that forward volatilities are a biased predictor of future implied volatility, we establish that "spot" volatility does not converge to the forecast level quickly enough. This implies that a strategy that consistently sells (or buys) FVAs when too high (or low) against implied volatility (the FVA spread) can generate consistent excess returns over time.

We introduce a strategy which does exactly that: it sells FVAs in the 3 steepest volatility curves, and buys FVAs in the 3 flattest (or most inverted) curves. The selection process scans through FVAs in the 9 currency pairs whose options markets are the most liquid, as shown below[50]. The choice of FVAs to buy or sell is based solely on the spread between forward and spot implied volatilities; it sells the highest and buys the lowest, in order to capture the "roll" through the volatility curve. Simply put, the strategy exploits the *carry* of implied volatility. The FVA tenors used are 3-months, 3-months forward, rebalanced every 3 months one week before the IMM date. This choice is based on simplicity, liquidity and better risk-adjusted returns over time[51]. Finally, we chose using two sub-strategies (buying and selling FVAs) as opposed to a single one in order to reduce the correlation between the different components of each FVA sub-strategy, hence providing a more diversified parent strategy.

Figure 46: Distribution of daily volumes in FX options



Note: we use the Apr-07 semi-annual surveys. "Other" relates to currency pairs that were not specified, or whose volume was below that of USD/CHF. Source: FBNY, Bank of England

Figure 47: FVA Strategy – comparison of returns

	1m FVA 1m forward start	**3m FVA 3m forward start**	6m FVA 6m forward start
Annualised Return	-0.34%	**2.02%**	1.49%
Annualised Volatility	4.25%	**2.34%**	1.77%
Sharpe Ratio	-0.1	**0.9**	0.8
Maximum Drawdown	-15.86%	**-2.97%**	-2.63%
Return / Max D-D	6.1	**41.9**	44.7

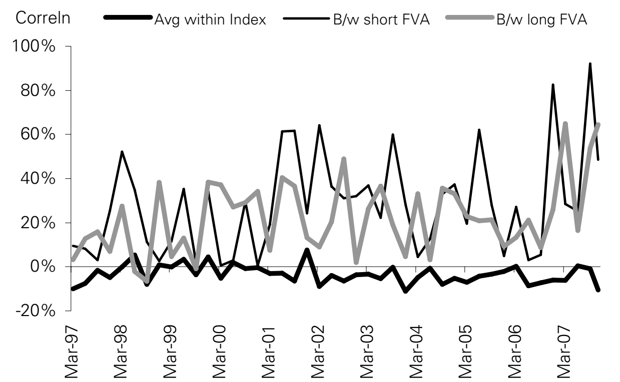
Note: we assume a quarterly running cost of 50bp for the strategy. Source: Deutsche Bank, BBA

[49] Note that the constant term α, which indicates an average level of stochastic volatility that the market is unable to predict, is also robust in most currency pairs.

[50] Our criteria for liquidity was based on the semi-annual surveys of derivatives market activity in the UK and North America provided by the Bank of England and the Federal Reserve Bank of New York. These two surveys encompass a greater variety of currency pairs compared to the triennial BIS Survey, in addition to being more frequent and having held a stable ranking over the past 10 years. According to the latest BIS data, approximately 70% of the trading turnover in FX options goes through these two financial centres.

[51] A detailed back-test of the strategy using different tenors shows that shorter contracts show an excessively high volatility and heavier drawdowns, while longer contracts do not capture as much "roll" through the volatility curve.

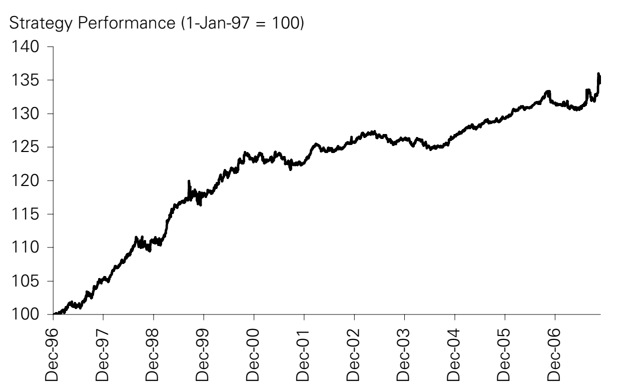
Figure 48: Correlation between the components of each FVA sub-strategy and the overall parent strategy



Source: Deutsche Bank

The strategy yields strong returns in both absolute and risk adjusted terms. The annualised returns in this "carry of volatility" strategy were 2.8%[52] since inception at the start of 1997; with a Sharpe ratio of 1.2 and total return / max-drawdown ratio of 45x. Since the strategy is self-financing, these returns can be achieved without expending any cash; therefore, a notional amount of capital can be put on deposit while simultaneously investing in the forward volatility bias.

Figure 49: Returns of the forward volatility bias strategy

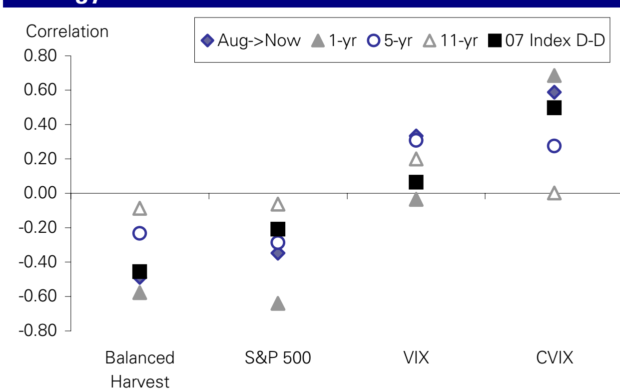


Note: we assume a 50bp of quarterly running costs. Source: Deutsche Bank, BBA.

Another interesting fact of this strategy is that is performs strongly during periods of risk aversion and general spikes in volatility. In our view, this is due to the fact that being long FVAs in curves that are either flat or inverted generally outperforms being short FVAs in curves that are steep at times of aggressive corrections in market risk appetite. While the inverted curves tend to invert even further, such is not sufficient to overcome the rise in longer dated volatilities; implied volatilities in inverted curves tend to be more volatile than those of positively-shaped curves.

The correlation chart below explains those arguments in better detail. Draw-downs in excess of 5% in the S&P 500, the DB G-10 Currency Harvest and the DB FX Balanced Harvest indices have been matched with a positive performance in the FVA strategy in 89%, 88% and 50% of the instances, respectively. Spikes in the VIX and CVIX have also been associated with positive performance in the strategy, as shown. Over longer periods, however, the FVA strategy is largely independent of the indices used, with correlation coefficients that are under 20% (in absolute terms). **This is particularly important when relative to the CVIX, as it demonstrates that the FVA strategy is independent of the trends in volatility over a longer horizon.**

Figure 50: Correlation of returns between the FVA strategy and different indices



Note: we use daily correlations for 07 Index drawdowns, 2-day correlations for the Aug->Now sample, weekly correlations for the 1-year sample, and monthly correlations for the 5-year and 11-year history.
Source: Deutsche Bank

Strategy draw-downs

By definition, draw-downs occur when future implied volatility moves in the contrary direction to that of the FVA sub-strategies and by a magnitude that is greater than what had been initially priced (in other words, by more than the "buffer"). Over the past 11 years, there have been 3 draw-downs in excess of 2%[53], which have typically occurred when volatility slopes are steepening due to a fall in short dated tenors, or (less frequently) due to longer dated tenors moving slightly higher and hence leading the "short FVA" sub-strategy to underperform. This is normally associated with the final stages of a rally

[52] We assume 50bp of rolling costs every quarter, equivalent to a bid-ask spread of 100bp. The positions are held to maturity, and hence there is no need for the full bid-ask spread to be charged.

[53] These are, namely, from Sep-99 to Dec-99 (3%), Nov-06 to Jun-07 (2.1%), and Jun-01 to Sep-01 (2.1%). The "short FVA" portion of the strategy was a key underperformer in the 2nd and 3rd instances, while the "long FVA" strategy drove the underperformance in the first instance.

in G-10 FX carry as the currencies become more range-bound or appreciate mildly but volatility curves steepen. It also generally precedes a larger move in FX volatility, when the "long FVA" sub-strategy outperforms substantially and well past the previous peak in returns.

Conclusion

We believe that forward implied volatility is a biased estimator of future implied volatility in G-10 FX markets. This bias has been present during different volatility regimes and results from the discrepancy between investors' expectations of future volatility and the average amount of time that it takes for the move to occur. In our view, a strategy that consistently buys (sells) FVAs where the FVA spread is highest (lowest) compared to "spot" implied volatility can capture consistent excess returns over time, in addition to being independent of volatility regimes and performing well as a hedge during periods of risk aversion. As of the last rebalancing date (early September), the strategy recommends being long 3-month, 3-month FVAs in USD/JPY, EUR/JPY and USD/CAD and short FVAs in GBP/USD, EUR/GBP, and EUR/USD.

Are Holidays Worth It? (15/11/07)

FX Derivatives: Are Holidays Worth It?

Another holiday season is coming up, which raises two key questions for volatility traders: how much is empirical volatility expected to fall due to reduced trading activity, and how accurate is the market at estimating this (potentially) calmer period. In this article, we address both of these questions by verifying how volatile the three most liquid currency pairs (EUR/USD, GBP/USD and USD/JPY) have been during holiday periods compared to the market price of volatility for those specific dates (through overnight straddle[54] prices) over the past 10 years. We conclude that there has been a consistent "risk premium" attached to overnight "holiday" options over time, concentrated around a few specific holiday dates and periods, with trading implications for all three of the currency pairs analysed.

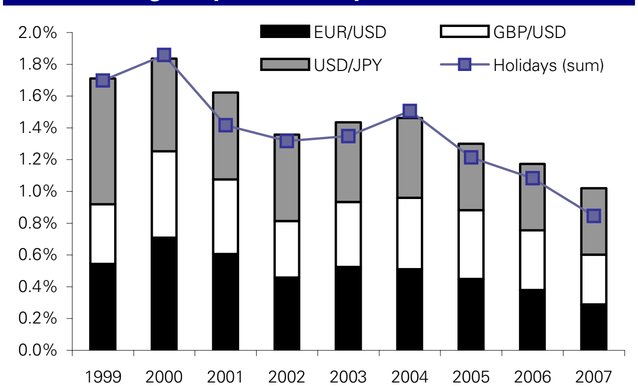
Overnight options and volatility risk premium

First, we briefly address the behaviour of overnight options (and volatility risk premium[55]) over the year as a whole. It is generally believed that overnight implied volatility trades at a consistent premium to realised 0volatility. History shows that this is indeed the case - the spread between overnight straddle prices and daily FX moves has been at a consistent 8bp over time (3bp most recently) for the three most liquid currency pairs in global FX: EUR/USD, G**B**P/USD and USD/JPY. The rationale, in our view, relates to market participants attaching a particular premium for being insured against any sort of uncertainty that may affect prices overnight – either in the form of position adjustment or simply "gap risk" - the risk that prices react aggressively to new information with very slim trading in between. As a trader calls it, the consistent risk premium reflects the price of "sleeping at night", which, albeit expensive in implied volatility terms, is cheap from a price perspective (the current price of an overnight straddle in EUR/USD in roughly 55bp, 30% that of a 1-month straddle). The persistence of this positive risk premium in overnight options - particularly earlier in this decade - has prompted the development of several trading programmes that exploit this historical discrepancy through being consistently short overnight straddles and based on the argument that the occasional drawdowns are not enough to overcome the consistently positive returns of the strategy.

While the behaviour of volatility risk premium in overnight options throughout is a topic that deserves attention on its own, this article focuses on a small subset of that - the analysis of "holiday insurance", or the price of protecting against currency moves (or "gap risk") specifically during holiday dates. In order not to bias the analysis using dates where gap risk is artificially minimised, we only included a set of 6 holidays where the main criteria was that only one of the two main global FX trading centres - New York and London was closed[56].

An important observation in the data has been that the price of "holiday insurance" has been on the same declining trend as the average price of standard overnight insurance - it has literally halved over the past 10 years, and currently cost approximately 60%[57] of the average overnight options in the currency pairs analysed. While the trend of declining overnight straddle prices can be attributed to a multi-year trend for volatility, the relative cheapness of holiday options is intuitively explained by the expectation that trading ranges will be narrow over the course of the holiday date, as a combination of lower liquidity and lack of new information.

Figure 51: Median cost of overnight straddles over time – average day and holiday dates



Note: For holidays, we sum the median prices of the 3 currency pairs in order to make the final numbers comparable to the height of the columns. Source: Deutsche Bank

But while the pricing of holiday straddles compared to the rest of the year shows some revealing results, the most

[54] An FX straddle combines a call and a put of the same tenor and strike; in this case, the ATMF strike for options expiring the following business day.

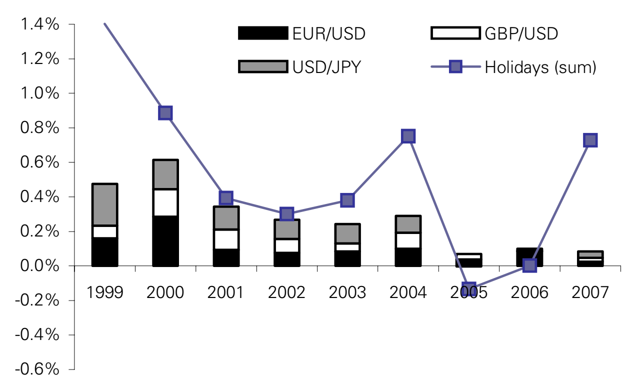
[55] Volatility risk premium relates to the spread between implied and realized volatility for a given period. In this study, we proxy this measure by analyzing the spread between straddle prices and currency ranges.

[56] This criteria excluded, for instance Good Friday and Christmas Day, which are holiday dates in both the US and UK.

[57] 60% is the average cost for 2007; over a longer sample period the average cost is about 71% of that of overnight straddles for normal working days.

important finding from the data relates to the discrepancy between straddle prices and actual trading ranges over the respective holiday dates. History suggests that overnight implied volatilities have consistently over-estimated the realised currency ranges over the years, with the exception of 2005 and 2006, and that this modified version of volatility risk premium has not followed the same downtrend as seen in straddle prices. The difference between straddle prices and the close-to-close price ranges[58] in the three currency pairs analysed was on average 50% above that of the equivalent during normal business days, even including the two years when holiday straddles seemed to under-estimate actual volatility during holiday dates. This excess "premium", in our view, most likely relates to the fact that gap risk, while reduced, is not completely minimised during holidays - especially when one of the two major trading centres is still open.

Figure 52: Median spread between straddle prices and close-close FX ranges – average day and holiday dates

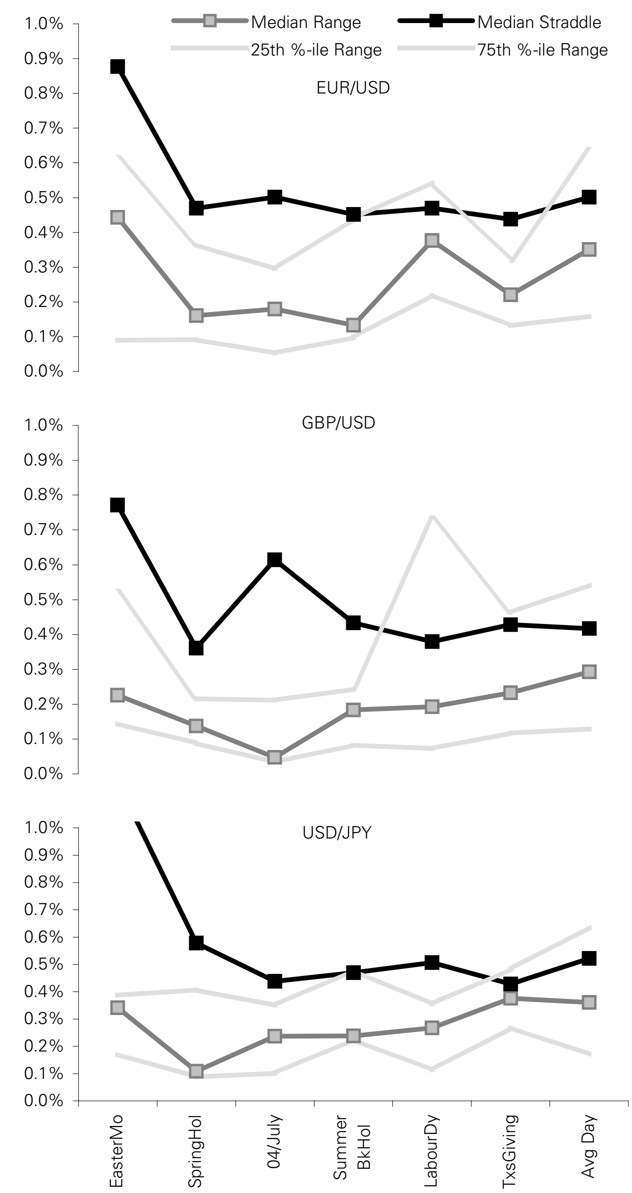


Note: For holidays, we sum the median price vs currency range spread of the 3 currency pairs in order to make the final numbers comparable to the height of the columns. Source: Deutsche Bank

Easter Monday – the best holiday option to sell

Having defined that there seems to be a more consistent "holiday premium" over time, we move on to identify which particular dates tend to drive it. The charts below show the price behaviour for the three currency pairs analysed, lined up in chronological order. Easter Monday, the first qualifying holiday in our analysis[59], sees the highest (median) insurance costs of all; it is even higher than the cost of overnight straddles during non-holiday dates. This extra cost is normally well in excess of the empirical spot ranges, even though these ranges are also the highest among all holiday dates analysed over the year. The data also suggests that one can capitalise from this excess risk premium over time - selling short-dated straddles that expire on Easter Monday have generated a profit hit ratio of 100% in USD/JPY over the past 10 years, with other encouraging results also found for the other currency pairs.

Figure 53: Close-close FX ranges and straddle prices in G-3 FX during holidays and average day



Note: we use 10 years worth of data (9-10 observations per holiday). The straddle prices are lagged to match the empirical range data. Source: Deutsche Bank

The behaviour of overnight volatility risk premium over the subsequent holidays - Spring bank holiday (UK), August bank holiday (UK), Labour Day (US), and Thanksgiving (US) all witness somewhat similar characteristics. That is, the

[58] By close-to-close ranges, we refer to the absolute percentage change between one day and the other (S[t-1] / S[t] - 1). In order to match the convention for implied volatilities, we used the FBNY fixing levels (10.00hs EST) or WM fixings when the former was unavailable. Straddle prices are calculated using mid-levels, but success hit ratios take into account the bid-ask spread (200bp in EUR/USD and GBP/USD, 250bp in USD/JPY).

[59] We decided to exclude the UK's January bank holiday from our analysis as there were only 3 instances over the past 10 years where this UK holiday date was a normal business day in New York.

fall in the close-to-close FX spot ranges is more acute than that of the fall in implied volatility, hence leading to a continuation of the overnight bias in all the three currency pairs analysed (albeit smaller for EUR/USD). According to the data, selling overnight straddles during holiday days would have yielded a success ratio of approximately 67% in EUR/USD, GBP/USD and USD/JPY.

Figure 54: Success ratio: short overnight straddles

	EUR/USD	GBP/USD	USD/JPY
July 4th	86%	86%	71%
Thanksgiving	63%	63%	50%
Easter Monday	78%	67%	100%
August Bank	67%	78%	56%
Labour Day	56%	67%	67%
Spring Holiday	67%	100%	67%
Average Day	61%	59%	60%

Note: we assume a 200bp bid-ask spread in EUR/USD and GBP/USD, and 250bp for USD/JPY. Source: Deutsche Bank

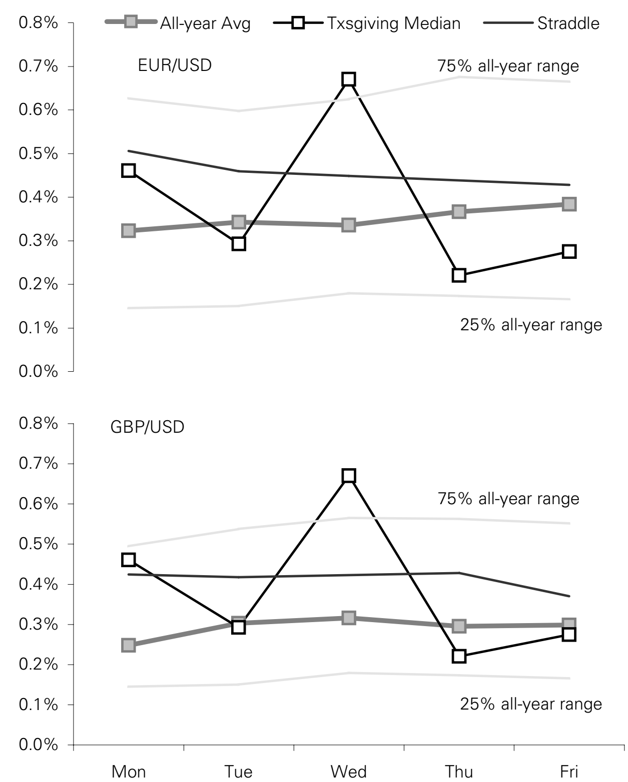
Intra-week analysis – Thanksgiving week

While our analysis of holiday dates showed the evidence of a persistent risk premium, the anecdotal evidence suggests it is also worth analysing the price action at days around a particular holiday in order to better assess how influenced they become to the actual holiday date. In this particular study, we concentrated on the price action during the five days of Thanksgiving week.

The charts show a clear pattern for EUR/USD and GBP/USD: the price action on Monday and Tuesday is similar to that of the average over the rest of the year, while the magnitude of close-to-close FX ranges rises considerably on Wednesday - enough to reach the 75th percentile of all Wednesdays throughout the year. Thursday sees a considerable fall in realised volatility as the holiday comes in, though volatility rises again on Friday despite the drop in activity compared to earlier in the week.

This pattern also seems to generate opportunities - being long one-day straddles on Wednesday has provided a success hit ratio of 63% in EUR/USD and 75% in GBP/USD over the past 10 years, which compares favourably with the 58% and 62% historical averages over average Wednesdays. The results are weaker in the case of the JPY crosses, which we attribute to the influence of trading during Tokyo hours.

Figure 55: Close-close FX ranges and straddle prices in during Thanksgiving week and average day



Note: we use 10 years worth of data (9-10 observations per holiday). The straddle prices are lagged to match the empirical range data. Source: Deutsche Bank

Intra-month analysis – the month of December

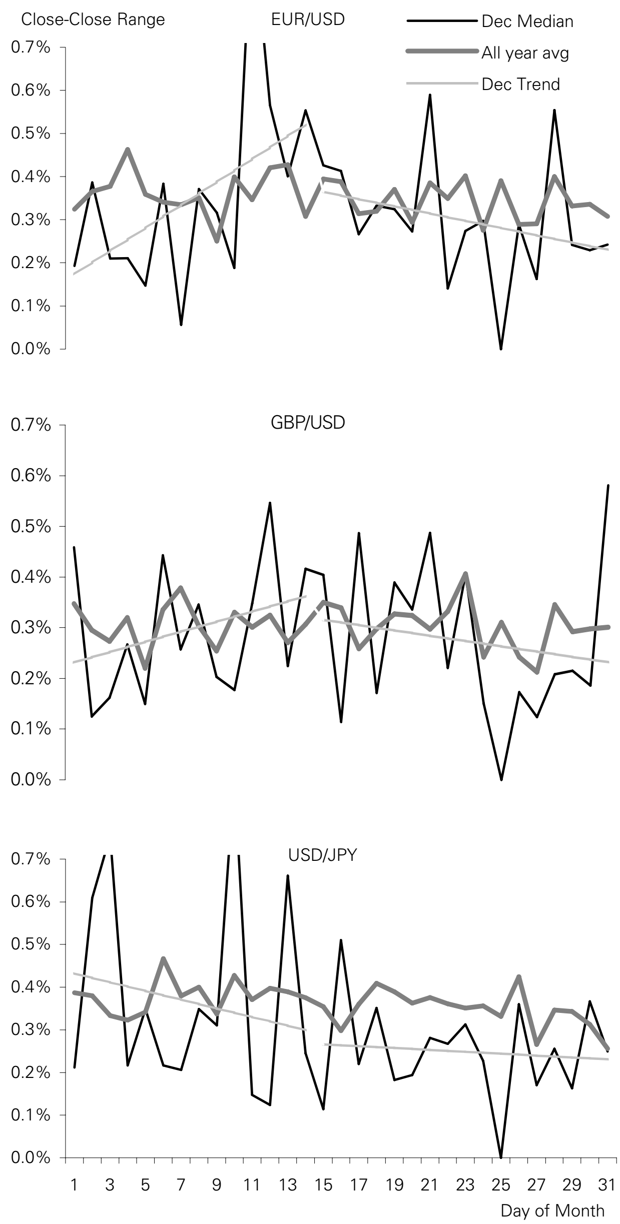
Having assessed the intra-week price behaviour around holidays, the next question relates to the intra-month performance of volatility risk premium when the whole month may be affected by a particular holiday. In our view, December is the month which most notably fits the criteria as the Christmas and year-end celebrations tend to affect price action considerably.

According to the data, the close-to-close FX ranges seem to exhibit a particular intra-month pattern in December in EUR/USD and GBP/USD, where their magnitude rises over the first half of the month, followed by a considerable fall over the second half as the year-end festivities approach. In our view, the rationale for this dynamic is intuitively simple: participants are less inclined to trade during the second half of December as trading books get closed for the year and little new information is normally introduced to the market[60]. The dynamic also holds for USD/JPY, though the tighter price ranges in the second portion of the month can also be verified during

[60] The data also suggests that there is a slight pick-up in realised volatility at the very end of the month, which we attribute to the final squaring of positions prior to the end of the year.

other months of the year - which we attribute to factors such as the seasonality of data releases and of capital flows. In fact, the data suggests that the close-to-close FX ranges in USD/JPY in most days of December are on average smaller than other days in the year.

Figure 56: Close-close FX ranges in G-3 FX during December and average day



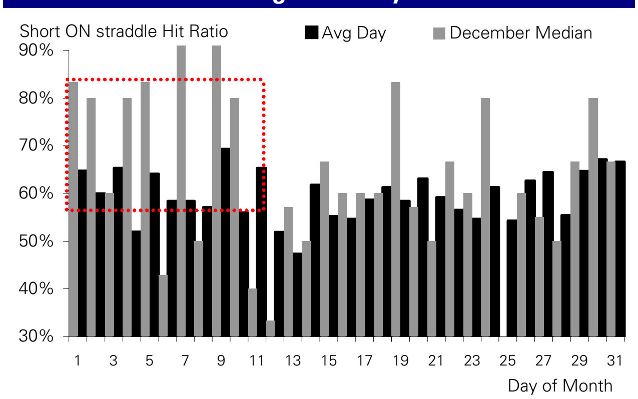
Note: we use 10 years worth of data (9-10 observations). The straddle prices are lagged to match the empirical range data. Source: Deutsche Bank

The way that this intra-month pattern is reflected in market prices differs between currency pairs. In the case of EUR/USD, as the chart below shows, the volatility risk premium tends to be higher during the first half of the month though it falls over the second half (especially the third week) as implied volatility levels fall considerably and converge back to the average over the rest of the year. in other words, even though the close-to-close FX ranges can be as high as during other months, implied volatility rises even further. In the case of GBP/USD and USD/JPY, however, the pattern is not as clear and divergences occur throughout different days of the month though as the chart above shows, USD/JPY implied volatilities also consistently over-estimate the realized ranges over the second half of December.

Conclusion

Market participants have consistently over-priced the potential for intra-day moves in FX during holidays over the past 10 years, even though implied volatility levels have been on a multi-year downward trend. The data suggests this over-pricing is most evident on Easter Monday, but it also persists during other holidays over the course of the year. The data also suggests it is generally worth being long volatility in EUR/USD and GBP/USD during the Wednesday prior to Thanksgiving, and switching to a short volatility during the subsequent Thursday. In our view, it is also worth considering being short volatility during the first half of December through overnight straddles in EUR/USD, and short straddles in USD/JPY over the second half of December, given how straddle prices tend to over-estimate the potential for intra-day moves.

Figure 57: Success ratio for selling overnight straddles in December and throughout the year – EUR/USD



Note: we use 10 years worth of data (9 observations). We assume 200bp of bid-ask spread (implied volatility) in getting the price for the overnight straddles. Source: Deutsche Bank

The Relationship Between Carry and Volatility in EMFX (29/10/07)

Understanding the relationship between volatility and carry

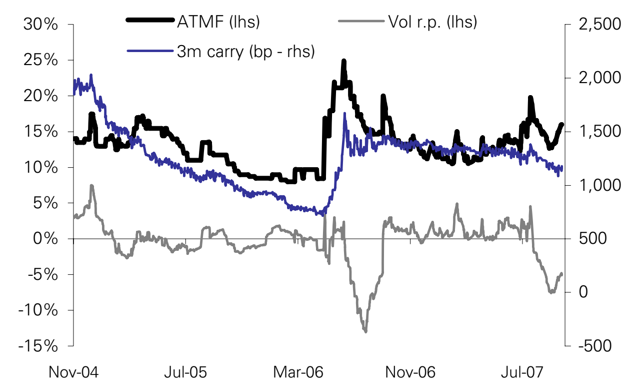
Introduction: the intuitive argument for how carry and volatility relate in EM and G-10

Among the many terms used in defining risk premium, the widely used convention is that it compensates investors, above a risk-free rate of return, for incurring additional risk. Foreign exchange markets relate that measure, in its simplest form, to the market price of future volatility for a currency pair (either on its own or relative to empirical volatility) and the difference between the investment rate and the funding interest rate in the same currency pair[61].

Intuitively, carry and implied volatility seem to relate differently depending on the level of interest rate differentials: a positive correlation for (very) high yielding currencies while negative for low and medium yielding currencies. In the first case, we believe that one of the explanations for the positive (and strong) correlation between carry and volatility relates to the historical relevance of foreign investors in defining the level of risk premium for local assets[62] in countries with high levels of interest rates, and also to the greater volatility in economic indicators and in the credibility of domestic policy makers in those markets. If there is general uncertainty in a particular country, investors normally require greater carry in order to take on (long) currency exposure, and the cost of insurance (implied volatility or risk reversals) will also be high. In other words, the correlation between carry and implied volatility tends to be positive and strong in higher yielding currencies as they relate to countries where the sustainability of their external balances is more of an issue.

An example of that dynamic can be seen in Turkey, as shown in the following chart. High carry prompts strong capital inflows, which then improve the perception of sustainability in the country's external balances and allow for currency appreciation and a fall in implied volatility (and risk-reversal levels). This improved perception of risk, coupled with an appreciating currency, allows for monetary policy to be more expansionary. The whole process is typically reversed during market sell-offs, as shown in the chart, and the magnitude of the reversal is defined by the size of the unwind in investors' positions.

Figure 58: Implied volatility and carry in high yielding EMFX – the case of Turkey



Note: we use 3-month ATMF implied volatility. Carry is defined as the 3-month interest rate differential between TRY FX implied yields and USD borrowing rates. Vol risk premium is the difference between 3-month implied and realized volatility at a given time (not lagged). Source: Deutsche Bank

On the other hand, countries with fewer external sustainability issues will tend to witness a negative correlation between interest rate differentials and implied volatility. This dynamic is typically seen in G-10 countries and, most recently, in many emerging countries as well[63]. Countries with better external balance dynamics are generally capable of containing the level of real interest rates without sparking major investor concerns, and hence any pricing of tighter monetary policy tends to be viewed as positive for the currency as it signifies better returns on domestic deposits and encourages portfolio inflows. This in turn reduces the risk premium associated with owning that particular currency - and hence implied volatility falls. As a result, domestic interest rates and implied volatility are negatively correlated in general.

The intuitive argument seems rather straight-forward, but it tends to be more complex in practice. Currencies are analyzed in the form of currency pairs, and hence the risk premium measures related to that currency pair reflect

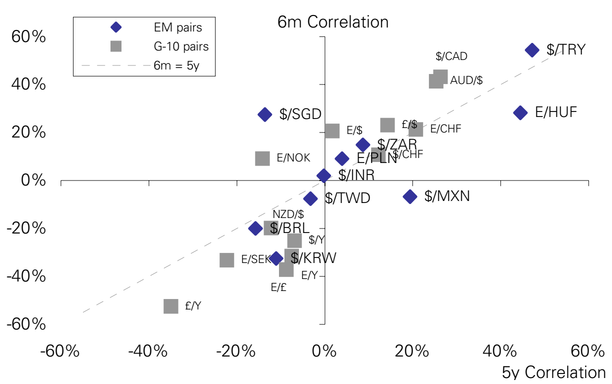
[61] These relate to the simplest measures of risk premium in FX and interest rate markets; a series of more specific measures are also widely used especially by fixed income investors - such as curve premium and inflation risk premium.

[62] We also include domestic interest rates (and hence carry) in this measure as the FX pass-through into consumer price inflation is usually high in emerging markets, thus leading to a greater dependency of monetary policy to the exchange rate.

[63] In fact, only TRY implied volatility currently bears positive correlation to interest rate carry during the most recent observations; the correlations have turned negative even in the case of ZAR, currently second highest yielding currency in (liquid) global FX.

investors' views on both currencies (as opposed to a single one). This has a particular impact in G-10 currency markets; for instance, in AUD/USD the correlation between implied volatility and carry is positive as it reflects investors' expectations regarding the Australian dollar (as opposed to the USD); in EUR/SEK, on the other hand, it is negative as it is biased to reflect investors' view on the Swedish krona (as opposed to the Euro). In currency pairs such as EUR/USD, the correlation between implied volatility (and risk reversals) and carry tends to change over time depending upon whether investors are focusing their attention on the base (EUR) or the terms (USD) currency. Finally, there are other currency pairs where the carry-to-vol relationship may be influenced by factors other than the perception of idiosyncratic risk, as seen in USD/SGD (where the relationship is influenced by local monetary policy) and the JPY crosses (which tend to reflect investors' views on global FX carry).

Figure 59: Correlation of changes between implied volatility and FX carry – short and long sample

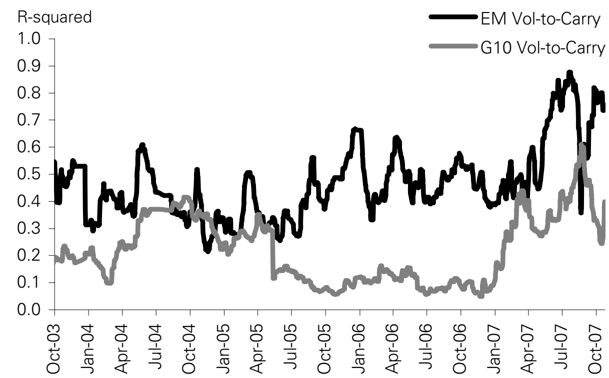


Note: we use weekly changes for the 6-month sample and monthly changes for the 5-year sample. Source: Deutsche Bank

But while it may be difficult to model the relationship between implied volatility (and risk reversals) and FX carry for a given currency pair as they change over time, analyzing their behavior at an aggregate level is more straight-forward as it can be verified on a cross-country basis.

The following chart illustrates the argument in more detail. There we show the proportion of the level in implied volatility that can be explained by the level of interest rate differentials at a given point in time for EMFX and G-10 FX. The data shows that this year has seen a strong rise in synchrony between interest rate differentials (carry) and implied volatility levels, in both EMFX and G-10 FX. A similar pattern is also found for risk reversals (another measure of risk premium in FX) and carry, in both developed and emerging currency pairs. The data also suggests, however, that the relationship has been more robust in EMFX than in G-10 FX over time, as the role of foreign investors in defining the level of carry and volatility risk premium has been stronger in EM than in G-10. If we exclude the two consistent outliers (USD/ZAR and USD/INR), the long-term median R-squared from the cross-currency regression almost doubles from 45% to 80%[64].

Figure 60: R-squared of implied volatility to FX carry in EMFX and G-10 FX – cross-sectional sample



Note: we use a 5-day moving average. The regressions are cross-sectional in that we regress 3-month implied volatilities in 13 and 11 currency pairs in G-10 and EM against their respective FX carry at a given point in time. Source: Deutsche Bank

The analytical framework: assessing robustness through simple trading strategies in EMFX

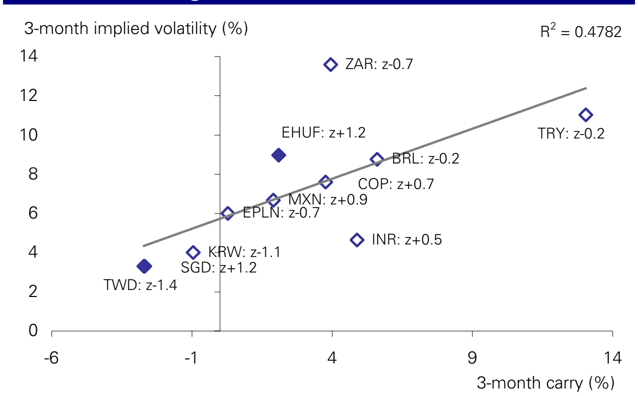
Having verified that FX carry and implied volatilities have had a stronger relationship in EM (compared to G-10) over time, we decided to concentrate our strategy specifically to EMFX. Our choice of currencies was based on liquidity and the availability of historical data, concentrated on the currency pairs mentioned in the following chart.

In order to further test how robust the relationship between EMFX carry and implied volatilities (and risk reversals) has been over time, we devised a strategy aimed at exploiting temporary divergences between these measures of risk premium. More specifically, we bought (or sold) delta-hedged straddles in some of the currency pairs based on whether implied volatility was too low (or high) compared to the current level of interest rate differentials; we also took the opposite position in local interest rates. The same methodology was applied for taking positions in risk-reversals; they were bought and sold according to how they related to carry. An example of the strategy employed is shown in the chart below, where we plot implied volatilities and FX carry for 11 different currency pairs. The numbers correspond to one

[64] Different reasons are likely to be behind the consistent divergence between implied volatility/risk reversals and FX carry in these two crosses; in the case of USD/ZAR, we believe such has historically been due to the volatility generated by equity market flows, which tend to be less directly affected by FX carry.

of the rebalancing dates, April 23rd, 2007. The labels identify each of the currency pairs and the z-score of the current deviation from the fit compared to a rolling 1-year history. As the chart shows, USD/TWD implied volatility held the lowest z-score of deviation from the fit (of the vol-to-carry regression) at that time, signaling that its deviation was the most significant of the currencies analysed. Consequently, the strategy signaled going long implied volatility in USD/TWD while also receiving TWD rates and paying USD rates. EUR/HUF was at the exact opposite in terms of historical deviations from the fit, with a z-score of 1.2, and hence the strategy signaled going short delta-hedged straddles in EUR/HUF while also paying HUF rates and receiving EUR rates. Note that the absolute deviations from the fit were more significant in USD/ZAR and USD/INR, though the z-score readings suggest that the two crosses have consistently deviated from the fit.

Figure 61: Carry vs volatility strategy example – April 2007 rebalancing



Note: all values are measured against the USD, except for HUF and PLN (vs EUR). Source: Deutsche Bank

We used 3-month straddles and 3-month 25-delta risk reversals, hedging the option deltas on a daily basis as we wanted to minimize the direct dependency to spot levels and concentrate on the exposure to implied volatilities and implied skew. The interest rate positions were generated using synthetic 1v3 forward rate agreements from FX-implied yield curves for both the base and the terms currency. We also rebalanced the strategies every month given the speed of reversion between the fitted levels and actual levels of implied vols and risk reversals, and also in order not to be too dependent on price action during the exact day of putting on the position[65]. Different bid-ask spreads for volatility and FRA levels were assumed depending on the currency pair analyzed[66].

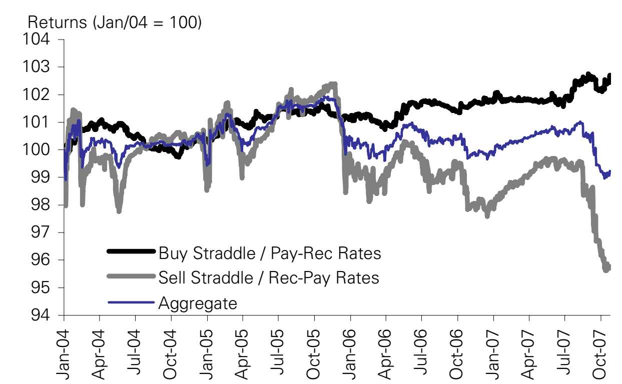
Please refer to the tables at the end of the article for a summary of the positions taken by both the vol-to-carry and risk reversals-to-carry strategies over time.

The results: carry versus implied volatility for EMFX

The results of the strategy that tested carry versus implied volatility were encouraging, but most of the returns were concentrated in the portion that went long straddles in the crosses where implied volatility looked too low for a given level of FX carry.

Buying delta-hedged straddles in the currency pairs with the most negative (historically-adjusted) deviation from fit yielded positive returns in approximately 60% of the instances, accompanied by a 65% hit ratio for over-borrowing/over-lending in synthetic FRAs in the base and terms currency respectively. In our view, this suggests that the market indeed has a bias to revert the most out-of-sync vol-to-carry ratios back in line with the cross-market average[67].

Figure 62: Straddle-vs-Carry strategy – returns



Source: Deutsche Bank

The reverse strategy - selling implied volatility while over-borrowing in the term currency against the base currency - failed to generate a hit ratio of over 50%. More importantly, the volatility of those returns was considerably high given the frequency of corrections in the particular crosses. For instance, the strategy consistently advocated being short straddles in USD/MXN and EUR/HUF going into the periods of domestic political instability in Q2 and Q3 2006; the negative returns from

[65] Using monthly rebalancing of 3-month option positions also allowed for the P&L to be more sensitive to moves in volatility compared to spot, as the options' vegas were more significant than the gammas for most of the period in which the positions were held.

[66] The bid-ask spreads on implied volatility ranged from 25bp to 200bp depending on each currency pair; they ranged from 0bp to 20bp on the synthetic FRAs.

[67] We also tested the strategy for the second and third outlier FX pairs, whose results suggested that the multi-year trend in volatility did not have an overpowering impact in the testing framework.

these positions far outweighed the positive returns from being over-borrowed in short-dated FRAs in the term currency.

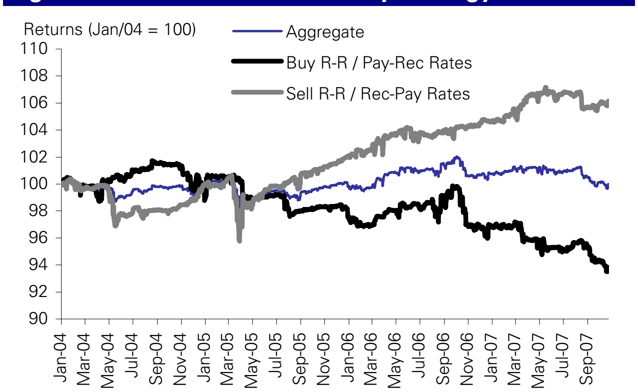
The results: carry versus risk reversals in EMFX

The strategy that tested the historical returns of trading carry versus risk reversals yielded overall un-encouraging results: the returns were highly volatile and reverted to around where they started after 3.5 years of back-testing.

Nevertheless, a more detailed assessment of the attribution of returns shows a clear decouple: selling delta-hedged risk reversals (with an accompanying rates position) yielded 12% since the start of 2004 (a Sharpe ratio of 2.1), versus a loss of 13% when buying the set of risk reversals that were too low versus FX carry.

The hit ratios also confirm this difference in results: 79% of the short risk reversal positions were profitable, against a 54% success ratio in the long risk reversal positions. Of the strategy that consistently sold delta-hedged risk reversals according to the historically-adjusted deviation from fit, the returns were subject to tail risk though most of that was offset by the delta hedge. Most of the selling of risk reversals was done in the Asian currency pairs (USD/KRW, USD/SGD, USD/INR).

Figure 63: Risk Reversals vs Carry strategy – returns



Source: Deutsche Bank

In our view, the results for the testing strategy suggest that historical discrepancies between the two measures of risk premium (carry and risk reversals) can be better exploited when the risk reversals look abnormally high[68]. As was the case with the carry vs volatility back-testing strategy, the impact of the FRA positions in the overall returns was very limited compared to that of the risk reversal positions.

Conclusions

We believe that the main conclusion that we can draw from the study relates to the asymmetry of the results, which seem to identify opportunities when risk premium is over-priced in risk reversals but under-priced in implied volatility. Risk reversals that look abnormally high to the level of FX carry tend to revert to a lower level, while implied volatilities that look abnormally low to the level of carry also have a tendency to rise as the market corrects itself. This dynamic holds particularly for the crosses that are particularly out-of-sync, as opposed to applicable to the entire data set, thus increasing the robustness of the results as they are less dependent upon the current environment of implied volatility and risk appetite. This conclusion further enhances the importance of the charts relating to volatility-to-carry and risk reversals-to-carry in our volatility chart-pack, which show the current signals of the strategy.

[68] As with the carry vs volatility strategy, we verified the results for currency pairs in second and third rankings in order to assess whether the multi-year trend of falling implied volatility had biased the results. The difference in the behaviour of returns, the currencies used in the strategies, and the fact that the results are different to what was identified in the carry vs volatility strategy all suggest that the overall trend of EMFX volatility had a limited impact in the results of the strategies.

Figure 64: Volatility vs carry strategy: historical signals

Date	Buy Straddle	Sell Straddle
19-Oct-07	USD/ZAR	USD/SGD
19-Sep-07	USD/ZAR	USD/SGD
20-Aug-07	USD/ZAR	USD/BRL
20-Jul-07	USD/ZAR	USD/INR
20-Jun-07	USD/ZAR	USD/SGD
21-May-07	USD/TWD	USD/SGD
23-Apr-07	USD/TWD	EUR/HUF
23-Mar-07	USD/TWD	EUR/HUF
23-Feb-07	USD/TWD	USD/MXN
23-Jan-07	USD/TWD	EUR/HUF
25-Dec-06	USD/ZAR	EUR/HUF
27-Nov-06	USD/KRW	USD/MXN
27-Oct-06	USD/KRW	EUR/HUF
27-Sep-06	USD/KRW	EUR/HUF
28-Aug-06	USD/KRW	EUR/HUF
28-Jul-06	USD/KRW	EUR/HUF
28-Jun-06	USD/KRW	USD/MXN
29-May-06	USD/INR	USD/TWD
01-May-06	USD/TRY	EUR/HUF
03-Apr-06	USD/ZAR	EUR/HUF
03-Mar-06	USD/ZAR	USD/BRL
03-Feb-06	USD/ZAR	USD/BRL
03-Jan-06	USD/ZAR	USD/TWD
05-Dec-05	USD/ZAR	USD/BRL
07-Nov-05	USD/TRY	EUR/PLN
07-Oct-05	USD/INR	EUR/HUF
07-Sep-05	USD/INR	USD/SGD
08-Aug-05	USD/INR	USD/SGD
08-Jul-05	USD/INR	USD/BRL
08-Jun-05	USD/KRW	USD/ZAR
09-May-05	USD/MXN	USD/TWD
11-Apr-05	USD/INR	USD/TRY
11-Mar-05	USD/MXN	USD/TWD
11-Feb-05	EUR/HUF	USD/TWD
11-Jan-05	USD/TRY	USD/ZAR
13-Dec-04	EUR/HUF	USD/TRY
15-Nov-04	USD/MXN	EUR/HUF
15-Oct-04	USD/KRW	USD/SGD
15-Sep-04	USD/KRW	USD/INR
16-Aug-04	USD/MXN	USD/SGD
16-Jul-04	USD/MXN	USD/SGD
16-Jun-04	USD/MXN	USD/SGD
17-May-04	USD/MXN	USD/BRL
19-Apr-04	USD/MXN	USD/INR
19-Mar-04	EUR/HUF	USD/SGD
19-Feb-04	EUR/HUF	USD/BRL
19-Jan-04	USD/MXN	USD/ZAR
19-Dec-03	USD/BRL	USD/ZAR

Source: Deutsche Bank

Figure 65: Risk-reversals vs carry strategy: past signals

Date	Buy Risk Reversal	Sell Risk Reversal
19-Oct-07	EUR/PLN	USD/BRL
19-Sep-07	EUR/PLN	USD/BRL
20-Aug-07	USD/INR	USD/KRW
20-Jul-07	EUR/HUF	USD/INR
20-Jun-07	EUR/HUF	USD/SGD
21-May-07	EUR/HUF	USD/SGD
23-Apr-07	USD/INR	USD/BRL
23-Mar-07	EUR/HUF	USD/BRL
23-Feb-07	EUR/HUF	USD/BRL
23-Jan-07	EUR/HUF	USD/BRL
25-Dec-06	USD/INR	USD/BRL
27-Nov-06	EUR/HUF	USD/BRL
27-Oct-06	EUR/HUF	USD/BRL
27-Sep-06	EUR/HUF	USD/BRL
28-Aug-06	USD/TRY	USD/BRL
28-Jul-06	USD/TRY	USD/BRL
28-Jun-06	USD/INR	USD/BRL
29-May-06	EUR/HUF	USD/TWD
01-May-06	EUR/HUF	USD/MXN
03-Apr-06	USD/INR	USD/BRL
03-Mar-06	EUR/HUF	USD/BRL
03-Feb-06	USD/INR	USD/BRL
03-Jan-06	USD/TRY	USD/BRL
05-Dec-05	USD/TWD	USD/INR
07-Nov-05	USD/TWD	USD/MXN
07-Oct-05	USD/SGD	USD/MXN
07-Sep-05	USD/SGD	USD/MXN
08-Aug-05	USD/SGD	USD/MXN
08-Jul-05	USD/SGD	USD/TRY
08-Jun-05	USD/TWD	EUR/HUF
09-May-05	USD/SGD	USD/TRY
11-Apr-05	USD/SGD	USD/TRY
11-Mar-05	USD/BRL	USD/TRY
11-Feb-05	USD/MXN	USD/TRY
11-Jan-05	USD/MXN	USD/KRW
13-Dec-04	USD/BRL	USD/TRY
15-Nov-04	USD/TWD	USD/BRL
15-Oct-04	USD/INR	USD/KRW
15-Sep-04	USD/INR	USD/KRW
16-Aug-04	EUR/HUF	USD/KRW
16-Jul-04	USD/MXN	USD/BRL
16-Jun-04	USD/MXN	USD/TRY
17-May-04	USD/MXN	USD/TRY
19-Apr-04	EUR/HUF	USD/INR
19-Mar-04	EUR/HUF	USD/KRW
19-Feb-04	USD/MXN	USD/TRY
19-Jan-04	USD/KRW	EUR/PLN
19-Dec-03	EUR/PLN	EUR/PLN

Source: Deutsche Bank

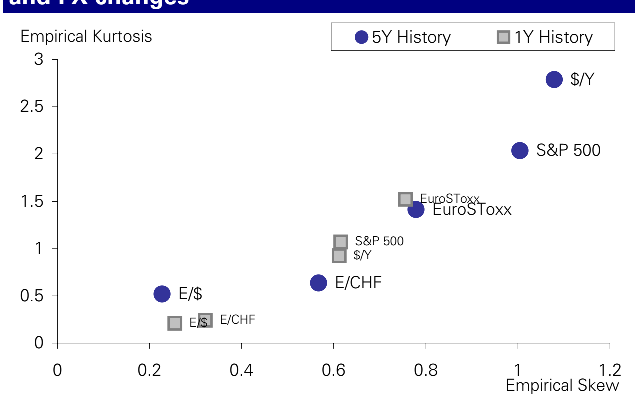
Hedging Equity Drawdowns Through FX Options (14/10/07)

A cost-effective way to hedge equity market risks

Hedging equity exposure through foreign exchange options has become an increasingly popular topic among equity investors. The increased presence of active FX overlay managers and global macro investors has brought greater resemblance in the way that both global equity markets and FX carry trades behave during rallies and drawdowns.

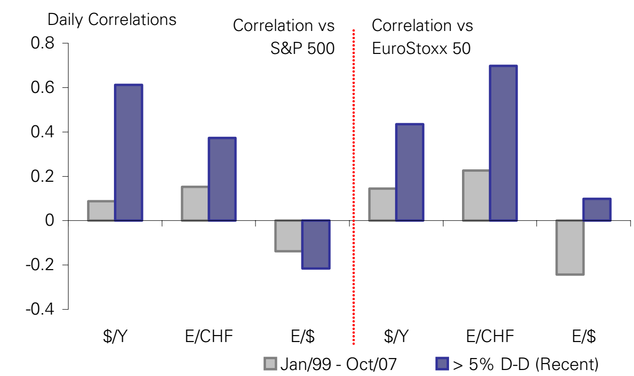
Indeed, the distribution of returns between two key global equity indices, the S&P 500 and EuroStoxx 50, and some of the main currency pairs (USD/JPY, EUR/CHF and EUR/USD) bear striking similarities. The two equity indices and the currency pairs analysed have held comparable trend and "fat tail" characteristics since the start of this multi-year bull market period, with the similarities becoming even stronger recently (most notably in the case of the "carry" FX crosses of USD/JPY and EUR/CHF). As such, the level of kurtosis witnessed in the distribution of weekly returns in USD/JPY over the past year is not only equivalent to that of the equity indices analysed but, most recently, has even exceeded them. Another key point to highlight is the syncronous behaviour during excessive market volatility; while FX and equities may seem uncorrelated on a daily basis, the correlations in instances of severe equity market drawdowns have been in excess of 60% in the case of both USD/JPY and the S&P 500 Index and EUR/CHF and the EuroStoxx 50 Index.

Figure 66: Empirical skew and kurtosis of equity index and FX changes



Note: we use weekly log-normal changes. The kurtosis measure relates to "excess" kurtosis (i.e. > 0 represents leptokurtosis). Source: Deutsche Bank

Figure 67: Correlations between FX and equities – full period and drawdown occasions



Note: we use exponentially-weighted correlations for the drawdown samples in order to better capture the inter-asset relationship at those instances. We use standard daily correlations for the full period. "D-D": drawdown. Source: Deutsche Bank

This behaviour suggests that equity market investors should consider foreign exchange assets as potential hedges to their long exposure. The intuition is simple: i) the two asset classes become highly correlated at times of equity market drawdowns (when protection is most valuable), ii) realised volatilities can rise to similar levels (2-week realised volatilities in both USD/JPY and the S&P 500 rose to 29% in early August), and iii) foreign exchange options are cheaper (the VIX is currently around 18%, while ATMF 1-month USD/JPY volatilities are at around 7.85% and the CVIX[69] is at 7.2%). Finally, as the data shows, the two asset classes may not be so closely linked during average trending periods, but are more closely linked when a currency hedge would matter the most - at heavy equity market drawdowns.

In a simple approach, foreign exchange hedges can be separated into three broad categories: "outright directional" options, pure volatility products, and options against excessive drawdowns. We analyse the effectiveness of each category through the behaviour of representative contracts during equity market drawdowns over the past 9 years. As outright directional options, we use ATMF and 25-delta puts of 1-month expiry on USD/JPY, EUR/CHF and EUR/USD, rolled at maturity. We also use variance swaps as hedges for outright volatility

[69] Deutsche Bank's Currency Volatility Index. For more details, please refer to "Deutsche Bank Guide to Currency Indices", October 2007.

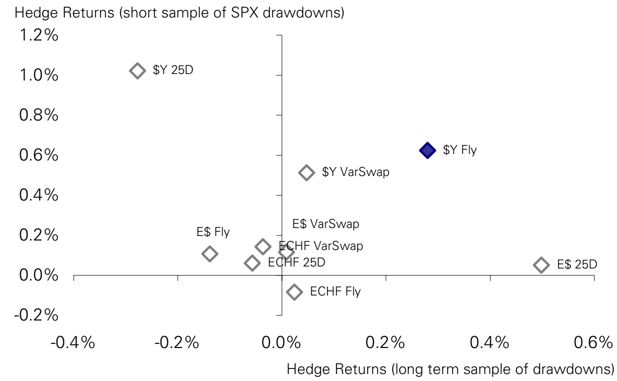
and butterfly structures[70] on the same currency pairs as hedges for market "tail" events.

The high skew in the distribution of returns above represents the fact that both the equity indices and the currency pairs analysed are trending, and equity-hedging strategies using FX will perform best when the trend does not negatively affect their P&L. Vanilla puts are not immune to that exposure, as trending markets (typically towards weakening "safe haven" currencies) lead into an overall negative P&L in the returns of currency puts. Vanilla puts are also more expensive in nature (as can be seen by the high implied volatility and volatility risk premium assumptions) and provide an over-hedge for the equity investor's exposure at times when correlation between equities and FX is not as significant.

Variance swaps fall into a similar problem - they tend to be relatively expensive and require the assumption that volatility will rise over the period of the trade[71]. Trending FX (and equity) markets are accompanied by falling volatility in asset prices and hence yield negative returns for a large portion of the trade holding period. Small drawdowns and sideways price action are usually not enough for variance swaps to provide an effective hedge either, and hence the overall returns over the longer sample period have always been negative. That said, the recent performance of USD/JPY variance swaps as an equity hedge has been favourable.

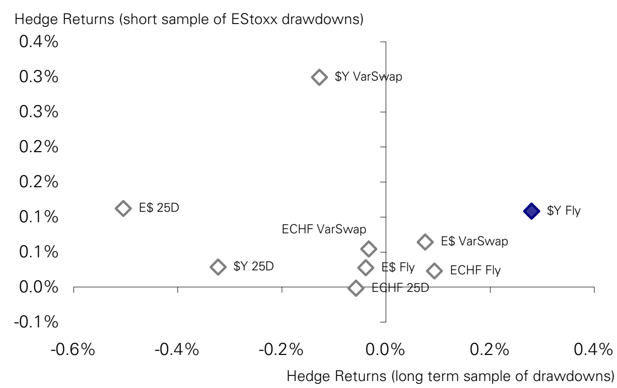
The most effective hedge, as the data on historical drawdowns shows, is in specific "tail risk" hedging structures such as FX butterflies. The similarities in the distribution of returns of USD/JPY and the S&P 500, for instance, mean that the equity investor who is long a USD/JPY butterfly structure will profit from being short volatility and gamma in the higher strikes (hence not losing money in a low-vol trending market) but also be protected against acute drawdowns in the S&P, and these will accompany aggressive currency moves which will take the lower-delta options (which the investor is long) into the in-the-money territory.

Figure 68: The returns of different hedging strategies using FX – Drawdowns in the S&P 500



Note: the "short sample" comprises of the 2006-07 period. The long sample looks at 9 years worth of data. Legend: $Y: USD/JPY; E$: EUR/USD; ECHF: EUR/CHF; 25D: 25-delta put on the base currency; "Fly": butterfly. We assume an equal notional position for each strategy. Source: Deutsche Bank

Figure 69: The returns of different hedging strategies using FX – Drawdowns in the EuroStoxx 50



Note: the "short sample" comprises of the 2006-07 period. The long sample looks at 9 years worth of data. Legend: $Y: USD/JPY; E$: EUR/USD; ECHF: EUR/CHF; 25D: 25-delta put on the base currency; "Fly": butterfly. We assume an equal notional position for each strategy. Source: Deutsche Bank

Having agreed that butterfly structures provide the most attractive protection among the FX hedges analysed, the next key question becomes how that particular hedge performs compared to the equivalent structure using options on the equity index itself. Vanilla puts on equity indices typically suffer from the same issues as those in foreign exchange when used as hedges against a long index exposure - they are expensive and create a material drag on performance in an upward trending (or in a sideways) market. Hence, we also stick to butterflies on equity indices. The main differences relate to the fact that butterfly structures on equity indices tend to be much more costly than those in the main currency pairs, even though the distribution of returns is similar. A 1-month 25-delta vs ATM butterfly on the S&P 500 assumes (mid) implied volatilities of 12.7% (25-delta call), 17.7% (25-delta put) and 15.1% (ATM straddle). The equivalent in USD/JPY assumes 7.35% for the USD/JPY call, 7.85% for the ATMF straddle and 8.9% for the USD/JPY put. The

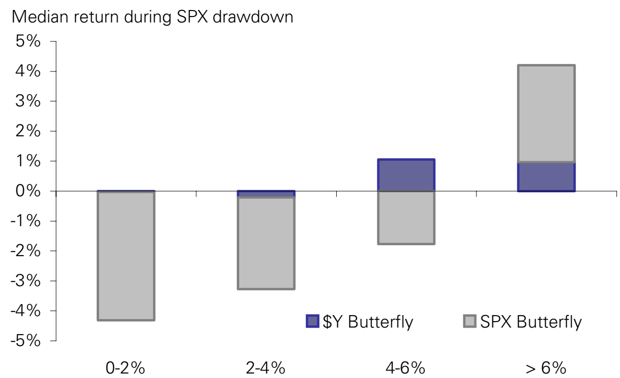
[70] The butterfly structures used comprise of being short 1-month ATMF straddles and long 25-delta calls and puts of offseting vega exposure at the inception of the contract. The positions are rolled at expiry. We use total return series with daily mark-to-market and rolling at expiry for all three strategy-types (vanilla puts, butterflies, and variance swaps). We use an equal notional position for each separate strategy.

[71] For a detailed overview of the pricing of variance swaps, please refer to "Volatility as an Asset Class", 13 January 2007. The pricing of FX variance swaps and equity variance swaps is very similar in nature.

respective differences in price are such that butterflies on index options require a more acute move in the FX index in order to yield a positive return at expiry.

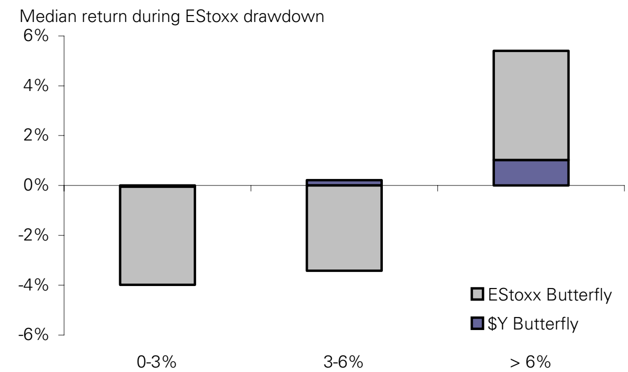
The charts below show the argument in more detail. The USD/JPY butterfly hedge provides a more convex return profile in drawdown periods for both the S&P 500 and EuroStoxx 50, compared to a more linear performance for the butterfly strategy on the equivalent equity index[72]. This performance is more clearly exhibited in the case of drawdown periods in the S&P 500. There, the USD/JPY butterfly did not perform as strongly as the index butterfly during excessive S&P drawdowns (> 6%) but it certainly outperformed at smaller drawdowns. Given that there were only 3 S&P 500 drawdowns of large magnitude over the past 1.5 years[73], an FX hedge would have performed better in aggregate over that period. Interestingly, the hedge also performed well using USD/JPY and EUR/CHF butterflies and the EuroStoxx index, but at smaller aggregate levels.

Figure 70: Returns of USD/JPY and S&P 500 butterflies over recent S&P drawdown periods



Note: we look at the returns of the strategies during recent drawdowns (2006-07 periods). Source: Deutsche Bank

Figure 71: Returns of USD/JPY and EuroStoxx50 butterflies over recent EStoxx drawdown periods



Note: we look at the returns of the strategies during recent drawdowns (2006-07 periods). Source: Deutsche Bank

In conclusion, during recent equity drawdowns we've seen that a long USD/JPY butterfly can reduce the P&L volatility of an equity portfolio. We believe that certain FX butterfly strategies – such as selling a 1-month ATMF straddle vs buying 25-delta calls and puts (vega-weighted) can offer a cost effective way to hedge specific equity market risks.

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[72] We apply the same vega notionals to both the FX butterfly and the equity index butterfly.

[73] Feb-Mar/07 (5.9%), May-Jun/06 (7.7%) and Jul-Aug/07 (9.4%). This compares with 11 drawdowns of smaller magnitude over the same time period.

Payrolls, Price Action, Gamma Valuation (05/10/07)

Understanding FX price action and the valuation of gamma around the US employment report

Friday sees another US employment report for September, in which Deutsche Bank is broadly in line with market expectations of a +100k reading on non-farm payrolls and a 4.7% unemployment rate. The US employment report has for long determined the price action of currency markets on the first Friday of the month, especially after the Fed decided to attach a heavier weight to this report in its setting of monetary policy.

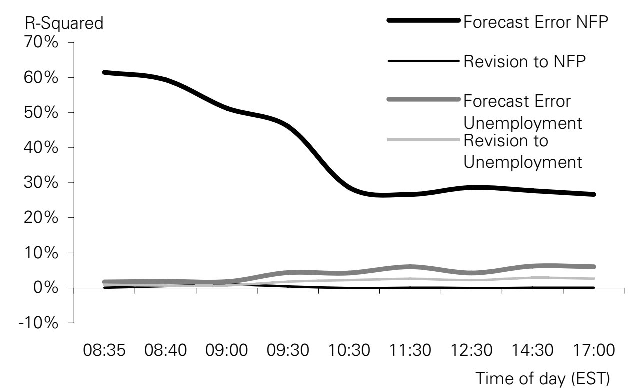
While the share of attention given by fundamental analysts to the non-farm payrolls announcement has changed over time, its relevance to FX options traders remains quite high - especially in what relates to estimating the appropriate cost of gamma around the release. This estimate is a function, among other factors, of the typical behaviour of currency markets in light of forecast errors and the historical profitability of trading overnight options. This article addresses these two topics – price action and the historical profitability of trading overnight gamma. We conclude that, while gamma has tended to be fairly priced over time, current conditions favour a long exposure in EUR/USD gamma versus a short exposure in GBP/USD gamma, and we recommend buying overnight straddles in the former while selling overnight straddles in the latter.

First things first: how do currency markets behave around the employment report?

In order to address the behaviour of currency markets during the US employment report, we look at intra-day spot moves in the 3 main pairs in global foreign exchange: EUR/USD, USD/JPY and GBP/USD, using 5-minute intervals (and their changes from 08:25 EST) and data back to the start of 2002 (a total of 69 report days). We also take 4 components into account in our analysis: the forecast error on the headline NFP and unemployment rate forecasts for the past month, and the revisions made to previous NFP and unemployment readings.

As we assess the interaction between tick data and the different components of the employment report, we find – as one would've expected – that the surprise from the non-farm payrolls reading is by far the most influential portion of the report for currency markets. Since 2002, over 60% of the changes in EUR/USD and GBP/USD and 47% of the changes in USD/JPY within the first 5 minutes of the release can be explained by how surprised analysts actually were. That relevance decreases as the day goes on, at the same time that – interestingly – the relevance of other components of the report (most notably the forecast error related to the unemployment rate) tends to rise modestly.

Figure 72: Percentage of changes in EUR/USD attributed to employment report (release date)



Note: each explanatory variable has been used separately. Source: Deutsche Bank

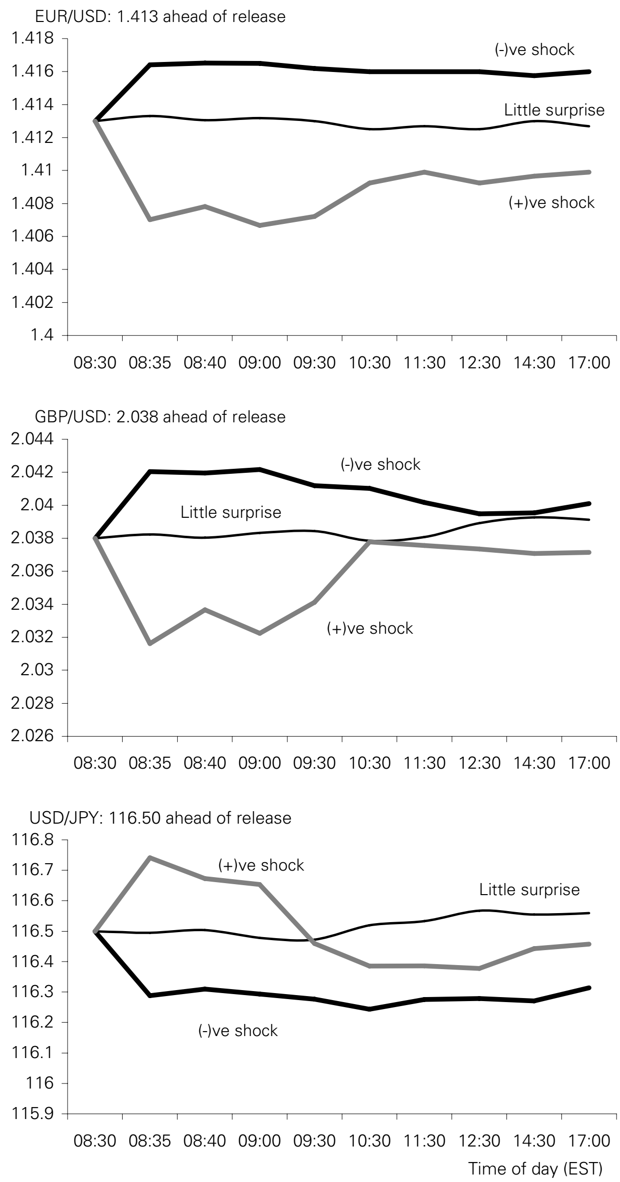
Through a "shock" OLS regression technique[74], we identify that the USD reacts more strongly to positive payroll surprises rather than negative ones against the EUR and GBP (a ratio of 1.6x). According to our estimates, a payroll surprise of +80k, coupled with an unemployment surprise of +0.15% will lead to a move lower of approximately 0.45% in EUR/USD and 0.30% in GBP/USD within the first 5 minutes of the release[75]. Against the yen, however, the surprises are pretty symmetric and slightly lower than in the other 2 crosses (about 0.25% for a similar surprise shock). Another interesting point relates to how the price action converges by the end of the day and how symmetric it is: most of the initial dollar strength impact

[74] We break the sample into subsets by setting the explanatory variables equal to either 0 or 1 depending on whether they meet a certain threshold criteria (>1 standard deviation, < - 1 standard deviation, and in between). The coefficients are then measured against the average rate of the explanatory variables that meet the threshold criteria.

[75] We decided to exclude the payrolls revision and unemployment revision from our regression estimates given the low significance of their coefficients, either treated separately or when coupled with the others.

(in the case of a strong payroll report) versus JPY will be over by the end of the day. The reactions in GBP/USD and EUR/USD are more symmetric as the day goes on, but converge back to the starting point in the case of GBP/USD. Only in EUR/USD the reaction is both symmetric and lasts (in notable magnitude) until the end of the day.

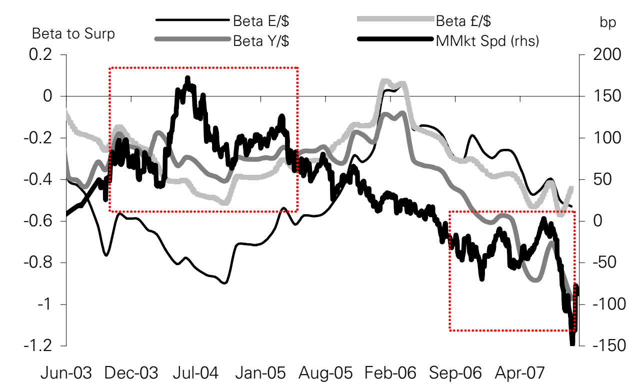
Figure 73: Intra-day projected path for G-3 FX as a function of surprises in the US employment report



Note: the expected path assumes spot at 08:30 EST equal to at the time of writing (EUR/USD 1.413, GBP/USD 2.0380 and USD/JPY 116.50). (-)ve shock is defined as an average of error forecasts of -80k (NFP) and -0.19% (unemployment rate). The opposite signs apply for (+)ve shock, and "little surprise" assumes the average for the observations that do not qualify under (+)ve or (-)ve shocks. Source: Deutsche Bank

The long-term regression results described above provide a good starting point to estimating the potential behaviour of FX on "Payroll Fridays", but further adjustment is needed to account for broad economic conditions, especially given how the reaction to payrolls has changed over time. As we analysed the impact of forecast errors on FX spot against a broad series of economic indicators, we found that market reaction to payroll surprises tends to be directly related to uncertainty surrounding monetary policy at a given point in time. The year of 2004, for instance, witnessed considerable volatility in the spread between US money market rates[76], followed by lower volatility for a large portion of 2005 and 2006, and a subsequent pick-up again later this year. The way in which EUR/USD, GBP/USD and USD/JPY react to this interest rate volatility - as one would expect in a carry-driven currency market - directly reflects these changing dynamics of interest rate risk premium. The data suggests that the less assured the interest rate market is about the future Fed Funds rate, the more FX reacts to the employment report. Given the fact that we're currently in a period of high uncertainty regarding US monetary policy, we would not be surprised if the sensitivity of FX to forecast errors on Friday is well excess of our initial coefficient estimates (mentioned above), and closer to (0.65% in EUR/USD and 0.45% in GBP/USD) for an 80k payrolls surprise as implied from a trimmed sample[77].

Figure 74: US interest rate spreads and the sensitivity of FX to forecast errors in the NFP



Note: we use the beta of changes in FX to a 80k forecast error at 14:30 EST in this example. The coefficients are gathered from simple linear regressions. We express the USD/JPY beta in terms of JPY/USD. Source: Deutsche Bank

[76] We used the 9x12 FRA (-) 3-month LIBOR as a measure of money market spreads as we believe it tracks the expectations of future monetary policy reasonably well.

[77] In this trimmed sample we restricted the data to 23 observations from Jan/04 - Apr/05 and Mar/07 - Sep/07. The coefficients relate to changes in FX at 14.30 EST compared to ahead of the report. We chose 14.30 as it excludes both end-of-day noise and the noise around the initial surprise impact.

FX gamma and payrolls – is it fairly priced?

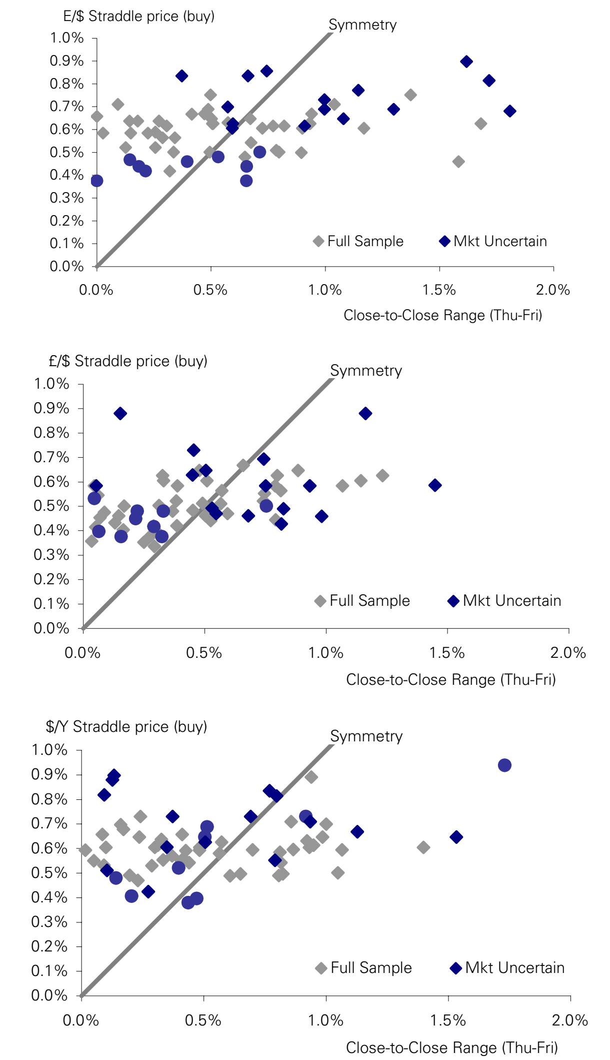
We now move onto the second question – the valuation of gamma around "Payroll Fridays". Option traders are often placed in a difficult position having to estimate the value of gamma at the day of the payrolls announcement. A good way of measuring how effective has the pricing of overnight gamma been at payroll events is to assess the P&L of a simple strategy that sells (or buys) FX straddles on the Thursday prior to the employment report, which expire overnight. Taking a conservative bid-ask spread estimate into account[78], we identify that the investor who sold ATMF straddles on the 3 currency pairs during the 69 Fridays analysed would have profited in approximately 43% of the instances, while selling the straddle would have yielded positive returns in 53% of the instances. In other words, the cost of gamma seems fairly valued at payrolls[79].

On the other hand, this calculation represents an average for the entire sample; a modified sample window seems more appropriate to analyse the behaviour of the strategy under today's conditions of uncertainty surrounding US monetary policy. In this revised sample, which includes a large portion of 2004-2005 and this year, we identify that buying overnight straddles would have yielded a positive P&L in slightly over 55% of the instances in EUR/USD (versus less attractive results in GBP/USD and USD/JPY).

That ratio may not seem over-encouraging, but when combined with our view that the gamma profile in EUR/USD is rather "slippy" on the downside[80], **we keep a bullish bias on EUR/USD overnight gamma and highlight that overnight straddles for a 0.65% cost are an interesting play.**

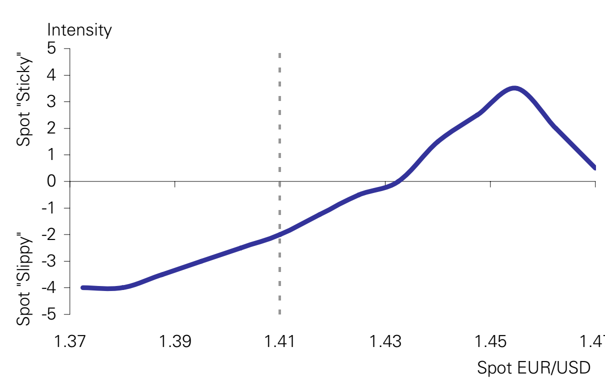
The contrary applies, in our view, to GBP/USD overnight volatility; it seems rather expensive at 7.8%. At the selling price of 0.5625%, the investor would have profited from selling the straddle at all payroll Fridays over the past 13 months. **Alternatively, the investor could look at a relative value trade in which one buys the EUR/USD overnight straddle and sells the GBP/USD straddle** - while the investor pays 20% more for the strike bought compared to the strike sold, the EUR/USD close-on-close range on payroll Fridays has been 35% above that of GBP/USD, which in our view well justifies the higher cost.

Figure 75: Valuing gamma at "Payroll Fridays"



Note: the points to the left of the chart suggest the gamma was expensive and the straddle-buyer did not profit from the strategy; the opposite applies for observations to the right of the "symmetry" line. "Mkt uncertain" relates to the Jan/04 – Apr/05, Mar/07 – Sep/07 periods. Source: Deutsche Bank

Figure 76: Our estimate of gamma profile for EUR/USD



Note: these are subjective estimates of market gamma exposure. Source: Deutsche Bank

[78] We assume 200bp of bid-ask spread for overnight volatilities in EUR/USD and GBP/USD, and 300bp of bid-ask spread in USD/JPY. The bid-ask spread is kept constant over time.

[79] Note, however, that the straddle selling strategy would have outperformed if no bid-ask spreads were taken into account.

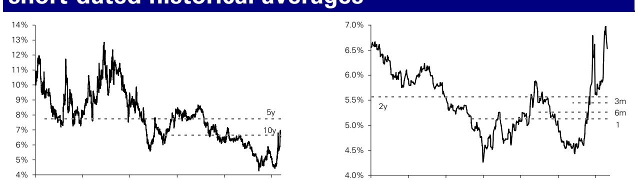
[80] In other words, EUR/USD accelerates as it moves lower.

GBP: A Sterling Performance for Vols? (29/09/07)

The pound is due to weaken – but how about sterling volatility?

Having developed a fundamentally bearish view on the British pound most recently, we have now decided to look at the implications of that view for GBP volatility. Given its "high carry" status, intuition suggests being long volatility across the sterling crosses as weakness in high yielding currencies tends to be accompanied by a rise in both implied volatility (the cost of insurance rises) and realised volatility (as moves can be abrupt due to investor positioning). On the other hand, the (already) aggressive spike in GBP volatility has prompted us to raise the question of whether the most recent rise represents a peak. Short-term mean reversion measures of volatility certainly suggest so, further supported by the historical evidence that selling GBP implied volatility on jumps has been generally a profitable strategy over the past seven years. In this report, we take a view on GBP volatility against some of the main currencies in G-10 according to a combination of techniques.

Figure 77: GBP volatility (vs TWI): long-dated and short-dated historical averages



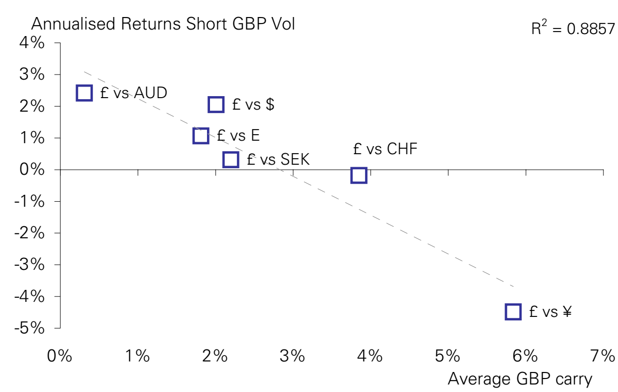
Note: we use an arithmetic average of GBP/USD, EUR/GBP, GBP/SEK, GBP/JPY, and GBP/CHF weighted according to their shares in the DB's GBP TWI. Source: Deutsche Bank

Our broad conclusions

Our approach to understanding (and forecasting) the behaviour of GBP volatility is based on how it relates to FX spot and to carry (please see the appendix at the end of the article for details). In a broad sense, the performance of a GBP volatility trading strategy (and hence, of GBP volatility risk premium) in an environment of a weakening pound is ultimately directional to the level of interest rate carry in the currency pair. The higher the rate differentials between the pound and the comparable currency, the higher the correlation between FX spot and implied volatility (and risk premium) and hence the more profitable it is to be long volatility in a weakening pound environment.

However, the findings are not as simple. The argument between carry and volatility used at the start of this text may apply broadly to the British pound, but there are clear differences in the way that a volatility trading strategy relates to spot behaviour even at currency pairs of similar interest rate differentials. From the six currency pairs analysed, we found that within the high carry crosses, GBP/SEK volatility relates far less to spot than in the case of GBP/CHF and GBP/JPY. Consequently, other predictability measures (such as mean reversion) bear more relevance in the returns of a volatility trading strategy in that pair. Similar implications can be derived for GBP/AUD, the lowest carry cross among those analysed. Among the medium carry crosses, short volatility strategies on pound weakness fare well for both EUR/GBP and GBP/USD but the correlation between implied volatility (and volatility risk premium) and FX spot is much less significant in the latter compared to the former.

Figure 78: Returns of a short GBP volatility swap versus carry



Note: we use the 3-month tenor for the volatility swap. We also restrict the data set to periods of GBP weakness over the past 10 years. Source: Deutsche Bank

Currency-specific conclusions and trade ideas

Our findings, and subsequent views are shown in more detail below:

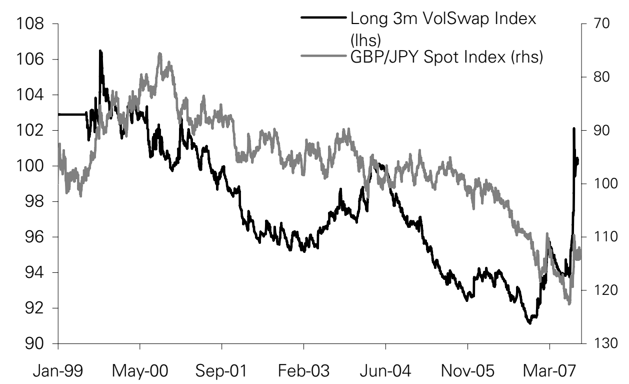
<u>GBP weakness versus JPY: buy 6-month volatility swaps (strike 10.5%)</u>

GBP/JPY volatility is by far the most carry-directional (and spot-directional) of the GBP implied volatilities, a relationship that has been robust over the past 10 years[81]. As a result, being long implied volatility through vol swaps in GBP/JPY over periods of weakness in spot would have

[81] The correlation between GBP/JPY implied volatility and FX spot has been -27% over the 550 days of GBP/JPY (spot) weakness included in our analysis.

returned an average of 4.5% (annualised) this past decade, which is also the strongest seen among the crosses analysed. This robust relationship, coupled with our view on spot, leads us to advocate a bullish stance on GBP/JPY implied volatility as we enter a multi-month period of sterling weakness against the yen. GBP/JPY implied vols may have doubled since the lows of Nov-06, but are only at the 10-year average and well below the 11% average seen at instances of GBP/JPY weakness.

Figure 79: performance of a long GBP/JPY volatility swap compared to a GBP/JPY spot index



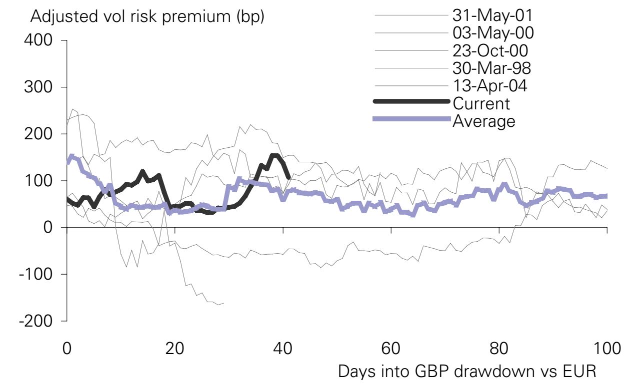
Note: by "long" the volatility swap the investor is buying implied volatility and selling realised volatility. Source: Deutsche Bank

GBP weakness versus EUR: sell 3-month and 6-month implied volatilities (strikes 5.65% and 5.45% respectively)

EUR/GBP volatility is reasonably directional to a weakening sterling, but the effect of that in the performance of volatility swaps has been reduced in the past by the multi-year presence of a positive volatility risk premium, expressed especially in longer tenors (3-6 months). As a result, being short implied volatility in this currency pair has generally been a profitable strategy over the course of the 920 days' worth of rising EUR/GBP included in our analysis.

The "adjusted" [82] volatility risk premium started at a relatively low level compared to the initial stages of other bullish EUR/GBP cycles, but has subsequently caught up to the historical average. As we expect the next leg of GBP weakness vis-à-vis the Euro to be in line with the average (5% from now until year-end), we also expect the behaviour of volatility risk premium to remain similar and hence being short GBP volatility swaps should perform well.

Figure 80: Volatility risk premium in EUR/GBP during times of GBP weakness



Note: the dates in the time series correspond to the dates in which a GBP downtrend vs EUR started. We use the 3-month tenor in our analysis. Source: Deutsche Bank

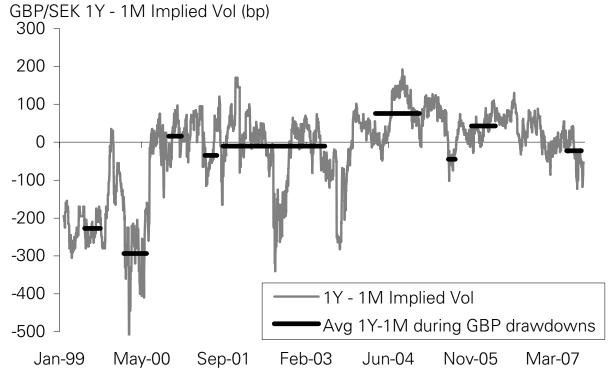
GBP weakness versus SEK: sell 1-month volatility swaps (strike 7.75%).

The return of 3-month GBP/SEK volatility swaps has been pretty flat over time periods of GBP weakness which reflects the lack of statistical strength in how implied volatility relates to spot behaviour and relative "fair value" of 3-month implied vols. The lack of correlation between EUR/SEK and EUR/GBP also leads to empirical volatilities that are considerably higher in GBP/SEK compared to the two EUR crosses. In other words, GBP and SEK have little association and hence tend to exhibit no historical trends.

An interesting point to note, however, is that the term premium of GBP/SEK implied vols is consistently flat or inverted (-55bp during GBP/SEK weakness periods and -25bp over the whole 10 years of data). This has led to a strong outperformance of selling implied volatility in 1-month tenors compared to 3 and 6 month tenors over time (10Y returns of 38% in 1-month volatility swaps, compared to 19.5% in 3-month and 14.2% in 6-month swaps). In our view, this is due to the "jump" nature of FX spot, which raises the risk premium for short dated option insurance compared to longer dated options. This risk premium can be extracted through trading around historical mean reversion behaviour; at the moment, the 1-month volatility risk premium looks particularly high and hence we favour being short volatility swaps in 1-month GBP/SEK.

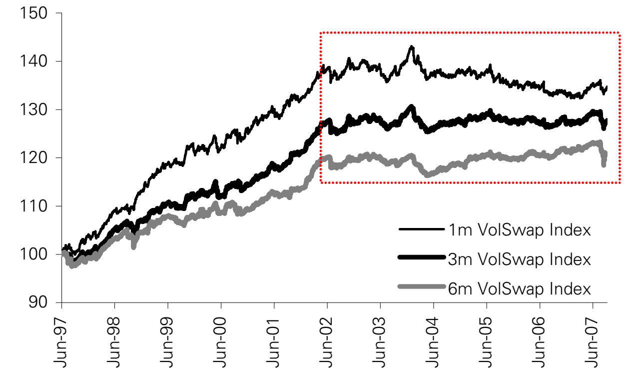
[82] The "adjusted" volatil risk premium bumps the implied volatilities forward by the length of their tenor in order to match the same time period as the historical volatility.

Figure 81: implied volatility term premium in GBP/SEK



Source: Deutsche Bank

Figure 82: Cumulative returns of a short GBP/USD volatility swap (different tenors)



Note: by "short" we mean selling implied and buying realized volatility. Source: Deutsche Bank

GBP weakness versus USD: Neutral on implied volatility

The relationship between GBP/USD volatility and FX spot seems similar to that of EUR/GBP in that a short volatility swap strategy has (on average) yielded positive returns during periods of GBP weakness over the past 10 years. Nevertheless, there are two distinct differences: first, the correlation between implied volatility (and volatility risk premium) and FX spot is much less significant; and second, the volatility risk premium has compressed significantly over the course of the years. The second difference is particularly important as the data shows that most of the positive returns from being short volatility swaps in GBP/USD over the past 10 years were attributed to the end of last decade.

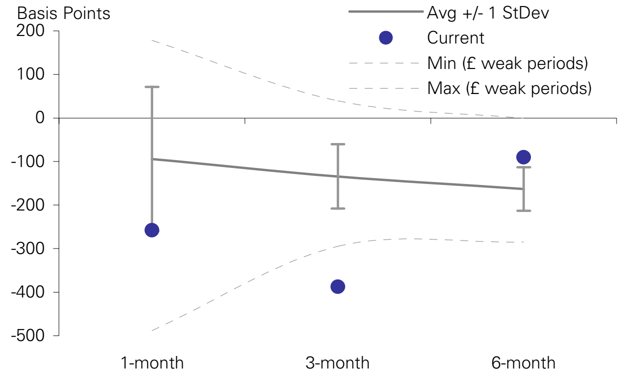
Using the returns of a volatility swap as a measure of "fair value" for GBP/USD volatility, one deduces that 1-month and 3-month implied volatilities for this currency pair have been at "fair value" for the past 5 years (though 6-month vols consistently trade at a higher premium and hence selling it has been a profitable strategy over the years). Given that our view on GBP/USD spot is of sideways price action (broad weakness for the USD), we do not see enough reasons for the current dynamic of volatility to change and hence allocate a neutral view on GBP/USD vols.

GBP weakness versus AUD: Neutral on implied volatility

Among the currency pairs analysed, GBP/AUD has been the most profitable currency pair for a short volatility strategy at times of sterling weakness. This is largely due to developments in the later part of the previous decade, and concentrated in the 3-6 month volatilities. In our view, this is largely due to the fact that broad GBP weakness has little association with the GBP/AUD cross over more recent years; interest rate differentials are insignificant and the price action in both currencies tends to be governed by how they relate to the broad USD trend. In other words, GBP weakness against AUD seems to bear little relationship to the profitability of a short vol swap strategy in GBP/AUD.

Given that FX spot is not much of a driver of GBP/AUD implied volatility, we resort to a general mean-reversion analysis to develop a view on GBP/AUD volatility. Both the volatility risk premium (very negative) and implied volatility levels (back to a 10Y average and at the lowest seen in previous periods of GBP weakness) suggest that GBP/AUD implied volatility will rise. However, our conviction is not as strong and history suggests that a long implied volatility strategy does not fare well at times of GBP weakness versus AUD (the investor would have lost money in 10 out of 13 instances). Therefore, we choose to stay neutral on GBP/AUD vols.

Figure 83: Volatility risk premium cone in GBP/AUD



Note: we only use periods of GBP weakness in our data set (total of 1,000 days) – hence the current VRP is below the minimum. We use the normal VRP calculation (implied vols have not been bumped forward to match the time period of historical vols). Source: Deutsche Bank

Appendix: the methodology for analyzing GBP volatility through time

Our approach to understanding (and forecasting) the behaviour of GBP volatility is based on how it relates to FX spot and to carry. As we expect the weakness of the pound to encompass different crosses, we analysed a sample that included the main currency crosses of our GBP trade-weighted index: EUR/GBP, GBP/USD, GBP/CHF, and GBP/SEK. We also added GBP/AUD to our analysis in order to assess the behaviour of pound volatility against other high-yielding G-10 currencies. We chose the returns on a 3-month volatility swap[83] as the measure of volatility behaviour, for it gives a better reflection of how the volatility risk premium[84] behaves over time. Finally, we restricted our sample to encompass only periods of GBP drawdowns[85] over the past 10 years, in order to use use a data set that better reflects what we expect to be the behaviour of FX spot over the coming months.

[83] Here, the investor sells the "strike" volatility and hence profits from implied volatility turning out above the realised volatility for the same sample period. In other words, they reflect the returns of being short implied against realised volatility. The strategy is marked-to-market every day, and rolled at expiry. The returns relate to the notional of 1 spot vega.

[84] The volatility risk premium represents the difference between the volatility implied by ATMF FX option prices and historical volatility.

[85] We used 6-month rolling drawdowns.

Exploring The World Of Long Dated JPY Volatility (20/09/07)

Long dated dual currency structures and JPY volatility: still a toxic match?

- Long-dated dual currency structures have been a popular topic recently due to the aggressive move lower in USD/JPY, and the accompanied rise in implied volatility and volatility skew.
- In order to assess whether such attention is warranted, we first address the main components related to these structures, followed by hedging implications, our understanding of market size, and the conclusions that can be inferred from recent moves in JPY implied volatility.
- In order to benefit from the current supply/demand balance of JPY vega in the market, we favour being short lower delta 2Y puts against long higher delta puts in USD/JPY. We also favour being long 2Y implied volatility in AUD/JPY.

Presenting the issue: long-dated dual currency notes issued in Japanese yen

The combination of low interest rates and a cash rich economy has prompted the aggressive growth of long-dated, multi-currency investment structures in Japan. These structures are normally used as "yield enhancement" tools, and their long-dated nature (up to 30 years) are an attempt to maximize that higher yield exposure. Given the lack of yield in JPY-denominated assets, the investor normally takes on exposure to other, higher yielding currencies through these products.

Of these structures, we highlight the two dominant ones: the PRDCs (Power Reverse Dual Currency Notes), and the TARNs (Target Redemption Notes).

- PRDCs are long-dated structured notes whose coupons are linked to a particular JPY exchange rate (typically USD/JPY); the first coupon is normally fixed at a high level, and the subsequent coupons are defined by movements in the exchange rate. The coupons are typically floored at zero, and are also capped at a level that is associated with a cancellation clause.
- TARNs are similar in economic exposure, though they differ in the construction of the coupon thus tending to have a shorter life expectancy and higher carry.

Below we show examples of simple PRDC and TARN structures, which provide a reasonable idea of the type of long-dated dual currency structures that were being issued earlier this year.

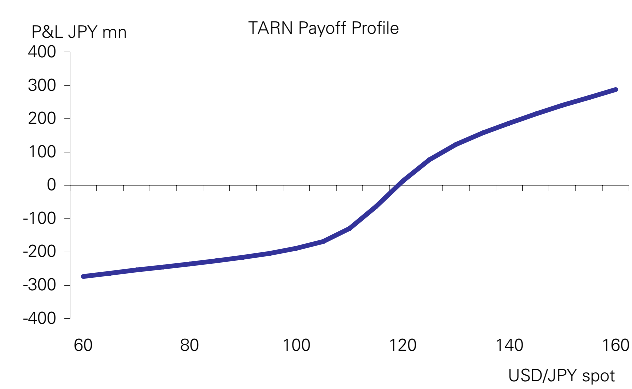
Figure 84: Example PRDC and TARN structures

Power Reverse Dual Currency Note (PRDC)	
Maturity	30y
Coupon	Semi-Annual, Initial Coupon 10% 1y, (USD/JPY / BaseFX) x 20.00% - 15% >= 0.0
Base FX	Spot USD/JPY - 17
Callable	NonCall 1y (Semi-Annual call)
Fwd Redemption Strike	80
Target Redemption Note (TARN)	
Maturity	30y
Coupon	Semi-Annual, Initial Coupon 10% 1y, (USD/JPY - BaseFX) x 1.00% >= 0.00%
Base FX	Spot USD/JPY - 10
Tarn Target	15%
Fwd Redemption Strike	USD/JPY = 90

Source: Deutsche Bank

The breadth, complexity and size of PRDCs and TARNs have grown substantially over the years, but the economic exposure remains similar in nature: the buyer will profit from purchasing long-dated dual currency notes if spot moves sideways or higher. The loss is limited at zero, though that comes at the cost of limited upside should the exchange rate continue to move in favour of the buyer. Effectively, as the charts show, the buyer of a PRDC/TARN is long a modified version of a call spread on USD/JPY.

Figure 85: P&L profile of TARN according to spot at inception



Note: the P&L profile of the PRDC shown earlier in this piece is very similar in nature to the TARN.
Source: Deutsche Bank.

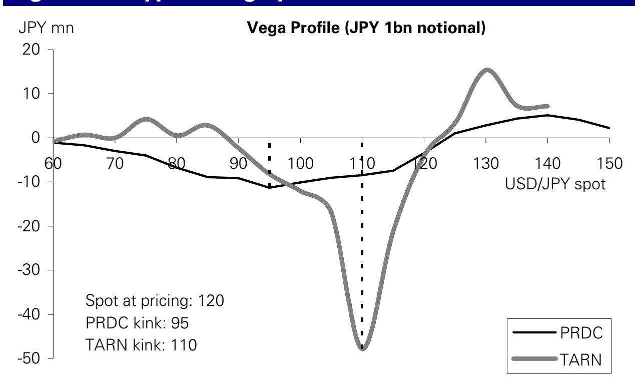
Hedging implications: what needs to be done when the Japanese yen moves

The issuance of both structures is usually straight-forward: note issuers (typically highly rated banks) will swap their cash flow exposure with a swap house, which will then hedge the position through buying and selling FX and FX options. In its simplest form, the pricing of PRDCs involves valuing the two main components of optionality - the cancellation (callability) clause, which the swap house buys, and the call option associated with the flooring of the coupon, which the swap house sells. A similar procedure is followed in the pricing and hedging of TARNs.

The most relevant question in the current environment of yen strength relates to the hedging of these structures. Both long dated dual currency-linked coupon notes analysed, together with just about any other yield-optimising principal protected product, tend to leave the hedging agent inherently short downside volatility and long upside volatility in USD/JPY, in similar fashion to being short a call spread.

The chart below displays that exposure more clearly. Here we show the vega profile of a typical TARN and PRDC issued in late February 2007. Numerous variations have been traded over the course of the years, though the economic exposure is broadly similar. The level of USD/JPY at issuance (around 120) also coincides with the average USD/JPY rate in the January-July period, hence providing a reasonable reflection of where the notes are most sensitive today to variations in spot FX. According to the example shown below, the current level of USD/JPY is associated with a net short FX vega position of JPY 7.5mn for a JPY 1bn PRDC, and a short FX vega exposure of JPY 21.2mn for a JPY 1bn TARN. The short vega peaks are at 20% and 10% below the starting spot rate, for the PRDC and TARN respectively, which generally reflects the coupon composition. Interestingly, the example shows that the short vega exposure of the TARN hedger peaks around USD/JPY 110, which is in line with current market talk that this is a sensitive level for those structures.

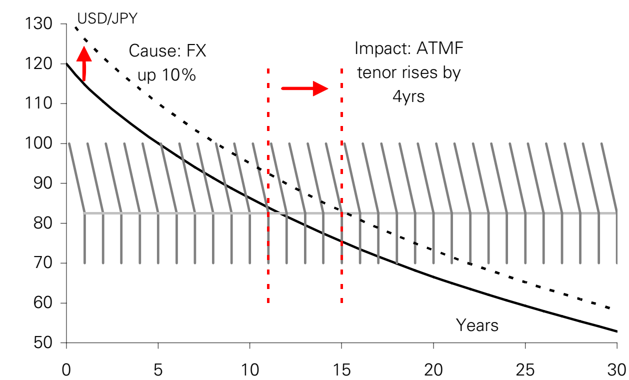
Figure 86: Typical vega profile for PRDC and TARN



Note: the notional of the notes amounts to JPY 1bn each. Source: Deutsche Bank

In addition to the size of the vega hedging requirement, another important component related to hedging these long-dated dual currency notes relates to the tenor of the vega exposure that needs to be hedged. As mentioned earlier, both PRDCs and TARNs provide the hedging agent with an economic exposure that resembles being short a call spread on USD/JPY. Given the nature of the embedded options, however, this "call spread" changes in tenor depending on the behaviour of spot FX and changes in interest rate differentials. In the PRDC example, a rise in the USD/JPY forward curve (either led by a higher spot or narrowing rate differentials) leads to a rise in the tenor where the USD/JPY forward crosses the 82.50 strike[86], hence leading to a rise in the ATMF option embedded in the structure. As a result, the hedging agent will need to purchase longer-dated options to hedge this short exposure. As per chart below, a 10% parallel rise in the USD/JPY forward curve will lead the vega tenor to move from 11 years to 14 years. On the other hand, the rise in USD/JPY brings the "callability" option (PRDCs) and the knock-out option (TARNs) closer in-the-money, thus reducing the overall size of the vega that must be hedged.

Figure 87: Impact of a rise in the FX forward curve on the tenor of the PRDC structure



Note: the gray lines are a representation of the USD/JPY calls purchased by the investor at a strike off 82.50, maturing at every coupon date. Source: Deutsche Bank

The opposite occurs as USD/JPY moves lower - the short vega exposure becomes of a shorter nature. Despite being easier to hedge, the loss in value of the "callability" option leads to a significant rise in the structure's overall short vega, with bigger implications for the book as a whole.

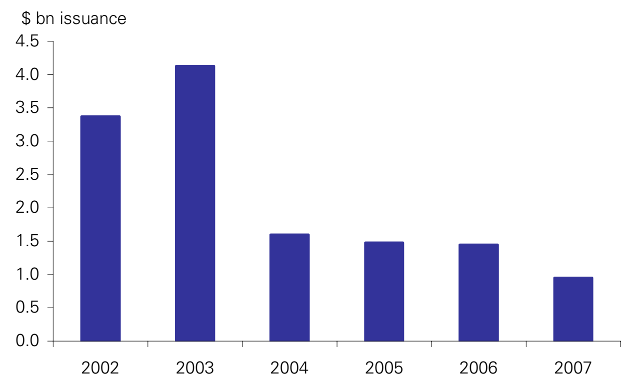
A sense of magnitude: how big are these structures?

Given that their hedging requirements have clear implications for price action, another key question relates to identifying the current size of the PRDC/TARN market. Such task is clearly difficult given the presence of private placements and the number of variations used depending on the needs of each particular investor. Estimates from Bloomberg and consultancy firm Dealogic put the annual issuance of these FX-linked MTNs at circa $ 1.5bn over the past three years (down from $ 3.5-4bn earlier in the decade), and the current stock outstanding adding up to around $ 1.4bn (given the amount of deals that have already been called). These figures, however, should be treated only as starting guidelines, as they do not take into account privately-issued notes. Some market participants estimate that the overall annual volume of PRDC-type structures has been as high as $ 25bn, which is also a good indication of the current amount outstanding. Of these, it is estimated that almost half of all new issuance is conducted in currency pairs other than USD/JPY (mostly AUD/JPY), up from an average of 25% earlier in the

[86] USD/JPY 82.50 is the level where the PRDC coupon is > 0; effectively, it is the strike of the calls bought by the investor at each coupon date.

decade, and that an increasing portion of issuance is targeted at smaller institutions as opposed to large banks. The discrepancy between market estimates and quantifiable figures serve to highlight the difficulty in coming up with an accurate measure of market size, even though the numbers below suggest the market size has shrunk over the recent past.

Figure 88: FX-linked MTN issuance estimates in JPY



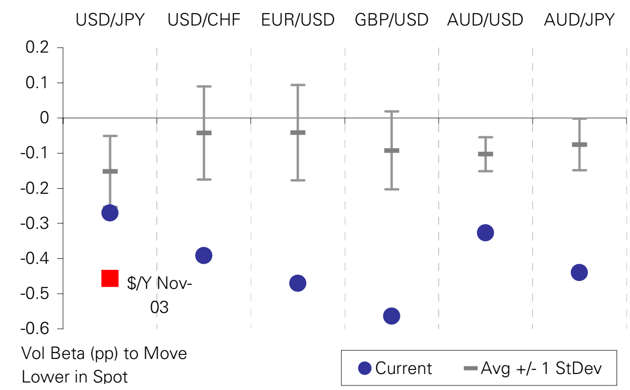
Note: these estimates do not include deals placed privately. Source: Dealogic, Bloomberg.

USD/JPY volatility – how has it behaved recently?

The next question relates to how does market exposure to PRDCs and TARNs tie-in with the recent behaviour of implied volatility in USD/JPY. Interestingly, the signs from the options market today suggest that the balance of supply and demand for JPY volatility is considerably more balanced than in the last comparable episode of Q4 2003[87]. One indication is shown in the sensitivity of 1-year implied volatility to downward moves in USD/JPY; the change in implied volatility was well in line with the accompanying behaviour of USD/JPY spot. Not only the change in implied volatility can be viewed as more "in line" with spot than in the case of the other main G-10 crosses, but it has also been much more tame than witnessed during the Q4-03 fall in USD/JPY.

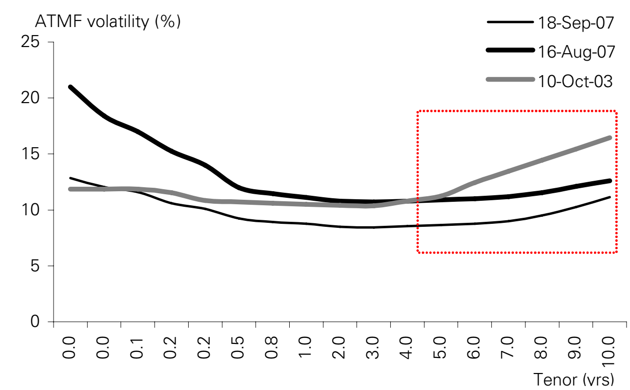
Another sign that the options market has not gone through a "demand shock" is shown in the levels reached by long-dated implied volatility in USD/JPY in light of August's carry unwind. While medium-term highs were reached at 12.5% (10-year implied volatility), these were far from the levels seen in late 2003; in addition, the 10Y-2Y spread actually flattened.

Figure 89: The sensitivity of 1Y implied volatilities to a move lower in spot FX



Note: data as of Jan-00. The sensitivities are calculated from weekly changes in rolling 6-month periods. We exclude upward moves in FX spot from the analysis. Source: Deutsche Bank.

Figure 90: USD/JPY volatility curve through time

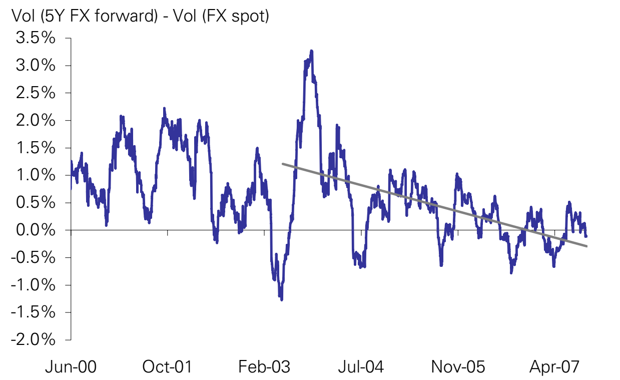


Source: Deutsche Bank

In our view, USD/JPY volatility can be attributed to four main factors. First and foremost, the size of the PRDC/TARN market has shrunk over the past year, due to early redemptions and market volatility. Second, the most recent wave of long-dated, FX-linked products traded in Japan includes structures that generate a somewhat offsetting vega profile for the market, such as Convex Forwards. Third, the rise in correlation between USD/JPY and interest rate differentials has reduced the volatility of long-dated FX forwards compared to USD/JPY spot. In other words, a fall in USD/JPY spot will have a steepening impact in the forward curve and therefore reduce the volatility of long dated forwards compared to FX spot. Finally, liquidity has improved considerably in the longer dated sectors of the USD/JPY volatility curve compared to the start of the decade; the rise in market depth also helped reduce volatility of long dated option prices.

[87] As had been alluded to in the note "Yen: A Perfect Storm Brewing?", 02-Oct-03.

Figure 91: USD/JPY historical volatilities – 5Y FX forward minus FX spot



Note: we use a rolling 3r-month window. Source: Deutsche Bank

So what is there to do now?

While the arguments above paint a better picture for implied volatility, they do not advocate that the impact of PRDCs and TARNs should be ignored. The level of long-term implied volatilities in JPY crosses is still well above the average for G-10.

<u>USD/JPY: sell the implied skew in 2-3Y volatility</u>

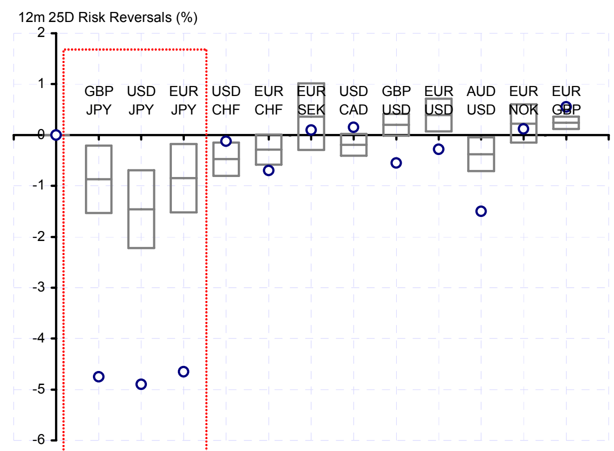
In USD/JPY, we believe the opportunity lies in trading the volatility skew. The vega profile of the structures above suggests that the demand for vega hedging is likely to accelerate if USD/JPY moves towards the 100-110 level, but fall considerably if it drops further towards the 85-95 level. Given how accurately this example reflects the average profile of the notes that were printed earlier this year, and the presence of other structures that generate further supply of vega at lower levels of USD/JPY, we believe there is a strong shift in the vega exposure of the hedging agents between these ranges in FX spot.

This *dVega/dSpot* dynamic is not at all reflected in the current level of risk reversals, which excessively favour lower delta JPY calls given their role as barometers for global risk aversion. Therefore, we favour trades that profit from a potential fall in the level of lower delta USD/JPY puts compared to higher delta USD/JPY puts. One type of structure that makes sense to us is buying ATMF 2Y USD/JPY puts (107.5) and selling 20-delta USD/JPY puts (93.5), for 2.1%, and hedging the delta exposure over the duration of the trade. Buying delta-hedged 2-year, 10-delta USD calls (strike 120.80) and selling 10-delta USD puts (strike 82.80) for a total cost of 60bp also looks attractive to us.

<u>AUD/JPY: buy 1Y-2Y implied volatility</u>

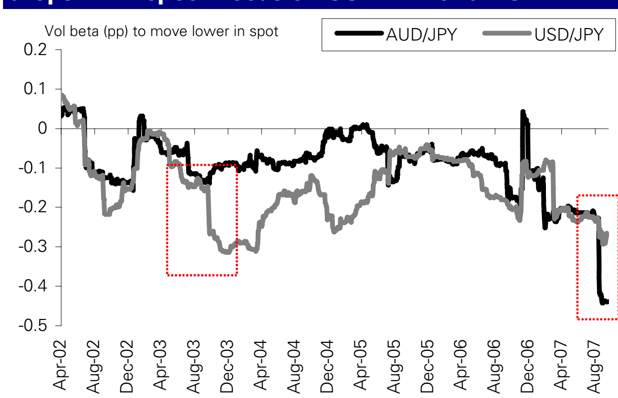
While most of the report has focused on the structures issued in USD/JPY, a similar amount of PRDC/TARN-type notes has been issued in AUD/JPY, which suggests that a similar type of vega profile exists in that currency pair. On the other hand, our estimates of market volume suggest that the liquidity in long-dated AUD/JPY volatility is considerably lower than that of USD/JPY; in fact, it looks similar to that of USD/JPY in 2003. Judging by the behaviour of 1-year implied volatility in both currency pairs now and in Q4-03, we notice strong similarities between the sensitivity of AUD/JPY volatility (to a drop in FX spot) today and the equivalent for USD/JPY in late 2003. Should another aggressive move lower occur in AUD/JPY spot, as witnessed in August, we believe implied volatility may well jump in similar fashion to how it has in August, even from today's already elevated levels. Therefore, we favour option positions that are long implied volatility in AUD/JPY in longer (but reasonably liquid) tenors such as 2Y or 3Y.

Figure 92: 12-month risk reversals in G-10 FX



Note: the numbers in the box refer to average +/- 1 standard deviation. The blue circles represent the current risk-reversal values. We use 6 years' worth of daily data. Source: Deutsche Bank

Figure 93: The sensitivity of 1Y implied volatilities to drops in FX spot – focus on USD/JPY and AUD/JPY



Note: data as of Jan-00. The sensitivities are calculated from weekly changes in rolling 6-month periods. We exclude upward moves in FX spot from the analysis. Source: Deutsche Bank.k

Section 2: Cross Asset Reports

Breaking Down the Equity/FX Barrier (25/06/08)

Positioning for Equity-FX Correlation

In a recently published report entitled, "FX Exposure in International Equity Portfolios," we highlighted the relationship between a country or region's local equity index and its currency. This correlation has received particular attention of late, especially in the US, where international equity portfolios have not only benefited over the last several years from local market appreciation, but also have appreciated even more so due to the "tailwind" of the depreciation of the dollar. As the market reaches what some consider to be a floor on the dollar, investor focus has shifted to the impact that the currency will have on equity portfolio returns.

Hybrid barrier options allow investors to combine a view on equity and FX

This report highlights a new hybrid product – the hybrid barrier option[88] – which enables investors to express nuanced views on the link between the FX and equity markets. Our analysis focuses on vanilla equity options that contain knock-in or knock-out features tied to FX rates. These products can be used to cheapen downside protection or upside participation. An investor with a good understanding of the equity-currency correlation for a given market will be well-positioned to take advantage of these structures.

Our analysis also breaks down several key factors for hybrid options, most noticeably currency skew, forward bias and correlation. We offer suggestions on which instruments may be the most attractive to employ at this time. We believe that investors can take advantage of the forward bias—to be discussed below—by employing strategies that utilize hybrid barrier options. In particular, we like:[89]

- *A 6-month ATM put on the S&P 500, with a knock-out if AUD/USD moves 7.5% below current spot, which costs 48% of the vanilla put price*
- *A 6-month ATM put on the Nikkei 225 with a knock-out if AUD/USD moves 7.5% below current spot, which costs 51% of the vanilla price*
- *A 6-month ATM call on the S&P 500 or Nikkei 225, with a knock-in if EUR/JPY rises 8% above current spot, which costs 38% of the vanilla ATMS price*

[88] For more information on hybrid barrier options, see the EDSG report, "Breaking Down Barriers", 4-Apr-08. Contact consult.edsg@db.com. Hybrid barrier options may also be referred to as "outside" or dual asset barrier options.
[89] All price levels are indicative. Please contact Equity Derivatives Sales in your region for pricing (see contact sheet at the end of this document).

Equity/FX Correlation and the Interest Rate Link

Carry trades spur the relationship between FX and equity markets

The relationship between developed currency and equity markets has been linked to interest rates. The performance of currencies with the highest and lowest interest rates amongst the G-10 has, over recent years, been highly correlated with that of domestic – and arguably, global – equity markets.

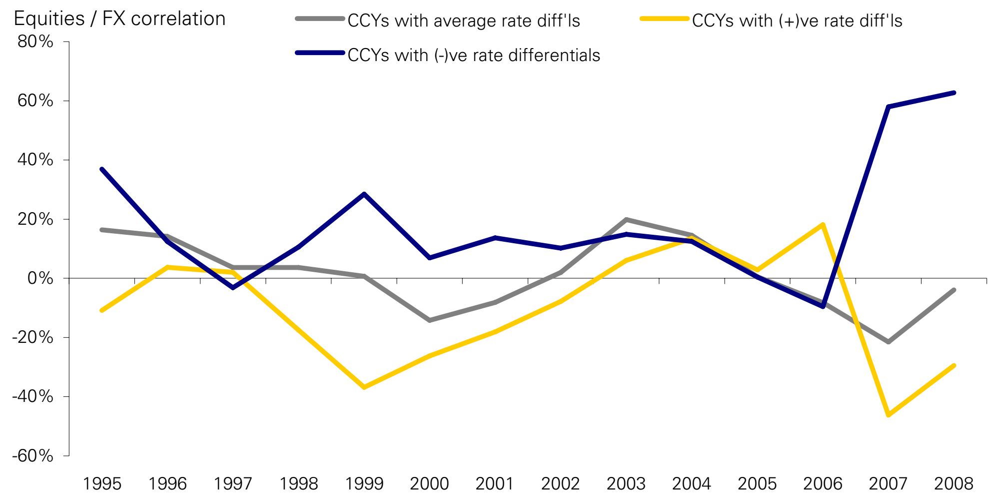
This link of equity/FX correlation to rates is intuitive; currencies with either very high or very low yields have been increasingly viewed as trading instruments in their own right (as part of the FX carry trade[90]), as opposed to simply a part of an international equity, fixed income or FDI transaction. Therefore, they are more influenced by risk appetite factors that drive international capital flows and also influence global equities.

Conversely, currencies of countries with interest rates that are closer to the G-10 average have historically been less correlated with the outright performance of domestic equity markets, as the two classes are driven by separate dynamics; in such cases, the link is more widely felt via the impact (on FX) from un-hedged equity flows.

Figure 94 shows correlations between the currency and equity markets for three subsets of markets. Note that currency pairs with the greatest interest rate differentials have experienced the strongest relationship with their country's underlying equity market performance since 2006 when FX carry trades re-emerged. It also shows that periods of excess risk-seeking behaviour, or periods of risk aversion, exhibit the strongest rise in correlation between a country's currency and its equity market, which normally results from adjustments in investor positioning.

[90] FX carry trades involve going long a high-yielding currency against a lower-yielding currency. Carry traders pocket the interest rate differential, net of FX spot changes. For a detailed review of the FX carry trade, please refer to *FX Forward Rate Bias Goes Global*, September 27th, 2005.

Figure 94: Progression of FX-equity correlations



Note: correlation of returns. We used the correlation of daily log-changes, concentrated on days of trending equity markets, in order to better capture the dual asset dynamic. The results for the full data sample (including trendless markets) are similar if using less frequent observations (1-week, 1-month). The currencies are quoted against the USD. Source: Deutsche Bank

Carry trade considerations dominate portfolio rebalancing effects in countries with very high or very low interest rates

This argument is supported by the academic evidence and flow data alike. For instance, the most recent BIS surveys of exchange rate activity have all pointed to the growth in carry trade-type flows in currencies such as the Japanese yen, Swiss franc and Australian dollar. On the other hand, studies that discuss the uncovered equity return parity condition (UERP) and portfolio rebalancing dynamics have generally yielded stronger results in countries whose interest rates are on average within the G-10, such as the Euro, and weaker results in countries with very high or very low interest rates (such as Australia and Japan)[91].

[91] See, for instance, Cappiello and Santis, *Explaining Exchange Rate Dynamics—"The Uncovered Equity Return Parity Condition," ECB Working Paper Series,* September 2005.

Hybrid Equity/FX Options

Breaking down the barrier options

The link between FX and equity markets can be directly used for the advantage of traders in both asset classes through the implementation of hybrid barrier options. Barrier options are structures which involve a vanilla option and a trigger (knock-in or knock-out) barrier. Hybrid equity/FX barrier options are structures that include a vanilla option in one underlying asset (in this case, an equity index) with a barrier on a separate underlying asset (in this case, a currency pair). Depending on the particular structure, hybrid options may be particularly efficient for currency pairs with large interest rate differentials where the link between FX and equities has historically been strongest, as we discuss below. In this article, we concentrate on the following types:

- *Down-and-out puts*: a put on an equity index that "knocks out" (ceases to exist) if a currency pair reaches a certain level below the current spot rate.
- *Down-and-in puts*: a put on the equity index that "knocks in" (is enacted) only if a currency pair reaches a certain level below the current spot rate.
- *Down-and-out calls*: a call on the equity index that "knocks out" (ceases to exist) if a currency pair reaches a certain level below the current spot rate.
- *Up-and-out calls*: a call on the equity index that "knocks out" (ceases to exist) if a currency pair reaches a certain level above the current spot rate.
- *Up-and-in calls:* a vanilla call that "knocks in" (is enacted) only if a currency pair reaches a certain level above the current spot rate.

Hybrid barriers express directional views on equities and currencies, as well as their correlation

We believe there are three main factors that impact the equity/FX hybrid barrier option in addition to volatility and moneyness: currency skew, the forward bias, and the correlation between the two underlying instruments. The next sections address these factors.

Currency skew

Rate differentials and skew can help cheapen options

One of the factors determining the probability of a trigger being reached is the implied volatility skew of the particular underlying, in this case the currency. Currencies with higher interest rates are typically viewed as "riskier"[92] than currencies with lower interest rates, and hence the higher the rate differentials, the higher the skew, implying that a large downside move is more likely. Therefore, investors should look to interest rate differentials as an input to hybrid barrier option choices given how carry relates to skew over time.

In this article, we define rate differentials as the difference between the terms currency and the base currency in a given currency pair[93], and "skew" as the difference between calls and puts on a currency pair with the same tenor and delta. In order to get a sense of the relationship between skew and interest rate differential, we present Figure 95, which shows currency skew as measured by risk reversal levels (25 delta call implied vols – 25 delta put

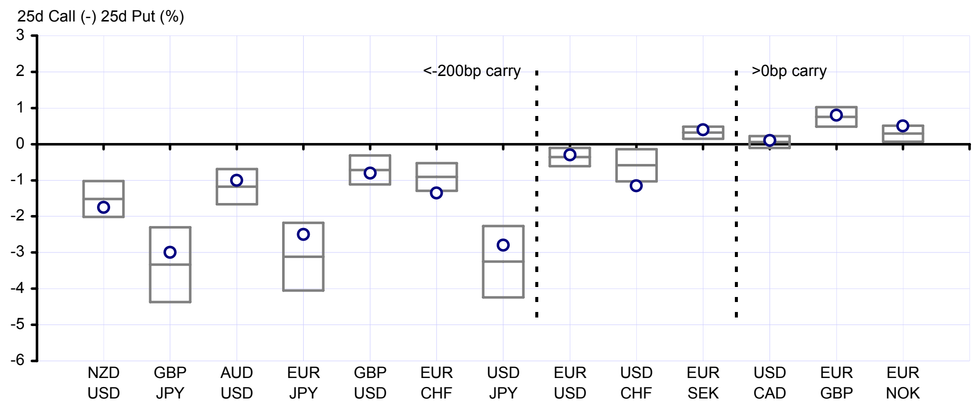
[92] For a more detailed discussion on carry, and its interaction with volatility indicators, please refer to FX Derivatives Focus, 29 October 2007.

[93] Put simply, it's the difference between the "numerator" and "denominator" currencies. In EUR/USD, which is currently at 1.56, the USD is the numerator currency and the EUR the denominator despite being quoted the opposite). The rate differentials in this currency pair is defined as the USD interest rate minus the EUR interest rate.

Skew is largest for the JPY crosses

implied vols) versus common FX pairs.[94] We see that skew is larger for JPY currency pairs due to the low interest rates in Japan. Given its impact on the market-implied probability that a certain barrier will be reached, skew can be exploited so as to cheapen FX barrier option structures.

Figure 95: Risk reversal levels in G-10 FX, ranked according to interest rate differentials



Note: the currency pairs are lined up in ascending order of interest rate differentials (denominator – numerator currency). The edges of the rectangles represent 1 standard deviation away from the average historical level and the circles represent current levels (1-year sample). Source: Deutsche Bank

All else equal, a higher skew will imply a greater likelihood of downside moves, since skew translates to the density function of the underlying changes in FX. As a result, this profoundly impacts the probability of a trigger being breached. But it's not the only factor…

Forward Bias

Research shows that FX forward rates are unreliable estimates of future spot rates

Hybrid barriers are priced assuming a risk-neutral distribution for the trigger currency, which is centered around the current forward rate. However, the FX forward is simply a function of two countries' interest rates, and may be an inaccurate estimator of the future spot rate.

It is widely documented that forwards are worse estimators of future spot rates than current FX spot rates when looking at intervals of less than one year[95]. Therefore, the market-implied probability of a certain FX level being reached in future – the basis of barrier option pricing – also suffers from the same bias. Such probabilities are further affected by curve skew, a factor which tends to exacerbate the bias as it raises the level of volatility associated with strikes that are farther from FX spot and in the direction of the forward.

Risk-neutral density functions are skewed towards the depreciation of high-yielding currencies and we find that option markets may price in too much "tail risk" for high-yielding currencies

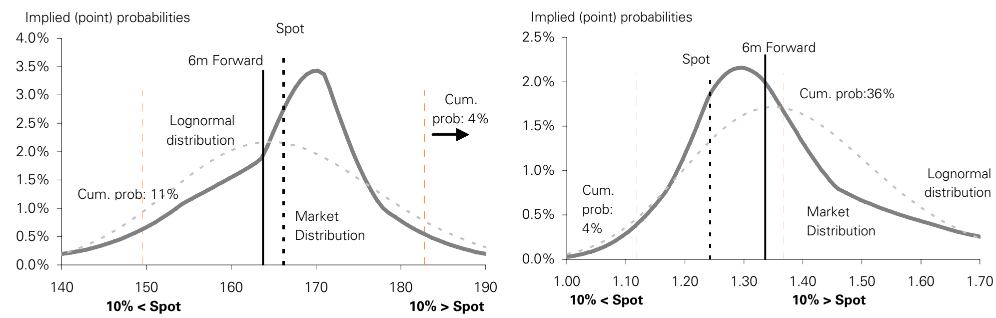
For example, consider the 6M option implied probabilities of 10% moves away from spot for EUR/JPY in Figure 96 (left). The risk-neutral density function (dark grey) is centered to the left of spot, implying a market expectation of Euro depreciation, resulting from the negative interest rate differential. Furthermore, the density function is negatively skewed, implying a higher tail risk of Euro depreciation. The cumulative probability of a 10% or greater EUR/JPY depreciation over 6 months is 11%, versus 4% for a 10% or greater EUR/JPY appreciation. Centering the distribution around spot would decrease the tail probability of a fall in EUR/JPY. The option market may be overpricing EUR depreciation versus the JPY, something the hybrid barrier option investor can take advantage of.

[94] A negative risk reversal reading in USD/JPY, for instance, means that JPY calls (USD puts) are favoured over JPY puts (USD calls).

[95] There is vast academic literature on the subject of forward rate bias. See, for example, Burnside, Eichenbaum, Kleschelski and Rebelo (2006), "The Returns to Currency Speculation."

These cumulative probabilities are skewed even further for the Turkish Lira, also shown in Figure 96 (right). Option markets are pricing in a 36% chance of a 10%-plus depreciation of the TRY against the USD over the next 6 months, versus 4% for a 10% or greater appreciation of lira against the US dollar. Had we used spot as the center of the risk-neutral distribution, the probabilities would have changed and likely been more symmetrical.

Figure 96: Options-implied probabilities–of a 10% move away from spot in EUR/JPY (left) and and USD/TRY (right).



-Note: the y-axis shows "point" probabilities – the cumulative probabilities are captured by summing up the area between the red dotted lines and the tail of the solid gray lines. Spot reference: EUR/JPY 166.20. Source: Deutsche Bank

Note: the y-axis shows "point" probabilities – the cumulative probabilities are captured by summing up the area between the red dotted lines and the tail of the solid gray lines. Spot reference: USD/TRY 1.24. Source: Deutsche Bank

Downside knock-outs and upside knock-ins options may offer discounts for high-yielding currencies

Barrier option structures using FX knock-outs will tend to look more attractive in instances where the implied risk-neutral distribution may overstate the probability of knocking out, whereas FX knock-ins will be more attractive when implied probabilities understate the likely moves in a currency pair. In particular:

- *Downside knock-out and upside knock-in barriers for currency pairs with negative interest rate differentials may look attractive:* the surface-implied probability of levels below spot to be reached will be greater than that of levels above spot. Such cases include the surfaces of USD/JPY (biased towards JPY appreciation) and AUD/USD (biased towards USD appreciation). To the extent that this differs from the empirical probability, it makes downside knock-out barriers and upside knock-in barriers attractive.

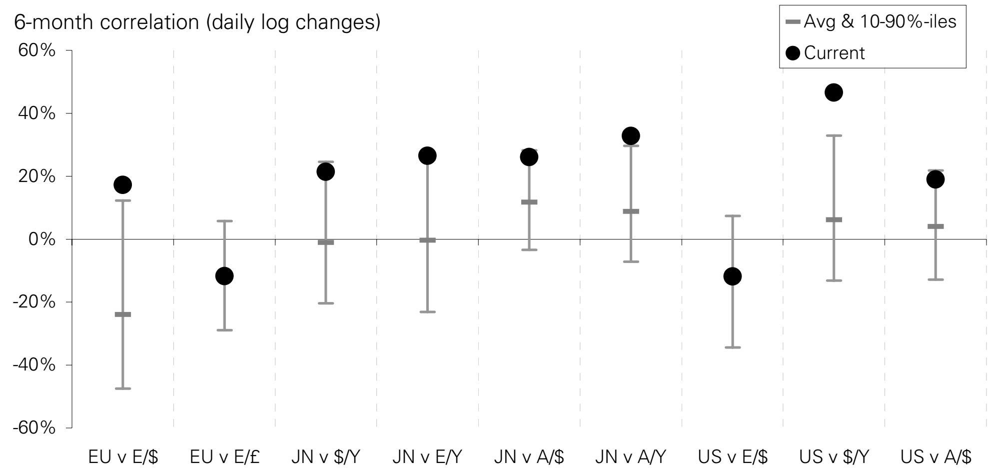
- *Upside knock-out and downside knock-in barriers for currency pairs with positive interest rate differentials may look attractive*: levels above FX spot are viewed by options markets as more likely to be triggered than levels below current spot. USD/EM currency pairs fall into this category. If these market-derived probabilities differ considerably from the empirical behaviour, downside knock-in and upside knock-out barriers will look attractive.

Correlation

Correlation impacts the likelihood a currency barrier will be triggered if the equity option moves closer to the money

Finally, correlation is also an important component in the pricing of hybrid barrier options, as it defines the strength of the relationship between the equity index and currency pair. Correlation will impact the likelihood that a hybrid barrier option will be in-the-money at maturity. Figure 97 shows historical ranges of equity/FX correlations for a variety of regions. Looking at this measure can be particularly useful when the investor believes the correlation coefficient implied by the hybrid option differs from his or her view on how correlated the assets will be in the future.

Figure 97: Equity – FX correlations in Europe, Japan and USA



Note: we look at data since 1995. EU stands for the EuroStoxx50, JN stands for the Nikkei 225, and US stands for the S&P 500. The currency pairs are, in order, EURUSD, EUR/GBP, USD/JPY, EUR/JPY, AUD/USD, AUD/JPY, EUR/USD, USD/JPY, and AUD/USD. Source: Deutsche Bank, Bloomberg.

Taking a view on EUR/JPY correlation with the Nikkei 225 Index: 3 examples

Here we present the case of the relationship between the Nikkei 225 index and EUR/JPY rate. The two assets have held a long-term average correlation of around 0%, though it can rise to levels as high as 40% when markets are risk-averse (equity markets are weakening and FX carry trades are being unwound). Consider these situations:

- ***Bearish on the Nikkei 225 Index, long equity / FX correlation view***: Given the potential for co-movement between the index and the FX rate, an investor who is bearish on the Nikkei 225 may express a long correlation view through an option that knocks in if EUR/JPY moves lower by a particular amount (a hybrid down-and-in put). The argument is that the same reasons that may lead the investor to be right on the Nikkei – it falls due to risk aversion – will also lead to a move lower in EUR/JPY to the point that it triggers the put option into existence.

- ***Bullish on the Nikkei 225 Index, long equity / FX correlation view***: Another long correlation trade is to use a currency barrier to annul an equity option that is likely to expire worthless anyway. Here, the investor buys a call on the Nikkei 225 with a knock-out trigger in EUR/JPY, at a level below the current spot rate (a hybrid down-and-out call). The intuition is that if the investor is wrong on the Nikkei – instead of rising, it falls – EUR/JPY will also fall. The price of this hybrid call is cheaper, and it will expire before the vanilla call as the EUR/JPY barrier gets triggered. Yet from a long correlation viewpoint, the vanilla Nikkei call would have likely expired out-of-the-money as EUR/JPY depreciated.

- ***Bearish on the Nikkei 225, short equity / FX correlation view***: Alternatively, investors may take a short correlation view using down-and-out puts. This Nikkei put option will knock-out only if EUR/JPY falls below a certain level. A short correlation position may be appropriate if the investor believes that the correlation levels implied by hybrid options are too high relative to historical realized correlations. Put another way, the investor may believe that the correlation between EUR/JPY and the Nikkei realized over the life of the option will revert to the long-term historical mean of approximately 0%. In this scenario, the potential for positive correlation between EUR/JPY and the Nikkei has been well priced into the down-and-out put, cheapening the option to attractive levels. So long as EUR/JPY does not fall as the Nikkei declines, the investor has purchased cheap protection on the Nikkei.

Skew, forward bias and correlation all impact hybrid barrier options. Investors should choose option positions that not only reflect their views on the currency and equity markets but also take advantage of insights into these factors. Figure 98 displays a summary table of the market views that each hybrid barrier option expresses, as well as currency factors that may cheapen each option:

Figure 98: Market views and cheapening factors of various hybrid barrier options (equity underlyings with an FX barrier)

	Down-and-out put	Down-and-in put	Down-and-out call	Up-and-out call	Up-and-in call
Market Views:					
Equity Directional View	Bearish	Bearish	Bullish	Bullish	Bullish
Currency Directional View	Neutral or Bullish	Bearish	Neutral or bullish	Neutral or bearish	Bullish
Currency Volatility View	Low	High	Low	Low	High
Equity / FX Correlation View	Short	Long	Long	Short	Long
Cheapening factors					
Forward Bias	Forward below Spot Rate	Forward above Spot Rate	Forward below Spot Rate	Forward above Spot Rate	Forward below Spot Rate
Currency Skew	Steep	Flat	Steep	Steep	Flat

Note: interest rate differentials are calculated as the yield on the terms currency minus that of the base currency. In USD/JPY, it is the JPY rate minus the USD rate, which in this case leads to a negative rate differential. In the currency skew section, "steep" means lower delta calls on the terms currency are favoured over higher delta calls, and "flat" means higher delta calls on the base currency are favoured over lower delta calls. Source: Deutsche Bank

Comparing the Options

A look at pricing of equity/ FX hybrids

Barrier options can be used to potentially exploit the forward rate bias for carry pairs

Our analysis shows that down-and-out puts and up-and-in calls for currency pairs with negative interest rate differentials benefit from the bias in forward FX rates. Figure 99 shows a set of examples on the pricing of such types of structures. Here we concentrate on the largest equity markets (S&P 500, EuroStoxx 50, Nikkei 225), and liquid currency pairs with substantially negative interest rate differentials (USD/JPY, EUR/JPY, AUD/USD)[96]. For possible pricing improvement, we've chosen to allocate the FX strikes at 5%, 7.5% and 10% away from the forward in the case of knock-out puts[97], and 6%, 8% and 10% away from the forward in the case of knock-in calls[98].

The lines show the price of 6-month at-the-money spot (ATMS) equity calls and puts with the FX knock-in and knock-out features, expressed as a percentage of the vanilla equity option.

As displayed, the price of the knock-in structures fall, in quasi-linear fashion, as the barrier level moves further away from current spot. This is due to the fact that options markets price a progressively lower probability of the options ever going in-the-money, as also evidenced by the falling empirical probabilities. Conversely, the hybrid down-and out put options cost less where the FX barrier is closer to spot.

The carry in AUD/USD has the strongest impact in higher-delta barriers, while the EUR/JPY skew is most noticed in lower-delta barriers

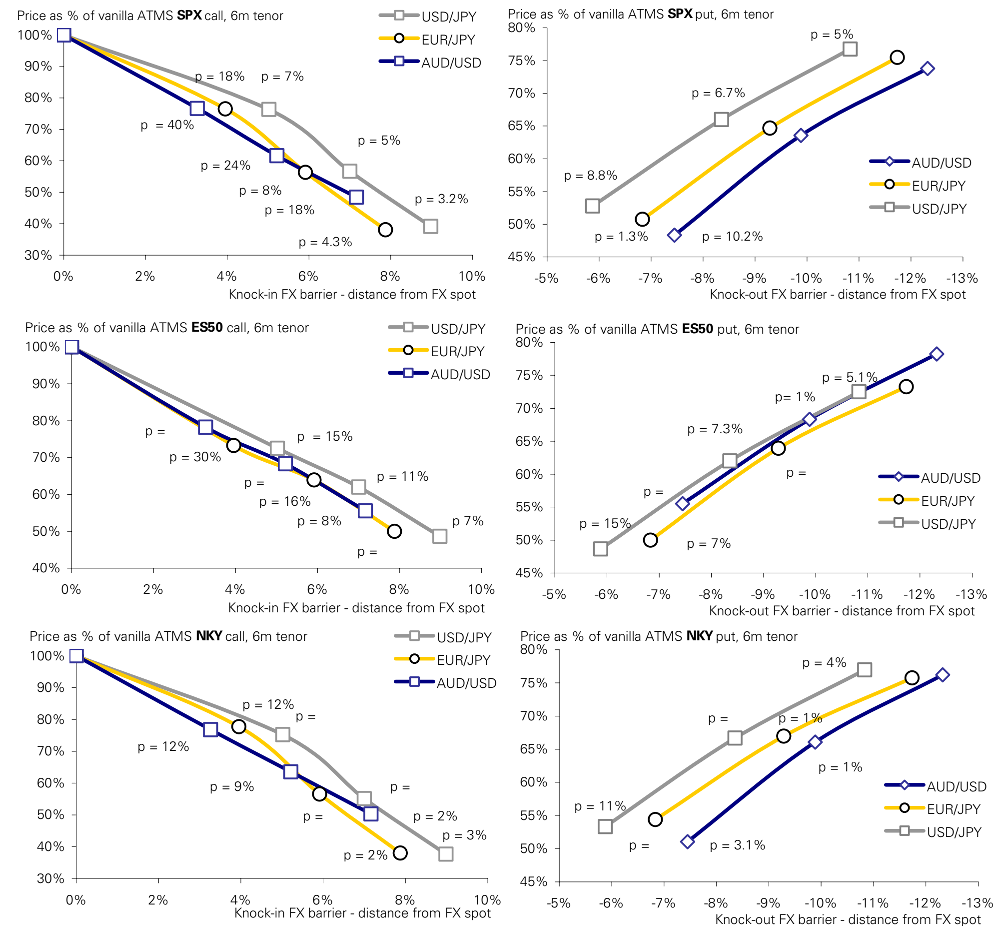
Also note the relative expensiveness of USD/JPY barriers compared to the other crosses, especially in the S&P 500 and Nikkei 225 options. This is largely a function of the fall in the interest rate differential between the Japanese yen and the USD, which adversely impacts the pricing of the barriers (the knock-out probabilities fall and the knock-in probabilities rise). The interaction between carry and skew should also be highlighted in AUD/USD and EUR/JPY. Although the final price is chiefly defined by the implied correlation (and volatility) assumptions, carry and skew are also important pricing factors – especially in the shape of the pricing curve. As the charts show, the carry in AUD/USD gives it greater cheapening advantage in the barriers that are closer to spot, though such impact is overpowered by the more aggressive skew in EUR/JPY as the FX barrier levels move further away from spot and the forwards.

[96] We refrained from looking at currency pairs with large positive interest rate differentials as these are mostly concentrated in emerging markets, and liquidity can be an issue.

[97] These represent 5.9%, 8.4% and 10.8% in USD/JPY, 6.8%, 9.3% and 11.7% in EUR/JPY and 7.4%, 9.9% and 12.3% in AUD/USD, respectively.

[98] These represent 5%, 7%, and 9% away from spot in USD/JPY, 4%, 6% and 8% in EUR/JPY and 3.3%, 5.2% and 7.2% in AUD/USD, respectively.

Figure 99: The FX factor – down-and-out puts, and up-and-in calls with FX barriers



Note: the vanilla prices for puts and calls are, respectively, 5.38% and 5.7% (S&P 500), 5.24% and 6.15% (EurStoxx 50), and 6.6% and 6.4% (Nikkei 225). Prices are indicative only. Source: Deutsche Bank.

The table above shows, in our view, the following attractive investment alternatives:

- ***Equity puts whose FX knock-out barriers are 5% away from the current forward (6-8% away from spot)***: these are roughly half the price of the vanilla put and require a 6-8% move in FX from current spot levels. Such examples would be a 6-month ATMS put on the S&P 500, with a knock-out if AUD/USD moves 7.4% below current spot, and costing 48% of the vanilla put price. Another example is a 6-month ATMS put on the Nikkei 225 with the equivalent knock-out in AUD/USD, and costing 51% of the vanilla price.

- ***Equity calls whose FX knock-in barriers are 10% away from the forward (7-9% from spot):*** these can cost even less than half the price of the vanilla call given the cheapening factors. Investors who are bullish both asset classes should consider calls on the S&P 500 with a knock-in if EUR/JPY moves 10% above the forward (7.9% from spot), which cost a respective 38% of the vanilla ATMS price. They should also consider calls on the Nikkei 225 with the equivalent knock-in features in EUR/JPY, which cost 38% of the price of the vanilla call.

Conclusion

The view on what option is most attractive will likely differ according to each reader. We highlight that the two currency pairs whose hybrid barriers seemed most attractive were precisely those with the highest rate differentials (AUD/USD) and the most aggressive skew (EUR/JPY). As shown, these can be used to considerably cheapen the price of a vanilla option, and be suited for investors with views on how both asset classes will interact with each other over the horizon of the trade.

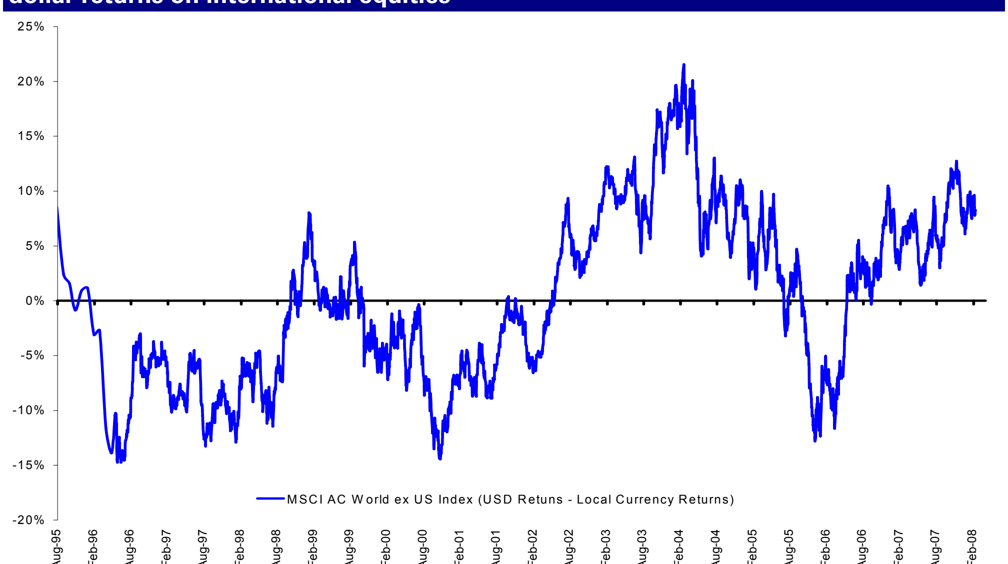
FX Exposure in International Equity Portfolios (14/02/08)

Currency benefits for USD-based holders of foreign equities during 2002-07

More than half the out-performance of international equity portfolios for USD-based investors since 2002 reflected USD weakness rather than local equity market out-performance

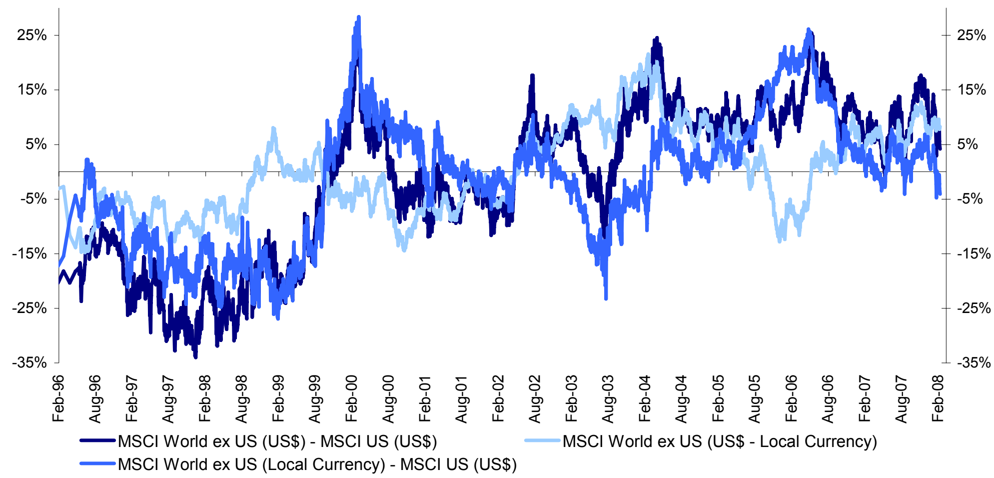
Unlike the second half of the 1990s, when dollar appreciation was a constant drag on international equity performance for USD-based investors, since the early 2002 peak, the dollar's depreciation has been a significant boon (see Figure 100 and Figure 101). Even including the period of the dollar's relatively short-lived rally in 2005, the depreciation of the dollar against the major currencies since early 2002 added an average 5.8% annually to the USD return on the MSCI All Country World Index ex the US. For calendar 2007, the dollar's slide was responsible for an impressive 8.8% of out-performance. The dollar's depreciation accounted for 60% of the out-performance of international equity portfolios relative to US equities since 2002 and 80% of the excess return during 2007. The phenomenon affected holdings in virtually every foreign currency, with some rather extreme observations in emerging markets. For example, a US investor who put $1 into the Bovespa index on 1-Jan-07 had a portfolio worth $1.72 on 31-Dec-07, a handsome profit that exceeded the return on the S&P 500 Index by almost 70 percentage points. The Bovespa, however, only appreciated 43.6% in 2007; the remaining performance was due to the depreciation of the US dollar (see Figure 102).

Figure 100: The dollar's depreciation since early 2002 has added significantly to US dollar returns on international equities



Source: Deutsche Bank

Figure 101: The dollar's depreciation has been the main contributor for international equity out-performance since mid-2006



Source: Deutsche Bank

Currency Classifications:

EM: emerging markets

G10: developed countries

HY: high-yielding currencies

LY: low-yielding currencies

Figure 102: International equity performance – local v. USD returns, 2007

Ticker	Name	Country	Ccy	Ccy Classification*	Local Return	USD Return	Return from Local Ccy Appreciation
XU100	ISE NATIONAL 100	TU	TRY	EM/HY	42.0%	71.8%	29.8%
IBOV	BRAZIL BOVESPA	BZ	BRL	EM/HY	43.6%	72.5%	28.8%
SPTSX60	S&P/TSX 60	CA	CAD	G10	8.8%	8.8%	26.4%
WIG20	WSE WIG 20	PD	PLN	EM	4.5%	4.5%	23.2%
AS51	S&P/ASX 200	AU	AUD	G10/HY	3.8%	24.3%	20.5%
SENSEX	BSE SENSEX 30	IN	INR	EM/Asia	47.1%	65.3%	18.2%
OBX	OBX STOCK	NO	NOK	G10	13.7%	31.3%	17.6%
SHCOMP	SHANGHAI SE COMP	CH	CNY	EM/Asia	96.7%	110.6%	13.9%
SX5E	DJ EURO STOXX 50	EC	EUR	G10	6.8%	18.5%	11.7%
NZSE50FG	NZX 50 FF GROSS	NZ	NZD	G10/HY	-0.3%	8.1%	8.5%
FSSTI	STRAITS TIMES	SI	SGD	EM/Asia/LY	18.7%	26.5%	7.8%
SMI	SWISS MARKET	SZ	CHF	G10/LY	-3.4%	4.1%	7.5%
OMX	OMX STOCKHOLM 30	SW	SEK	Sweden/LY	-5.7%	0.3%	6.0%
NKY	NIKKEI 225	JN	JPY	G10/LY	-11.1%	-5.4%	5.7%
TOP40	FTSE/JSE AFRICA TOP40	SA	ZAR	EM/HY	16.1%	18.6%	2.5%
UKX	FTSE 100	GB	GBP	G10/HY	3.8%	4.9%	1.1%
TWSE	TAIWAN TAIEX	TA	TWD	EM/Asia/LY	8.7%	9.5%	0.8%
SPX	S&P 500	US	USD	--	3.8%	3.8%	0.0%
HSI	HANG SENG	HK	HKD	EM/Asia	39.3%	38.8%	-0.5%
MEXBOL	MEXICO BOLSA	MX	MXN	EM/HY	11.7%	11.1%	-0.5%
KOSPI2	KOSPI 200	SK	KRW	EM/Asia	30.1%	29.3%	-0.9%

Source: Deutsche Bank

The weakening of the USD was a major theme in the currency markets for the year, but the impact on international equity portfolios has been, in our view, somewhat underappreciated. Should the USD reverse course, the resulting drag on overseas holdings by US investors could be significant. In this report, we focus on the impact of foreign currency risk in international equity portfolios, and discuss strategies to hedge currency risk for the upcoming year.

A Turning Point for the USD?

Introduction

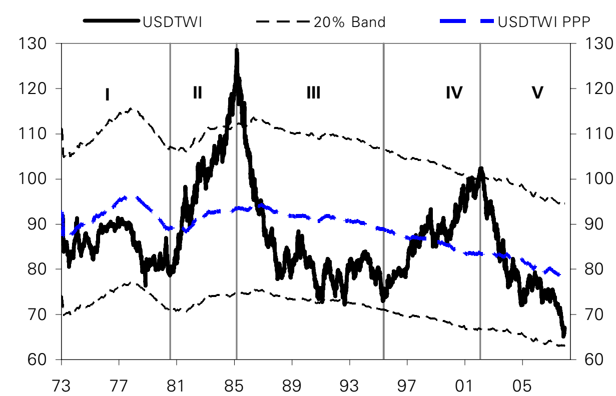
Before discussing strategies to hedge currency exposure in international equity portfolios, it is important to give some context to the current currency environment, in particular, the weak USD. We review lessons from previous cycles to gauge the likelihood of a recovery in the USD, and discuss the factors that drive the currency cycle and point to signs of a potential reversal in the USD.[99]

Lessons from previous USD cycles

The current dollar downcycle of -37% over 6 years compares to an average of -40% and 7 years

Since the end of the Bretton Woods era of fixed exchange rates the USD has exhibited a clear pattern of long-term cycles. In particular, we identify five distinct cycles from 1973 (see Figure 103 and Figure 104 below). They have had an average length of 7.1 years and an average magnitude of 40%.

Figure 103: The USD cycle is mature



Source: Deutsche Bank Global Markets, Bloomberg.

Figure 104: Magnitude and duration of past USD cycles

Start	End	Years	% Change
1-Jan-73	10-Jul-80	6.6	-14.1
11-Jul-80	25-Feb-85	4.7	63.4
26-Feb-85	8-May-95	10.2	-43.2
9-May-95	27-Feb-02	6.8	40.1
28-Feb-02	????	5.9 (so far)	-37%
Average (absolute)		7.1	40.2

Source: Deutsche Bank

Over the last 6 years, the USD has fallen 37% against the majors, suggesting that the current USD down-cycle is 'mature' and nearing its end. That said, currencies can remain under or overvalued in PPP terms for extended periods of time, and cycle lengths of USD cycles are, in of themselves, subject to change. Recoveries in the USD tend to be asymmetric: the USD has historically exhibited a 'V' shape correction from overvaluation extremes (in 1985 and 2002), but has taken a long time to recover from undervaluation extremes (late early 1980s

[99] Please see "Exchange Rate Perspectives," Global Markets Research, 18-Dec-07.

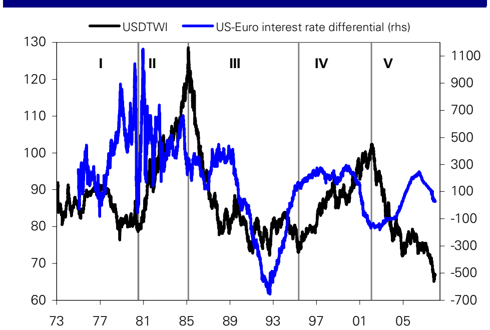
and 1990s). At first sight, this suggests that the USD may take some time to recover from current lows.

Drivers of turns in USD cycles

What drives turns in USD cycles and how can we identify the turning points? We see several factors as important drivers of the USD trend:

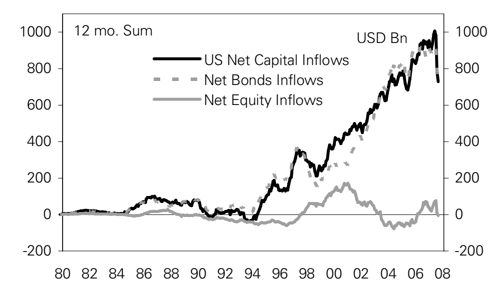
- *The US Current Account:* Upturns from USD down-cycles are usually preceded by significant adjustments in the US external accounts – with the current account deficit having peaked in Q4-2005 (as a share of GDP). However, the time lag between improvements in the trade deficit and turns in the USD are long and variable.
- *Interest Rate Differentials:* In general, a turn in interest rate differentials in favor of the USD occurs before the start of an upturn in the USD cycle (Figure 105). Interest rate differentials can vary in importance as an explanatory factor in terms of explaining exchange rate fluctuations and are subject to its own cycles.
- *Capital and Portfolio Flows:* The beginning of a USD up-cycle usually requires long-term increases in fixed-income and equity inflows into the US. The importance of each changes with time, with fixed-income inflows currently the predominant source of capital flows into the US. US net capital inflows have fallen off sharply since the financial crisis last summer but can be expected to recover with the US economy in H2 2008 (Figure 106).

Figure 105: The USD cycle and interest rate differentials



Source: Deutsche Bank Global Markets, Bloomberg.

Figure 106: US Net Capital Inflows have fallen off sharply



Source: Deutsche Bank Global Markets, Bloomberg.

Why the USD might be close to bottoming

Several factors point to a potential reversal in the USD…

We see several themes pointing towards the current USD down cycle being close to an end:

- The USD is close to the bottom of its historical valuation bands
- The US trade deficit is narrowing
- Interest rate differentials should move in favor of the USD by 2H 2008, as we expect the ECB to start cutting rates during Q2
- Oil and commodities prices appear to have peaked and are now moving more in line with fundamentals (i.e. slower global growth)

- US growth is expected to rebound in 2H 2008 with US fixed-income and equity inflows recovering as well

Given the arguments above, we believe that the USD is likely to bottom out in 2008 (with the exception of USD/JPY). Though we forecast considerable volatility and uncertainty in the first half of 2008, the second half of the year should see a preponderance of factors in favor of USD appreciation. The US markets are currently the center of focus, but we feel that the aggressive rate cuts already adopted by the US Fed combined with the fiscal stimulus will give the US and the USD a head start as the economy recovers and Fed easing is potentially taken back. This combined with the fact that trade-weighted USD index is undervalued in PPP terms, and the cycle is now relatively mature, suggests the USD is close to a bottom.

The risks of overshooting

…but risks of overshooting remain

Factors that point to the risk of further USD weakness in the near-term include:

- Though fixed-income inflows have fallen off sharply due to the ongoing credit crisis (Figure 106). Should the US enter a serious recession, it is quite possible that these flows will come under further pressure.
- The current ongoing correction in US equities may have further to run. Recent market nervousness may limit equity inflows into the US until investor confidence returns.
- Relatively low level of yields in the US should weigh on the USD – at least until other central banks start to ‘catch-up’ to the Fed

These near-term factors suggest risk of an ‘overshoot’ (i.e. further appreciation) in EUR/USD in Q1 and possibly into Q2, but our overall view is that the stars may be slowly aligning for a sustained turn in the USD as 2008 progresses.

The equity-FX relationship and the need to hedge

Introduction

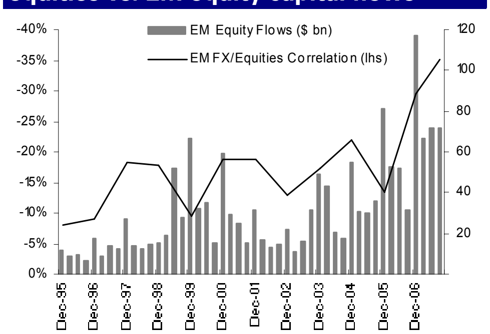
In our introduction, we motivated the need for considering an FX hedge as an overlay to an international equity portfolio by showing the dramatic effect of currency depreciation on overall returns. There's an important additional point to make: equity markets and currency markets are often correlated, and as such, understanding this relationship can impact the hedging consideration. In this section, we lend further support to the need to hedge currencies by discussion the correlation between the two markets and noting, in particular, the differences in correlation across regions.

Correlation between equities and currencies

The link between global equities and global FX has changed over time. US investors in foreign equities have benefited from a declining USD as local markets rallied; however, they may get hurt twice if equities sell off. The effect may be particularly severe in EM, where the equity / FX correlation (of log-returns) has been strongest. For example, a major sell-off in EM may be accompanied by a local-currency depreciation caused by portfolio outflows.

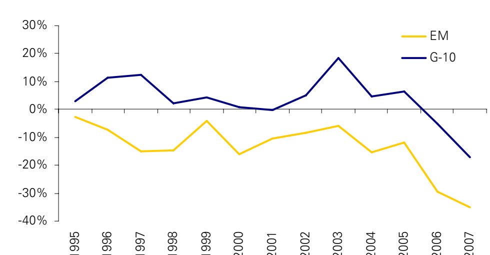
The changing nature of the equities-FX correlation is largely driven by the trends in global equity flows, in our view. As most equity flows are done currency un-hedged, the impact on FX is normally direct and quite transparent. In the case of emerging markets, the link has clearly grown stronger. This growing link results from a combination of factors, such as the global savings glut, falling restrictions on capital flows and an improved global macro-economic environment, all of which lead to a rise in international equity flows. These factors, coupled with increasingly flexible exchange rate regimes, have contributed to the rising strength in the correlation between the performance of equities and that of FX in EM (see Figure 107), and most recently, in G-10 as well (see Figure 108). Specifically, as the local equity market appreciates, the dollar depreciates.

Figure 107: Correlation between FX and equities vs. EM equity capital flows



Note: we use equity portfolio flows (in and out) for a broad set of EM countries. The log-return correlations are calculated using 1-year discrete samples Source: Deutsche Bank, Haver

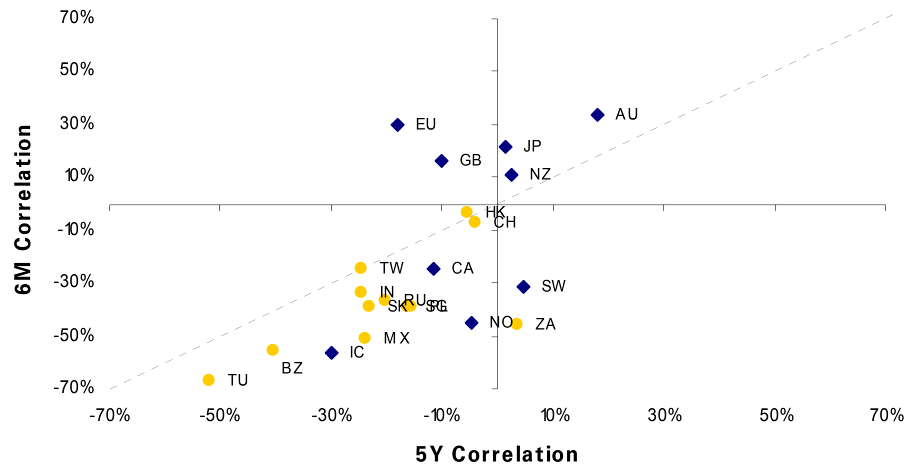
Figure 108: FX/Equity rolling correlation over time – EM and G-10 markets



Note: we use equity portfolio flows (in and out) for Canada, Norway, Sweden, Switzerland, Australia, and New Zealand (i.e. G-10 ex G-4). The log-return correlations are calculated using 1-year discrete samples. Source: Deutsche Bank, Haver

While currencies and equity markets have become increasingly linked across the globe, an important component in this dynamic is the asymmetric impact of equity flows in emerging markets compared to G-10 countries. USD/EM currency pairs have been more closely correlated with EM equity indices than the equivalent in G-10, which in our view is partially a reflection of EM local markets' (lesser) ability to take these equity flows[100], compared to G-10 markets (see Figure 108 and Figure 109).

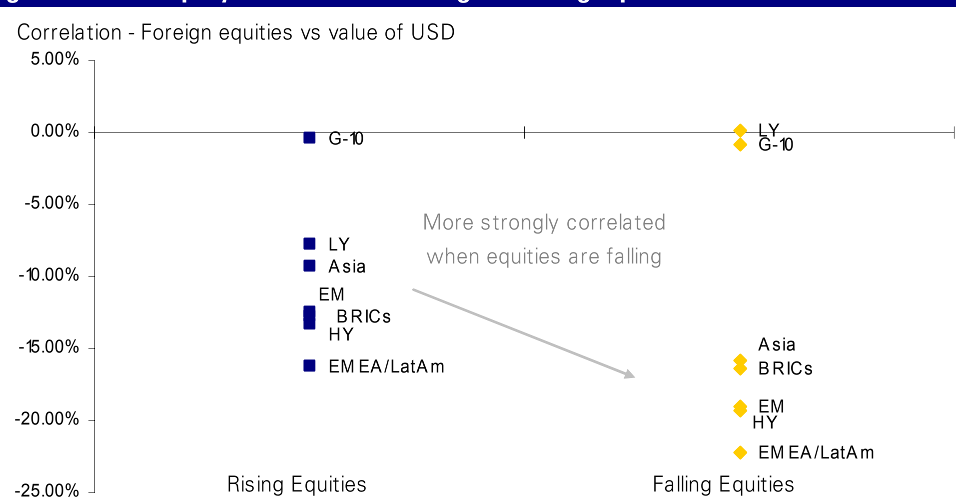
Figure 109: FX/Equity correlations, 6 months (y-axis) vs 5 years (x-axis), using inverted exchange rates



Note: the 6-month correlations using daily data, while the 5-year uses weekly data. The correlations are calculated using natural log-returns. Source: Deutsche Bank

Another, perhaps even more relevant, feature is that the correlation between equities and foreign exchange is also affected by the equity environment. This is particularly true in EM as outflows typically coincide with shrinking liquidity in both domestic equity and currency markets. As a result, currencies and equities tend to be more correlated when equity markets are falling, compared to when they are rising (Figure 110 and Figure 111).

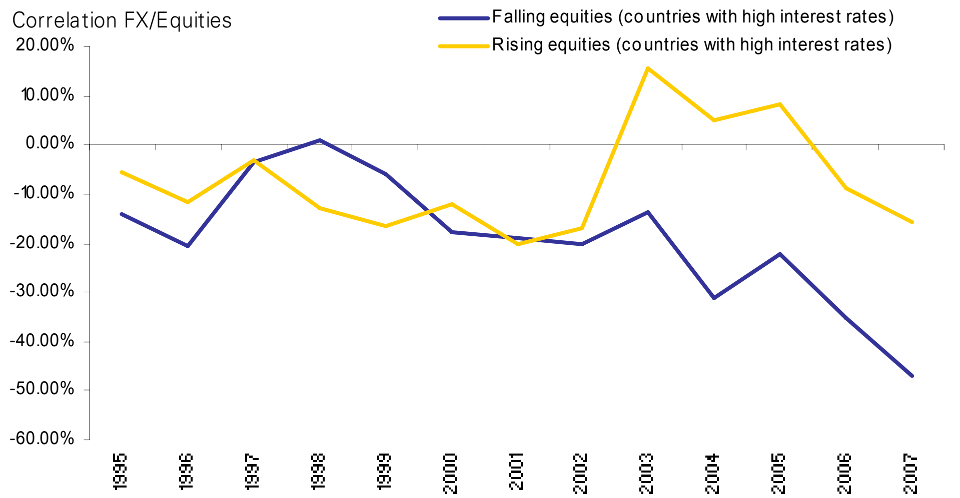
Figure 110: FX/Equity correlations – falling and rising equities



Note: we define "rising equities" and "falling equities" as periods when equity markets moved by over 4%, lasting for 20 days or more. Labels: LY: low yielding currencies, HY: high yielding currencies. The correlations are calculated using natural log returns. Source: Deutsche Bank

[100] We assume that a large portion of equity flows are done currency un-hedged, hence requiring the purchase of the local currency (sale of USD) in order to purchase local currency-denominated shares.

Figure 111: Beta of FX to equities – countries with high interest rates (rising equities, falling equities)



Note: the beta coefficients are calculated using natural log returns. Source: Deutsche Bank

Running un-hedged FX positions in an equity portfolio could hurt most when it matters the most: during equity drawdowns.

This asymmetry is particularly important as it raises questions about the widely held belief that hedging the FX exposure of a long position in foreign equities is unnecessary. This view is premised on the argument that the sources of the optimism - normally a favourable macroeconomic environment - will directly affect both assets. While this argument is often correct, it may also work against the investor as foreign currencies (typically the higher yielding ones) have tended to suffer more during regimes of equity weakness than they have gained during periods of equity strength. In other words, ***running un-hedged FX positions in an equity portfolio could hurt most when it matters the most: during equity drawdowns.***

We believe this asymmetric behaviour argues for a more active management of the currency exposure in international equity portfolios. In markets where the domestic currency and share index are highly correlated, such as in markets with higher interest rates, FX exposure should be managed with the aim of eliminating the directionality of currency returns to the performance of local equities. Conversely, in markets where the local currency bears a less significant relationship to the local equity market - such as in countries with lower interest rates - currency exposure should be considered in the context of the potential for portfolio diversification.

Hedging FX Exposure

Introduction

Given our view of a stronger USD in 2008, we suggest that international portfolio managers isolate their equity exposure by hedging FX risk. Derivatives, such as forward contracts and options, can be efficient for protecting equity holdings from FX losses. Here we describe common hedging techniques that can be applied to the currency risk embedded in an international portfolio. For more detail on the option strategies mentioned, please refer to our report, "Portfolio Protection for Bears and Bulls," published 1-Jun-07.[101]

FX forwards

Perhaps the simplest and most common way for an equity investor to hedge foreign currency exposure is to enter into an FX forward contract, adjusting the hedged amount according to changes in the underlying stock exposure. Through the currency forward contract, an investor agrees to buy (or sell) a particular currency at some date in the future, for a price that is set on the trade date. This price is derived through "covered interest rate parity" (CIP), a no-arbitrage relationship which sets the forward quotation as a function of the current FX spot rate and interest rate differentials[102].

FX forward contracts are normally agreed as contracts for differences, and no money changes hands up-front. However, hedging with forwards is not exactly cost-free, since the forward-sale price is rarely the same as the price at which the investor bought the currency. One measure of the cost of hedging with a forward is the difference between the forward price, at which the investor locks in the currency sale, and the exchange rate at trade date, a proxy for where the local currency would have been bought. Defined so, the "cost" of hedging with an FX forward is effectively the (discounted) rate differential between the USD and the currency whose exposure is being hedged.

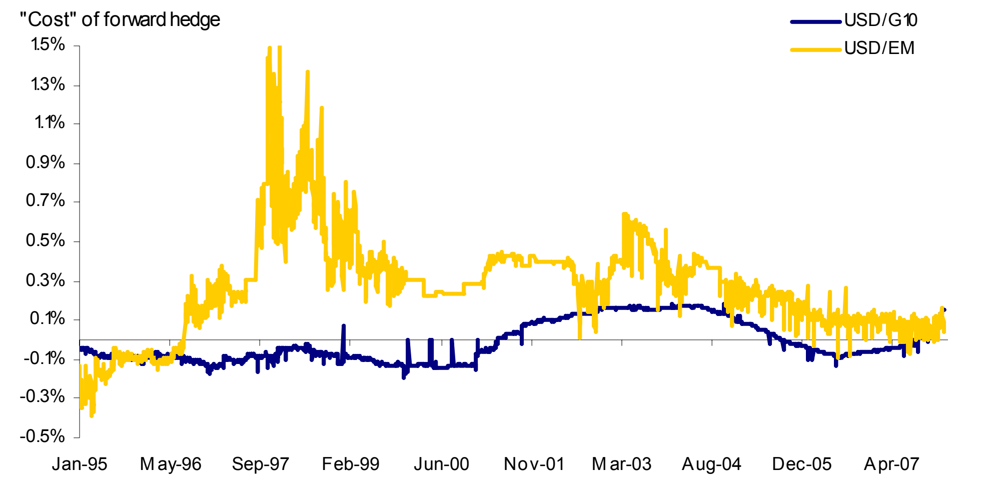
In Figure 112, we show the historical "cost" of hedging foreign currency exposure for a USD-based investor. The cost is expressed as the distance between the spot rate and the forward contract rate, expressed in percentage terms, for a 1-month FX forward contract. It shows that, on average, the US dollar would have needed to rally 0.28% against emerging currencies over the past 8 years in order for the FX forward contract to "break even," while in G-10 the cost has been roughly zero. Figure 112 also shows that hedging G-10 FX exposure through FX forwards had a "negative cost" for much of 2005-2007, which means that the hedger would have earned a profit if the spot rate did not change between the hedge inception date and the contract maturity date (a factor brought by the fact that USD interest rates were higher than average G-10 interest rates at the time). At the moment, the cost of

[101] Equity Derivatives Strategy Group, "Portfolio Protection for Bears and Bulls," 1-Jun-07. Please contact EDSG for a copy of the report.

[102] In simple form (not taking day-count issues into account), the CIP condition, and the derivation of the FX forward, is as follows: $F_{t0,T} = S_{t0} \times \frac{1 + i_{t0,T}^{(terms)} \times \Delta_{t0,T}}{1 + i_{t0,T}^{(base)} \times \Delta_{t0,T}}$, where $F_{t0,T}$ stands for the FX forward rate from the starting time (t0) to maturity (T), S_{t0} stands for the spot rate at t0, $i_{t0,T}^{(terms)}$ and $i_{t0,T}^{(base)}$ stand for the interest rate in the terms (usually foreign) and base (usually domestic) currencies from spot to maturity, quoted in annualized terms, and $\Delta_{t0,T}$ stands for the year-fraction between t0 and T.

hedging FX exposure through FX forwards is roughly the same between G-10 FX and EMFX, mostly due to the multi-year fall in EM interest rates and the rise in USD rates.

Figure 112: 1-month FX forward cost – historical progression



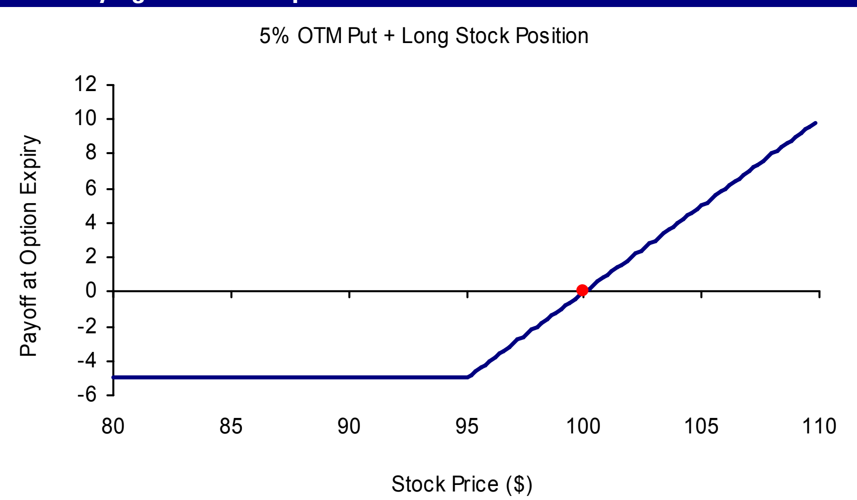
Note: we use an equally-weighted average of historical forward costs among 8 G-10 currency pairs and 12 EM currency pairs. Source: Deutsche Bank

With interest-rate differentials relatively insignificant across currencies, PMs that have benefited from a multi-year USD slide may find another "cost" of hedging with forwards harder to swallow – namely, foregoing future gains from the dollar's potential further depreciation. Please refer to the section titled *The proper currency hedge* for a discussion of how to incorporate forwards into an "optimized" hedging framework.

Basic hedging with FX options

To protect against a decline in stock prices, an investor might purchase put options to limit downside risk. Portfolio managers typically buy puts "struck" below current index levels, or "out-of-the-money"(OTM). Figure 113 shows how combining a put with a long equity position creates a floor on position value, such that if the stock sells off, the investor has the right to sell the position at the strike price. The investor is protected on the downside.

Figure 113: Buying a downside puts limits losses



Source: Deutsche Bank

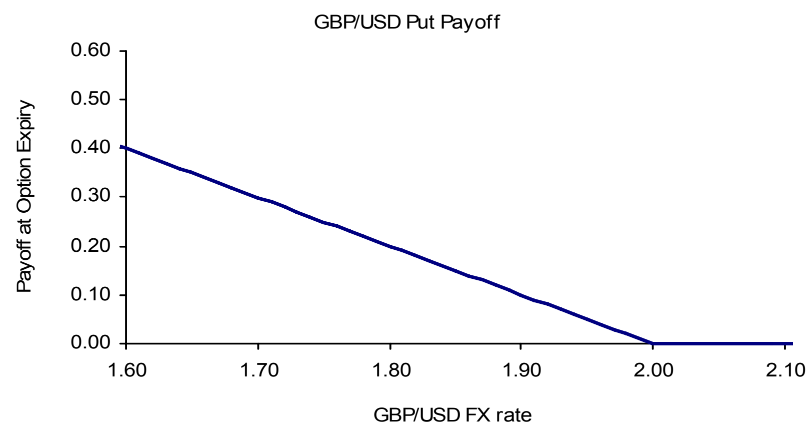
Of course, protection comes at a price. Downside-put protection can cost several percentage points of yield, depending on the put strike and time to maturity, and on the put, the investor can lose up to the entire premium if the put expires OTM.

However, equity options aren't designed to hedge currency risk, so currency options are need to hedge the currency risk, rather than the underlying equity position. Suppose that a US investor holds the FTSE 100 Index. The investor is exposed to the GBP/USD exchange rate. The investor, concerned about USD strengthening, can purchase a GBP/USD put, giving the investor the right to buy USD and sell GBP at a pre-specified exchange rate.

A long put position creates floor on an exchange rate

Say, for example, that the current GBP/USD exchange rate is at 2.01 and the option is struck at 2.00. If the USD strengthens, the GBP/USD exchange rate will fall, and a GBP seller would receive less than $2.01 for every GBP he or she wishes to sell. The put, however, protects the investor by providing a floor on the exchange rate of 2 USD per GBP, so even if the cross-rate drops to $1.75, the investor still receives 2 USD. Figure 114 shows the payoff structure of the GBP/USD put. ***Note that a put on the GBP is essentially the same instrument as a call on the USD. To keep our discussion of FX options consistent across currencies, we will treat all foreign-currency puts as calls on the USD.***

Figure 114: FX Puts can protect against currency losses on equity holdings



Source: Deutsche Bank

The cost of a put varies with strike and expiry

Figure 115 shows a sample of available USD calls (GBP puts) available as of 8-Feb-08. These options are quoted as a function of how in- or out-of-the-money they are, proxied by the option's delta. Delta describes how the option's price moves per unit-change in the underlying currency (e.g., we-d expect a 10-delta USD call to appreciate by 0.1 GBp if the USD appreciates by 1 GBp). As the USD rises toward the call's strike price, the delta increases, and the option's price behaves more like the underlying currency itself. Please check the appendix for the equivalent set of indicative prices for other USD/G-10 and USD/EM currency pairs.

Figure 115: Current indicative prices – GBP/USD options (1M tenor)

	Cost USD %	Cost USD "pips"	Option Strike (GBP/USD)	Break-even (GBP/USD)
10-Delta (or 10D) USD Call	0.30%	30.25	1.8677	1.8647
25-Delta (or 25D) USD Call	0.86%	85.5	1.9091	1.9006
50-Delta (ATMF or 50D) USD Call	2.09%	208.5	1.946	1.9252

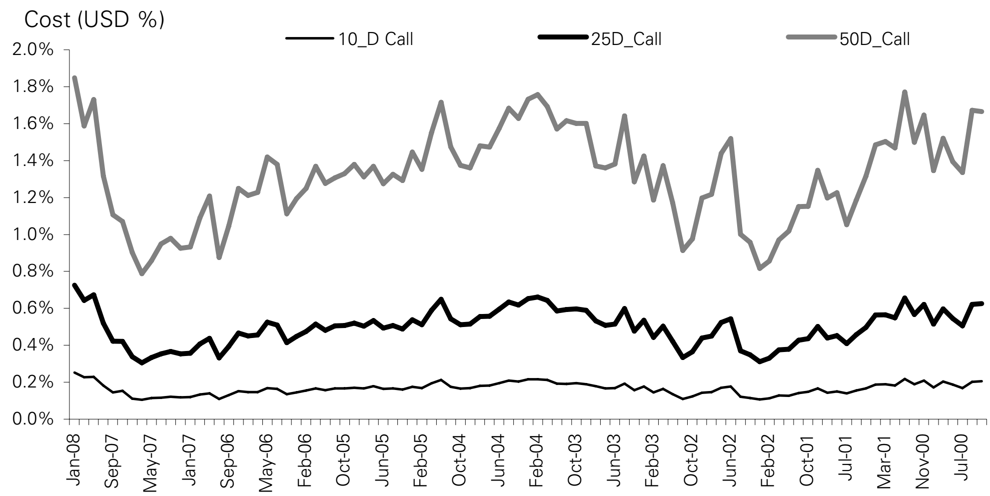
FX Spot Reference: GBP/USD 1.9495. "Pips" refer to the value of decimals (or "cents" in this case).
For example, 10 pips added to GBP/USD 1.9495 would be 1.9505.
Source: Deutsche Bank

A call option can protect the investor against a USD strengthening

Note how, just as with equity options, the premium on the option declines as the option becomes more out of the money. In addition, premia increase as the time to maturity rises. This difference in pricing is a key consideration when selecting an option hedge – the nearer to spot the strike price, the more protection a put offers but at a higher up-front cost. Please refer to the 'Assessing currency hedges' section of this report for an empirical analysis of various hedging strategies.

Figure 116 plots the prices of 1M GBP/USD option positions as a percentage of the price of the USD over time. Volatility of the exchange rate is the key driver to prices: as volatility rises, option prices become more expensive, as we have seen in months.

Figure 116: 1M EUR/USD option prices over time



Source: Deutsche Bank

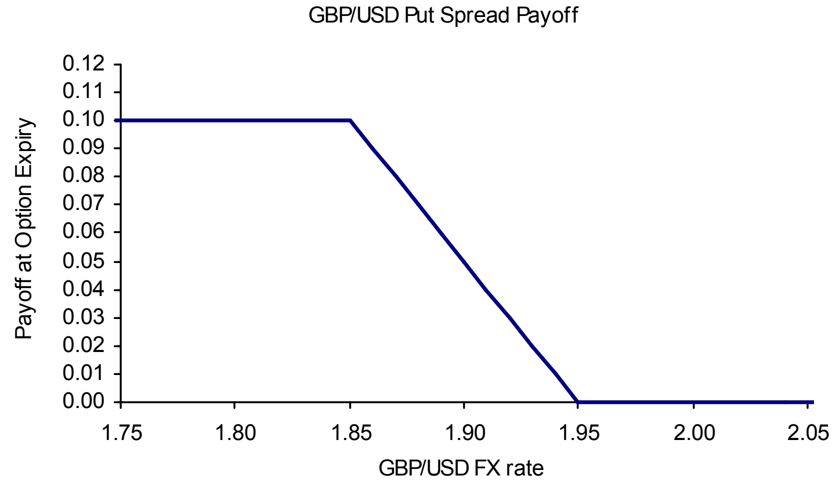
Put spreads

Put spreads protect currency exposure up to a point, say a mild strengthening of the USD, but not beyond that point

Suppose you are concerned about the USD strengthening below \$1.95/£, but you don't believe it will fall below \$1.85/£. If you simply purchased the 1.95-strike GBP/USD put, you would be buying protection below \$1.85/£ that you don't want. You can sell the unwanted protection back to the market, by adding a short 1.85-strike put to your position. This type of strategy is known as a "put spread." By selling the lower-strike put against the higher-strike put, you take in premium on the lower-strike sale, thereby reducing your currency protection cost. You still may lose up to the entire premium on the put spread. Figure 117 shows the payoff diagram to the put spread.

A put spread combined with the currency risk embedded in a foreign equity holding leaves the investor with upside exposure (i.e., the investor can benefit if the USD continues to weaken) and some downside protection against a moderate strengthening of the USD.

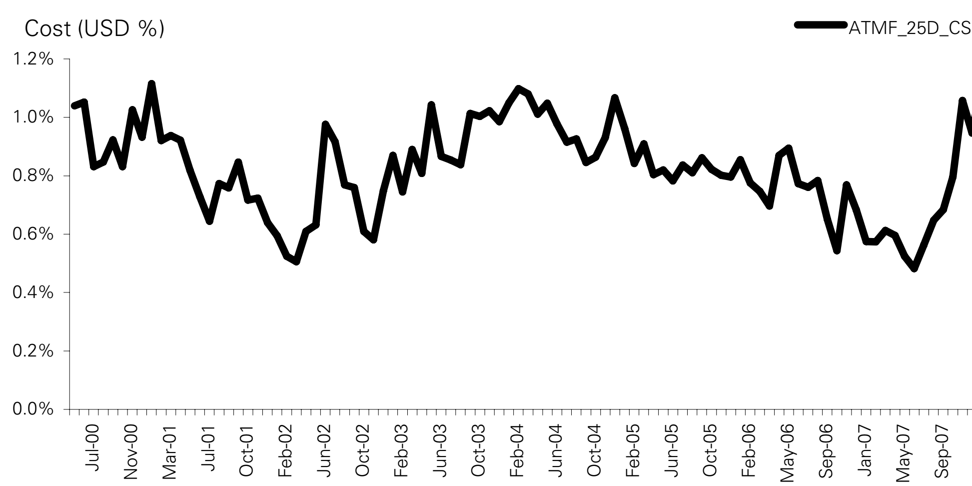
Figure 117: A put spread offers protection to a point, at a lower cost than a put



Source: Deutsche Bank

Referring back to Figure 115, the 1M ATMF/25D (long the ATMF, short the 25D) put spread costs approximately 1.25%, and reduces the premium in relation to the single ATMF-strike put by 40%. Figure 118 plots the premia on the ATMF/25D spread over time.

Figure 118: 1M ATMF/25D EUR/USD spread



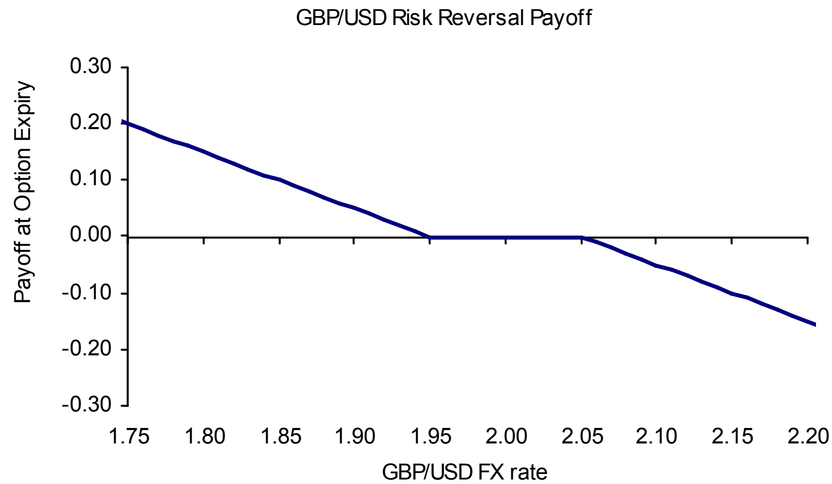
Source: Deutsche Bank

Collaring currency exposure with a risk-reversal

Risk reversals offer protection against USD appreciation but cap currency gains if USD weakens further

In the put spread example, the investor takes in premium from the lower-strike put to offset some of the cost of putting on the currency protection. The investor is not completely hedged on the downside, as we saw in Figure 117. Another way to cheapen currency protection is by selling upside calls. In the upside call, the holder has the right to buy GBP for a fixed pre-specified price, so if the USD were to weaken, the option holder would have the right to buy GBP for a cheaper price than spot. For an investor hedging against a USD-strengthening may sell the upside call to offset the premium paid for the put. This position is known as a risk-reversal, and the payoff diagram is provided in Figure 119.

Figure 119: Risk-Reversal payoff

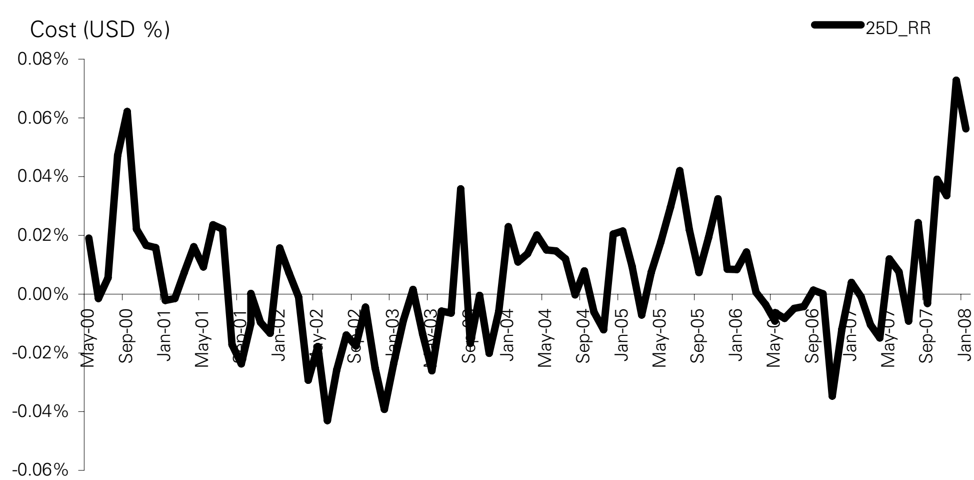


Source: Deutsche Bank

The strategy effectively provides a collar on the FX risk of an equity position. Downside currency exposure is limited in the event that the USD strengthens, but currency gains are capped in the event that the USD weakens further.

Figure 120 shows historical prices of the 1M 25D GBP/USD risk-reversal:

Figure 120: 1M 25D EUR/USD risk-reversal historical prices



Source: Deutsche Bank

Summary

We have proposed several strategies to hedge FX exposure in international equity portfolios, ranging from hedging using FX forwards to using multiple-option strategies such as risk-reversals. Far more-complex hedges are available as well, including path-dependent options, whereby the value of the option will be dependent not only on the terminal price at expiry but also on the path that the underlying exchange rate took to get there. While we don't delve into some of the more exotic strategies in this paper,[103] it is important to note that the depth of the FX option market is such that strategies can be easily implemented that protect a portfolio should particular views come to fruition. In Figure 121, we provide a summary of hedging strategies to assist the investor in coming up with the right basic strategy. Each of these strategies have risks associated with them. For in-depth hedging analyses and risk analyses, please contact the authors.

Figure 121: Summary of hedging strategies

Strategy	View
Forward	Lock in exchange rate in the future
Put	Protect against strong dollar appreciation
Put Spread	Protect against limited dollar appreciation
Risk Reversal	Protect against dollar appreciation while anticipating limited further depreciation
Path-Dependent	Enables more complex views

Source: Deutsche Bank

[103] Several other strategies are laid out in "Portfolio Protection for Bears and Bulls," Equity Derivatives Strategy Group, 1-Jun-07.

The Proper Currency Hedge

What works? An assessment through mean-variance optimization and scenario analysis

Having shown typical working strategies earlier in this article, we now address the question of what hedge works at a given equity (and currency market) environment. First, we consider the performance over the last 8 years of systematic FX hedging strategies utilizing the following instruments: FX forwards, 10-delta USD calls, 25-delta USD calls, 50-delta USD calls, and 25-delta risk-reversals. Then, we use mean-variance optimization to come up with historically optimal blends of FX hedges for different currency exposures (including no hedging). Finally, we focus the analysis on the hedges' performance during periods of severe equity draw-downs and strong equity rallies.

In order to purchase foreign-listed equities, the USD-based investor has to purchase a certain (variable) amount of foreign currency; the notional amount and the value of that currency exposure changes according to the performance of both foreign equity and foreign currency markets. In order to concentrate solely on the FX exposure of the equity investor, we exclude equity-related returns (i.e. the variations in notional amount of foreign currency), and concentrate on the value of that notional amount of FX. More specifically, we apply different techniques to assess the types of hedge that help reduce the volatility of the exchange rate position and at the same time allowing the US-based investor to profit from potential foreign currency gains.

The alternatives shown earlier can be divided into three main categories:

- *Maximized risk, maximized reward:* that's effectively the "no hedge" category, or in other words, simply running the FX exposure un-hedged. As discussed earlier in this article, such exposure would have yielded strong returns in 2007, although these would be asymmetrically biased against the USD-based investor, generate the highest volatility of returns, and may not work well in the (potentially) upcoming USD strength environment.

- *Minimized risk, minimized reward:* this category involves fully hedging the FX exposure through FX forward contracts. The USD-based investor minimizes the risks associated with the starting foreign currency exposure by agreeing to sell it back at a given time, at the market's best estimate of the future price of the currency – the FX forward. This type of hedge conduct may substantially reduce[104] the FX exposure, but it is subject to the cost of "carrying" that hedge (interest rate differentials) and the opportunity cost associated with (potential) foregone gains on the foreign currency.

- *Controlled risk, controlled reward:* this hedging category is introduced by the availability of FX options for the USD-based equity investor who is long foreign currency. By purchasing USD calls (foreign currency puts), the returns on the combined position[105] follow a positive convex function to the level of the currency, in that gains from the local currency are potentially unlimited, while losses are floored at the cost (premium) of the contract. Among the vanilla call options, 10-delta USD calls are the cheapest, though the least likely to go in-the-money and hence best used as insurance against heavy draw-

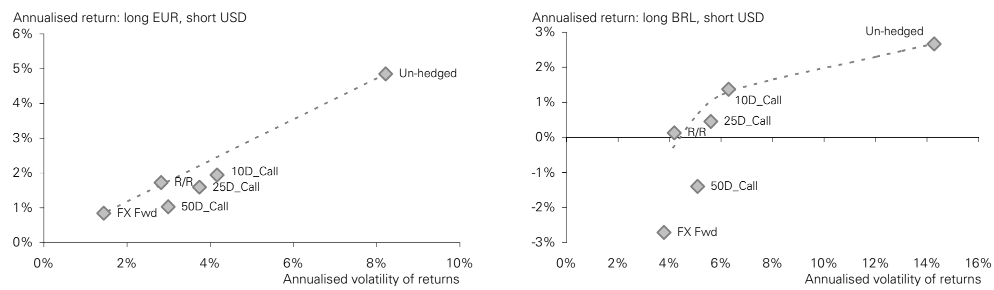
[104] While it reduces FX exposure, it does not eliminate it completely as the notional amount to be hedged changes according to equity market performance; such hedge adjustments give exposure to the exchange rate at the time the hedge is rebalanced.

[105] The combined position is to be long foreign currency spot, and long puts on the foreign currency, thus effectively holding a synthetic call on the foreign currency (put on the USD).

downs. The 25-delta calls are more expensive, but with a less distant strike and hence also insulate against moderate foreign currency draw-downs. ATMF (at-the-money-forward) calls are the most expensive due to the strike being at the level of the FX forward but are also the first to go in-the-money. Of the multiple option structures addressed earlier, USD risk-reversals, when combined with the long FX (spot) exposure, effectively turn the overall position into a foreign currency call spread – a cheaper alternative that profits from moderate FX gains and is insulated against FX losses.

The chart below displays the behavior[106] of the different types of FX hedges in more detail. Here, we look at the historical return of an FX investor who bought Euros (EUR) in order to purchase EuroStoxx shares, and Brazilian reals (BRL) in order to purchase Bovespa shares. In the case of the EUR, we look at data since 2000, while in Brazil we look at data since 2001. In both instances, the pure FX position would have yielded the highest returns, though at the cost of highest volatility. In both examples, the returns of the option hedge positions were a roughly function of their direct cost, except for the case of risk reversals. In the case of the forwards, the hedge would have yielded positive returns on average given that USD interest rates have tended to be above EUR rates for the majority of the sample period, while the opposite applies in the case of the Brazilian real.

Figure 122: Risk-return profile of different FX exposures since 2001 – the case of Brazil



Note: the positions combine long foreign currency spot plus the particular hedge type. We also exclude the equity market impact for adjusting the notional amounts of the currency hedge in order to concentrate on the direct FX portion of returns. Labels: 10D_Call: 10-delta USD call, 25D_Call: 25-delta USD call, 50D_Call: 50-delta USD call , R/R: 25-delta risk reversals, FX Fwd: FX forward, Un-hedged: long foreign currency un-hedged. Source: Deutsche Bank

Suggested results from mean-variance optimization

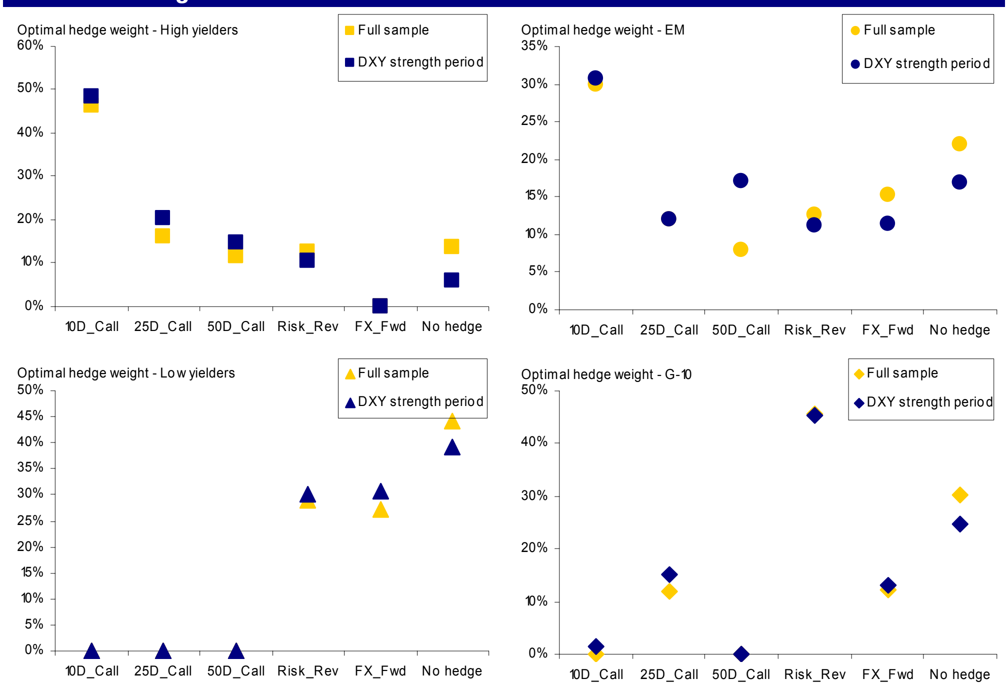
Mean-variance optimization (MVO), in simple form, is a computational technique aimed at identifying the asset weights that best achieve a certain target for a given set of assets with particular return and volatility characteristics. The desired weights generated from the technique are aimed at showing the composition which would have maximized the returns in the combined portfolio (for a given level of targeted portfolio volatility) for a given historical sample. The technique is robust when the user believes that the assumptions on returns and volatility of each asset (gathered through a historical sample) are reasonably accurate in depicting future returns, and when the higher moments of the distribution of returns (especially kurtosis) can be ignored.

[106] We assess the performance of each hedging type through strategies which systematically buy options (or the FX forward) with a 1-month maturity and re-balance the position every week. We use weekly rebalancing of positions in order for the results not to be heavily affected from specific hedging dates.

In this article, we apply an MVO approach to understand how close are the potential hedging alternatives (vanilla USD calls, USD risk reversals, FX forwards, and no hedge) to what would have been the most "optimal" hedging structure through time. Here, we set volatility to equal half of the volatility[107] of spot FX and compute what type of hedge composition would have yielded the highest (risk adjusted) returns. Our MVO analysis utilizes two data sets, one for the overall performance of the currency hedges over the past 8 years, and the other using a more compact sample, 2005-2006. The choice for the first data set is for completeness, as it includes periods of foreign currency weakness and strength. The second data set singles out a sample from when the US dollar was appreciating against its largest trading partners. That way, we can also assess the results under a scenario which more accurately reflects our fundamental view of USD strength against most other G-10 currencies.

Over the past 8 years, exposure to currencies with higher interest rates was better hedged with low delta USD calls, and exposure to lower yielding currencies was better hedged with a combination of risk reversals, FX forwards, and spot.

Figure 123: MVO-derived "optimal" currency hedge weights – full historical sample and USD strength environment



Note: please refer to the table in the introductory section for country classifications between high yield, low yield, EM and G-10. Labels: 10D_Call: 10-delta USD call, 25D_Call: 25-delta USD call, 50D_Call: 50-delta USD call, Risk_Rev: USD risk reversal, FX_Fwd: FX forward, DXY: USD index (a trade-weighted value of the US dollar against the world's main currencies). Source: Deutsche Bank

The results display two clear messages. Either over the past 8 years, or during 2005, *an exposure to currencies with higher interest rates was better hedged with low delta USD calls, and exposure to lower yielding currencies was better hedged with a combination of risk reversals, FX forwards, and spot.*

In our view, the high allocation of low delta options in high yielding (and most EM) currencies is attributed to the distribution of their historical returns: they appreciate gradually (positive drift), but also suffer from abrupt depreciation instances, typically to an extent greater than that of lower yielding currencies. This FX spot dynamic leads to higher returns and higher volatility, and the hedging through low delta options reduces the volatility while not dampening returns at the same time (it has the lowest cost). The positive skew suggests it is worth keeping an exposure to the foreign currency - it has appreciated over time just as local

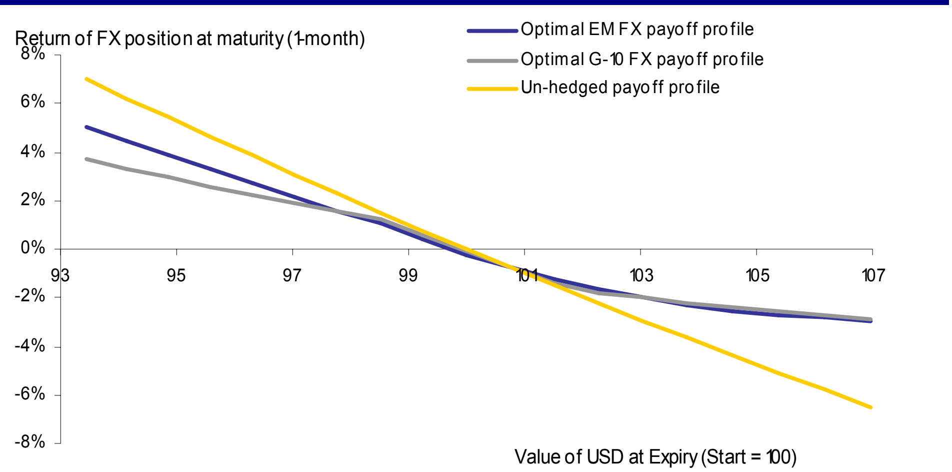
[107] We chose half the volatility of spot as it generates a better combination of lower volatility, higher diversification (for an equity portfolio) and higher returns in the overall position.

equities have – though the volatility of returns suggests it is worth purchasing cheap insurance for occasional "storms", usually driven by external shocks or the recycling of positions. Another reason for the preference to low delta calls (more specifically in higher yielding currencies) has to do with interest rate differentials and the forward rate bias: the final "break-even" levels are more favourable to the equity investor[108]. This suggests that investors who believe higher yielding currencies will either trade range-bound or appreciate (effectively generating a similar distribution of returns as that of the past), should look to use a greater portion of low-delta USD calls as a hedge.

In the case of lower (and some medium) yielding currencies, the greater weight allocated to non-option currency exposures (FX forwards and no-hedge) is likely to be attributed to two factors: the lower volatility of FX spot (compared to the high yielders), and the relative attractiveness of FX forwards brought by interest rate differentials. Given the lower volatility, less was needed to be spent on option-type structures (and hence the investor could have taken a naked short USD position), while the favourable interest rate differentials meant that the USD-based investor would be earning income from hedging the FX exposure[109]. The results suggest, in our view, that investors who believe that medium and low yielding currencies will tend to appreciate (or trade sideways) in similar fashion as the past few years should allocate less hedging capital to low delta FX options, and concentrate more on FX forwards (if the "FX carry" is negative) or keeping a larger position un-hedged.

As the chart below shows, the optimal payoff profile for currency exposure in USD/G-10 crosses and USD/EM crosses (over the past 8 years) suggested by the MVO exercise is similar to a USD put spread (foreign currency call spread); one should look to reduce the exposure to heavy local currency weakness by letting go of some of the gains associated with substantial local currency strength.

Figure 124: Return profile of MVO-induced "optimal" currency exposure in EMFX and G-10 FX



Source: Deutsche Bank

Assessing currency hedges through scenario analysis – distinct equity market regimes

As we discussed before, an "optimal" MVO-induced hedge exposure should be satisfying if i) the investor believes that the asset returns and volatilities assumed in the computation are a

[108] That is due to the fact that the strike of the low delta USD put exposure (USD call position combined with short USD spot) is further away from spot and hence leading to a break-even that is closer to the current spot level.

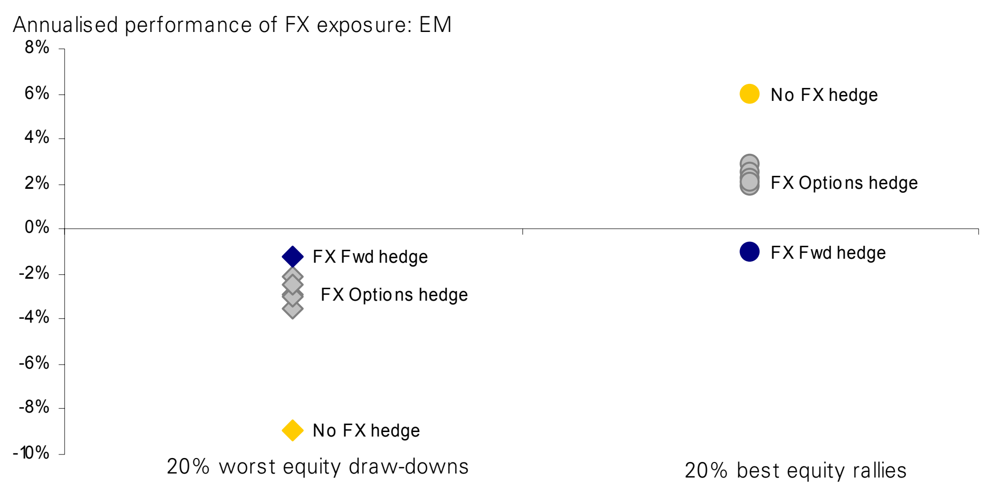
[109] That is because, due to rate differentials, the FX forward is struck at a level that is stronger (for the local currency) than the current spot level.

reasonable reflection of what they will look like in the future, and ii) if the risk of "fat tails" can be ignored. While we believe that most of the first caveat has been touched upon in our computation, the second has not been directly addressed. This is particularly worrying in equity and currency markets as FX returns are particularly "fat-tailed" – the occurrence of high standard deviation events is above those expected by a standard normal distribution. Further, assessing the effectiveness of the different currency hedges during those periods is particularly important as those are the instances when, arguably, the hedge matters the most.

We address the issue of leptokurtosis ("fat tails") by assessing the behavior of foreign currency hedges during specific periods of foreign equity market strength and weakness. While a proper modeling of "fat tails", and hence a "true" assessment of each hedge type under those environments is well beyond the scope of this article, we look at periods in history where foreign equity markets either rallied or sold-off well in excess of what would have been expected by a normally distributed series of returns - more specifically, the top 20% and bottom 20% of foreign equity market returns[110]. In the large majority of instances, these moves also affected the foreign currency and hence led to "doubly whammy" effects on un-hedged foreign equity portfolios.

Overall, this targeted scenario analysis has yielded results that are consistent with the approach above. As has been argued earlier in this article, strong equity draw-downs over the past 8 years have had tended to impact the foreign currency more than have equity rallies. This can be viewed in the asymmetry between the red dots in the charts below (more evident in the case of EM than G-10). On the other hand, as the charts also show, *hedging through FX options considerably reduced i) the volatility of returns in the foreign currency exposure, and more importantly, ii) the asymmetry of those FX returns.* In the case of EM, FX forwards have indeed provided the best currency hedge during large equity draw-downs, but they have also generated a substantial opportunity cost at times of equity market rallies.

Figure 125: The performance of FX hedging alternatives during fat-tailed events in emerging market equities

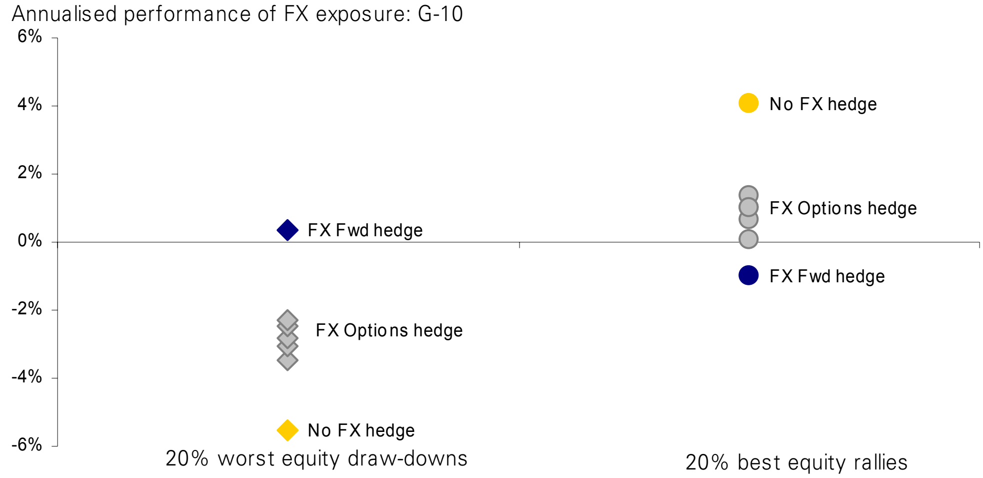


Note: the returns are annualized. Data from early 2000. As with the other results, the hedge positions assume the USD-based investor is long foreign currency, in addition to the hedging alternatives. Source: Deutsche Bank

Another result that is consistent with our MVO computation is that option hedges seem better applied to emerging currency exposure than to G-10. In G-10, the results show that un-hedged FX returns are more symmetric between strong equity rallies and heavy draw-downs, and that hedging through FX forwards behaves better than in the case of EM.

[110] We also specified that such periods had to last for at least 20 days, so as to exclude "blips".

Figure 126: The performance of FX hedging alternatives during fat-tailed events in G-10 equities



Note: the returns are annualized. Data from early 2000. As with the other results, the hedge positions assume the USD-based investor is long foreign currency, in addition to the hedging alternatives. Source: Deutsche Bank

Conclusion: what hedge for what environment?

Clearly, an investor who is very bullish foreign equities (and less concerned about the volatility of FX returns) should keep most of their equity capital currency un-hedged. Conversely, the opposite view implies a full hedge through FX forwards. FX options, however, provide lower volatility of currency returns in both cases, while also removing some of the negative asymmetry (seen in FX spot returns) relative to the direction of the equity shock.

The results of our analysis suggest that, on aggregate,

- USD-based investors should allocate a greater weight to FX options when hedging their EM currency exposure. Such an alternative reduces the volatility of currency returns, protects against substantial drawdowns, and also provides exposure to EMFX rallies.
- Of the alternatives analysed, low delta EMFX puts seem particularly attractive as they are cheaper and yet help insulate against "tail" risk.
- In G-10, the (generally) lower volatility in FX and lower interest rate differentials suggest that the US-based investor should consider more hedging through FX forwards, risk reversals and also keeping some of the exposure un-hedged.

Conclusion

Choose the strategy that matches your view

Equity investors should look to manage their foreign currency exposure in a manner consistent with their views on international equity *and* currency markets. They can choose from hedging strategies laid out in this report or other, more-sophisticated strategies. Hedging implications will differ according to the level of foreign interest rates, and more generally, to whether it is an EM or G-10 FX risk.

Our outlook for a stronger USD in 2008 implies that gains that USD investors of foreign equities enjoyed in recent years may not continue, and investors may suffer currency losses on their holdings. Hedging FX exposure allows portfolio managers to isolate equity performance and can help reduce their P&L volatility.

Appendix

Relevant research

"Portfolio Protection for Bears and Bulls," Equity Derivatives Strategy Group, 1-Jun-07.

"Exchange Rate Perspectives," Global Markets Research, 18-Dec-07.

"Choosing the 'Best' Hedge – Navigating the Field of Options," Equity Derivatives Strategy Group, 30-Jan-08.

Pricing tables for 1M options (as of 8-Feb-08)[111]

Figure 127: EUR/USD

	Price USD %	Cost USD "pips"	Strike (EUR/USD)	Break-even (EUR/USD)
FX Forward	0.08%	-12	1.4519	1.4519
10D USD Call	0.17%	23.25	1.3921	1.3898
25D USD Call	0.47%	66.5	1.4234	1.4168
ATMF USD Call	1.13%	163.5	1.4519	1.4356
ATMF / 25D USD Call Spread	0.65%	-94.5	1.4519 / 1.4234	1.4425
25D USD Risk-Reversal	0.05%	7	1.4237 / 1.4792	1.4230

FX spot reference: EUR/USD 1.4531. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to EUR/USD 1.4531 would mean 1.4541

Source: Deutsche Bank

Figure 128: USD/SEK

	Price USD %	Cost SEK "pips"	Strike (USD/SEK)	Break-even (USD/SEK)
FX Forward	-0.09%	57	6.4867	6.4867
10D USD Call	0.20%	131.75	6.8539	6.8407
25D USD Call	0.59%	384.75	6.661	6.6225
ATMF USD Call	1.49%	973.5	6.4867	6.3894
ATMF / 25D USD Call Spread	0.84%	597.5	6.4867 / 6.6610	6.5465
25D USD Risk-Reversal	0.09%	75	6.6538 / 6.3321	6.6463

FX spot reference: USD/SEK 6.481. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/SEK 6.481 would mean 6.482

Source: Deutsche Bank

[111] All prices are indicative.

Figure 129: USD/NOK

	Price USD %	Cost NOK "pips"	Strike (USD/NOK)	Break-even (USD/NOK)
FX Forward	0.04%	-21	5.5155	5.5155
10D USD Call	0.23%	124.75	5.84	5.8275
25D USD Call	0.66%	362.75	5.6707	5.6344
ATMF USD Call	1.65%	910	5.5155	5.4245
ATMF / 25D USD Call Spread	0.92%	555	5.5155 / 5.6707	5.5710
25D USD Risk-Reversal	0.16%	118.5	5.6608 / 5.3780	5.6490

FX spot reference: USD/NOK 5.5176. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/NOK 5.5176 would mean 5.5186

Source: Deutsche Bank

Figure 130: AUD/USD

	Price USD %	Cost USD "pips"	Strike (AUD/USD)	Break-even (AUD/USD)
FX Forward	-0.07%	6	0.9054	0.9054
10D USD Call	0.26%	22.5	0.8551	0.8529
25D USD Call	0.73%	64.25	0.8814	0.8750
ATMF USD Call	1.74%	157	0.9054	0.8897
ATMF / 25D USD Call Spread	0.98%	-88.5	0.9054 / 0.8814	0.8966
25D USD Risk-Reversal	0.24%	21.75	0.9284 / 0.8818	0.9262

FX spot reference: AUD/USD 0.9048. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to AUD/USD 0.9048 would mean 0.9058

Source: Deutsche Bank

Figure 131: NZD/USD

	Price USD %	Cost USD "pips"	Strike (NZD/USD)	Break-even (NZD/USD)
FX Forward	0.43%	-34	0.7874	0.7874
10D USD Call	0.27%	19.75	0.7369	0.7349
25D USD Call	0.73%	55.5	0.764	0.7585
ATMF USD Call	1.72%	135.75	0.7874	0.7738
ATMF / 25D USD Call Spread	0.96%	-75.5	0.7874 / 0.7640	0.7799
25D USD Risk-Reversal	0.07%	-5.5	0.7650 / 0.8106	0.7656

FX spot reference: NZD/USD 0.7908. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to NZD/USD 0.7908 would mean 0.7918

Source: Deutsche Bank

Figure 132: USD/CAD

	Price USD %	Cost CAD "pips"	Strike (USD/CAD)	Break-even (USD/CAD)
FX Forward	-0.04%	4	1.0031	1.0031
10D USD Call	0.18%	18.25	1.0541	1.0523
25D USD Call	0.54%	54.25	1.0279	1.0225
ATMF USD Call	1.39%	139.75	1.0031	0.9891
ATMF / 25D USD Call Spread	0.81%	-80.75	1.0031 / 1.0279	0.9950
25D USD Risk-Reversal	0.01%	-0.5	1.0264 / 0.9797	1.0265

FX spot reference: USD/CAD 1.0027. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/CAD 1.0027 would mean 1.0037

Source: Deutsche Bank

Figure 133: USD/JPY

	Price USD %	Cost JPY "pips"	Strike (USD/JPY)	Break-even (USD/JPY)
FX Forward	0.21%	-22	106.75	106.75
10D USD Call	0.16%	16.75	111.38	111.2125
25D USD Call	0.49%	52.75	109.14	108.6125
ATMF USD Call	1.40%	149.75	106.75	105.2525
ATMF / 25D USD Call Spread	0.84%	-89.25	106.7500 / 109.1400	105.8575
25D USD Risk-Reversal	0.10%	10.75	108.98 / 104.04	108.8725
FX spot reference: USD/JPY 106.97. "Pips" refer to the value of decimals (or "cents", in this case).				
In this case, 10 pips added to USD/JPY 106.97 would mean 107.07				

Source: Deutsche Bank

Figure 134: USD/SGD

	Price USD %	Cost SGD "pips"	Strike (USD/SGD)	Break-even (USD/SGD)
FX Forward	0.16%	-22	1.416	1.416
10D USD Call	0.10%	13.75	1.45389	1.4525
25D USD Call	0.26%	36.25	1.43259	1.4290
ATMF USD Call	0.61%	86.25	1.416	1.4074
ATMF / 25D USD Call Spread	0.32%	-43.75	1.4160 / 1.4326	1.4116
25D USD Risk-Reversal	0.03%	-2	1.43009 / 1.40210	1.4302
FX spot reference: USD/SGD 1.4182. "Pips" refer to the value of decimals (or "cents", in this case).				
In this case, 10 pips added to USD/SGD 1.4182 would mean 1.4192				

Source: Deutsche Bank

Figure 135: USD/KRW

	Price USD %	Cost KRW "pips"	Strike (USD/KRW)	Break-even (USD/KRW)
FX Forward	-0.05%	50	946.2	946.2
10D USD Call	0.12%	108.75	976.5	975.4125
25D USD Call	0.29%	272.75	958.91	956.1825
ATMF USD Call	0.70%	648.25	946.2	939.7175
ATMF / 25D USD Call Spread	0.35%	-320.75	946.2000 / 958.9100	942.9925
25D USD Risk-Reversal	0.05%	-28.25	957.20 / 935.70	957.4825
FX spot reference: USD/KRW 945.7. "Pips" refer to the value of decimals (or "cents", in this case).				
In this case, 10 pips added to USD/KRW 945.7 would mean 945.8				

Source: Deutsche Bank

Figure 136: USD/HKD

	Price USD %	Cost HKD "pips"	Strike (USD/HKD)	Break-even (USD/HKD)
FX Forward	0.08%	-59.5	7.79225	7.79225
10D USD Call	0.02%	16.75	7.83798	7.8363
25D USD Call	0.05%	37.75	7.80963	7.8059
ATMF USD Call	0.12%	90	7.79225	7.7833
ATMF / 25D USD Call Spread	0.04%	-27.75	7.7923 / 7.8096	7.7895
25D USD Risk-Reversal	0.01%	6.25	7.80334 / 7.77770	7.8027
FX spot reference: USD/HKD 7.7982. "Pips" refer to the value of decimals (or "cents", in this case).				
In this case, 10 pips added to USD/HKD 7.7982 would mean 7.7992				

Source: Deutsche Bank

Figure 137: USD/CNY

	Price USD %	Cost CNY "pips"	Strike (USD/CNY)	Break-even (USD/CNY)
FX Forward	0.64%	-459	7.1382	7.1382
10D USD Call	0.03%	20	7.1929	7.1909
25D USD Call	0.12%	87.25	7.1778	7.1691
ATMF USD Call	0.39%	277.5	7.1382	7.1105
ATMF / 25D USD Call Spread	0.18%	-131.5	7.1382 / 7.1778	7.1251
25D USD Risk-Reversal	0.06%	40.5	7.1730 / 7.0843	7.1690

FX spot reference: USD/CNY 7.1841. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/CNY 7.1841 would mean 7.1851

Source: Deutsche Bank

Figure 138: USD/INR

	Price USD %	Cost INR "pips"	Strike (USD/INR)	Break-even (USD/INR)
FX Forward	0.08%	-300	39.63	39.63
10D USD Call	0.10%	405.25	40.78	40.7395
25D USD Call	0.26%	1014	40.12	40.0186
ATMF USD Call	0.64%	2514.5	39.63	39.3786
ATMF / 25D USD Call Spread	0.22%	-792	39.6300 / 40.1200	39.5508
25D USD Risk-Reversal	0.02%	-21.5	39.94 / 39.25	39.9422

FX spot reference: USD/INR 39.66. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/INR 39.66 would mean 39.661

Source: Deutsche Bank

Figure 139: USD/TWD

	Price USD %	Cost TWD "pips"	Strike (USD/TWD)	Break-even (USD/TWD)
FX Forward	0.63%	-20	31.75	31.75
10D USD Call	0.07%	2.25	32.3	32.2775
25D USD Call	0.21%	6.75	32.03	31.9625
ATMF USD Call	0.60%	19.25	31.75	31.5575
ATMF / 25D USD Call Spread	0.33%	-10.5	31.7500 / 32.0300	31.6450
25D USD Risk-Reversal	0.05%	1.75	31.95 / 31.43	31.9325

FX spot reference: USD/TWD 31.95. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/TWD 31.95 would mean 32.05

Source: Deutsche Bank

Figure 140: USD/MXN

	Price USD %	Cost MXN "pips"	Strike (USD/MXN)	Break-even (USD/MXN)
FX Forward	-0.26%	279	10.7924	10.7924
10D USD Call	0.10%	106.5	11.0851	11.0745
25D USD Call	0.28%	295	10.9263	10.8968
ATMF USD Call	0.65%	700.25	10.7924	10.7224
ATMF / 25D USD Call Spread	0.35%	-371.5	10.7924 / 10.9263	10.7549
25D USD Risk-Reversal	0.03%	-28	10.9136 / 10.6834	10.9158

FX spot reference: USD/MXN 10.7645. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/MXN 10.7645 would mean 10.7655

Source: Deutsche Bank

Figure 141: USD/BRL

	Price USD %	Cost BRL "pips"	Strike (USD/BRL)	Break-even (USD/BRL)
FX Forward	-0.53%	94	1.7679	1.7679
10D USD Call	0.26%	46	1.8977	1.8931
25D USD Call	0.72%	126.25	1.8253	1.8127
ATMF USD Call	1.59%	279.25	1.7679	1.7400
ATMF / 25D USD Call Spread	0.85%	-149.75	1.7679 / 1.8253	1.7529
25D USD Risk-Reversal	0.18%	-31.25	1.8243 / 1.7260	1.8274

FX spot reference: USD/BRL 1.7585. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/BRL 1.7585 would mean 1.7595

Source: Deutsche Bank

Figure 142: USD/RUB

	Price USD %	Cost RUB "pips"	Strike (USD/RUB)	Break-even (USD/RUB)
FX Forward	-0.16%	400	24.71	24.71
10D USD Call	0.11%	281.25	25.5	25.4719
25D USD Call	0.30%	748.25	25.06	24.9852
ATMF USD Call	0.76%	1826.25	24.71	24.5274
ATMF / 25D USD Call Spread	0.34%	-827.5	24.7100 / 25.0600	24.6273
25D USD Risk-Reversal	0.01%	7	24.98 / 24.41	24.9793

FX spot reference: USD/RUB 24.67. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/RUB 24.67 would mean 24.671

Source: Deutsche Bank

Figure 143: USD/ZAR

	Price USD %	Cost ZAR "pips"	Strike (USD/ZAR)	Break-even (USD/ZAR)
FX Forward	-0.64%	494	7.7594	7.7594
10D USD Call	0.39%	301	8.6256	8.5955
25D USD Call	1.09%	839.75	8.1432	8.0592
ATMF USD Call	2.51%	1935.5	7.7594	7.5659
ATMF / 25D USD Call Spread	1.33%	-1024.5	7.7594 / 8.1432	7.6570
25D USD Risk-Reversal	0.22%	-165.75	8.1241 / 7.4722	8.1407

FX spot reference: USD/ZAR 7.71. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/ZAR 7.71 would mean 7.711

Source: Deutsche Bank

Figure 144: USD/PLN

	Price USD %	Cost PLN "pips"	Strike (USD/PLN)	Break-even (USD/PLN)
FX Forward	-0.18%	44	2.4943	2.4943
10D USD Call	0.20%	49.75	2.6327	2.6277
25D USD Call	0.57%	142.5	2.559	2.5448
ATMF USD Call	1.44%	357.5	2.4943	2.4586
ATMF / 25D USD Call Spread	0.81%	-201	2.4943 / 2.5590	2.4742
25D USD Risk-Reversal	0.01%	-3.25	2.5543 / 2.4358	2.5546

FX spot reference: USD/PLN 2.4899. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/PLN 2.4899 would mean 2.4909

Source: Deutsche Bank

Figure 145: USD/TRY

	Price USD %	Cost TRY "pips"	Strike (USD/TRY)	Break-even (USD/TRY)
FX Forward	-0.99%	122	1.231	1.231
10D USD Call	0.32%	39	1.3429	1.3390
25D USD Call	0.87%	106.25	1.2799	1.2693
ATMF USD Call	1.90%	231.75	1.231	1.2078
ATMF / 25D USD Call Spread	0.92%	-112.5	1.2310 / 1.2799	1.2198
25D USD Risk-Reversal	0.21%	-26	1.2761 / 1.1975	1.2787

FX spot reference: USD/TRY 1.2188. "Pips" refer to the value of decimals (or "cents", in this case).

In this case, 10 pips added to USD/TRY 1.2188 would mean 1.2198

Source: Deutsche Bank

Section 3: FX Weekly Reports

The Timezone Factor (18/09/08)

- In this study of which timezone tends to drive the price action in EUR/USD and USD/JPY, we conclude that the London/New York overlapping hours are the key driver in both. But if the reader is interested in EUR/USD, it is also worth watching the price action in Asia, and for USD/JPY, the price action in New York.

Currency markets open during Asia's early morning on Monday and close on New York's Friday evening. The over-the-counter, de-centralised nature of FX trading is one of the factors that make it distinct from other asset classes.

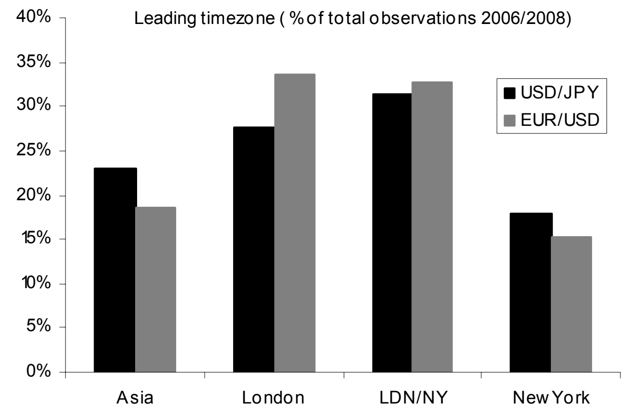
This de-centralised nature raises the question of whether there are intra-day patterns associated with each particular timezone, and if those patterns can be useful in providing information about the price action over the course of the day. In this article, we provide some findings for EUR/USD and USD/JPY, having analysed 2 years' worth of intra-day data relating to four timezones: Asia, London, London-New York, and New York[112]. Our findings follow below.

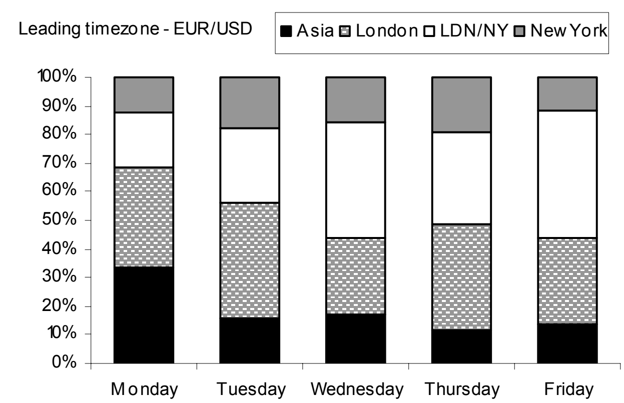
The period when both London and New York are open is the key driver of EUR and JPY volatility and directional moves, a result that is arguably obvious in light of trading volume statistics[113].

The more relevant findings relate to the secondary driver. In EUR/USD, trading during the Asia timezone has been carrying significant importance over the NY hours (when non-overlapping with London). It has also driven the daily trend in EUR/USD just as often as London on Mondays, which we attribute to the effect of information released on weekends[114].

The New York trading hours seem to gain importance in the case of the yen: one-fifth of the daily trends in USD/JPY over the past two years have been defined after 11:00AM in New York, compared to 13% in EUR/USD, which has come at the detriment of trading during the London morning. Further, the magnitude of the move during NY hours relative to the entire day's trend has been far greater than that of the other timezones when the price action is defined after the London close.

Figure 146: Timezone that drives the daily trend – total and divided by days of the week





Source: Deutsche Bank

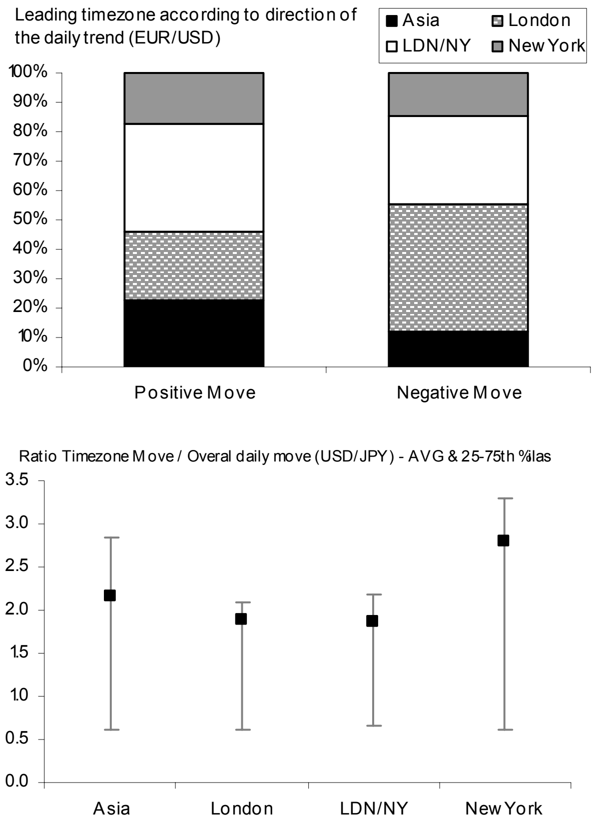
Separating the intra-day price action by timezones also uncovers an important fact about asymmetry and the size of the moves. While all 4 timezones have driven the upward move in similar frequency, the majority of the move lower in EUR/USD over the past two years has occurred during the London morning. The days when Asia was the driver of the USD strength, the moves were on average smaller than when London or NY was in the driving seat. In USD/JPY, the picture is very different. USD strength, and weakness, have both been well distributed among the different timezones.

[112] Asian trading hours were defined (in GMT +1hr terms) as 9:00PM to 7:00AM; London hours were defined as 7:00AM to 12:00PM, London-New York hours were from 12:00PM to 4:00PM and New York trading hours were from 4:00PM to 9:00PM.

[113] According to figures from official authorities, the total spot turnover in London was approximately 47% of the sum of turnovers between London, NY, Singapore and Tokyo. New York contributes with some 34%, while the other 2 took 9.5% each. The data is as of 2007.

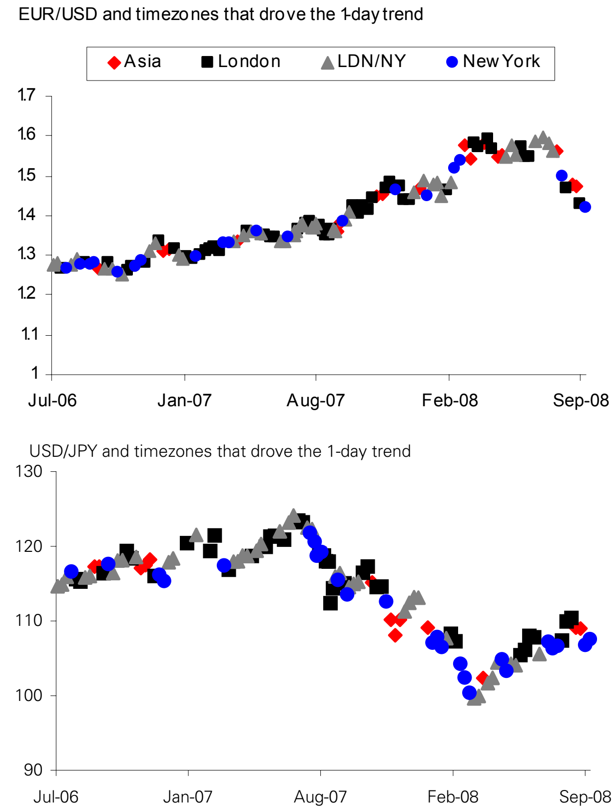
[114] This is due to the fact that Asia is the first timezone to absorb the news published over the weekend.

Figure 147: Size and direction of daily moves according to timezones – EUR/USD and USD/JPY



Source: Deutsche Bank

Figure 148: The drivers of intra-day trend – EUR/USD and USD/JPY



Note: we use the weekly average moves. Source: Deutsche Bank

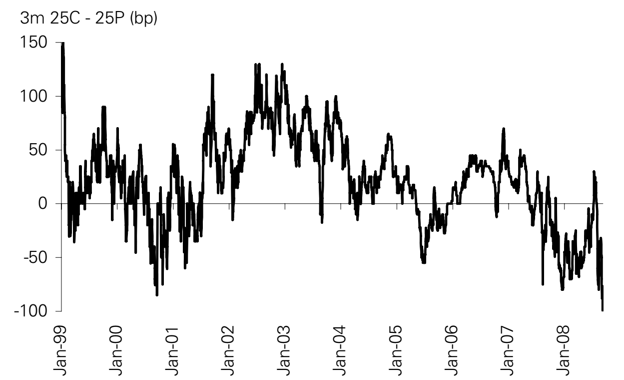
While the facts above help our understanding of how different timezones related to intra-day price action in EUR/USD and USD/JPY over the past two years, it seems difficult to draw conclusions that have strong predictive power. Nevertheless, the results seem robust enough to conclude that the London/New York overlapping hours are most likely to define a day's price action. But if the reader is interested in EUR/USD, it is also worth watching the price action in Asia, and for USD/JPY, the price action in New York.

FX Special: Watch the low delta EUR calls (11/09/08)

- We believe low delta EUR/USD calls are cheap relative to ATMFs, and recommend 3-month spread trades.

The pace of the EUR/USD move in the recent month has been nothing short of stunning. Unsurprisingly, risk reversal levels also look stretched in their favouring of EUR puts relative to EUR calls.

Figure 149: EUR/USD 3m risk reversals over time

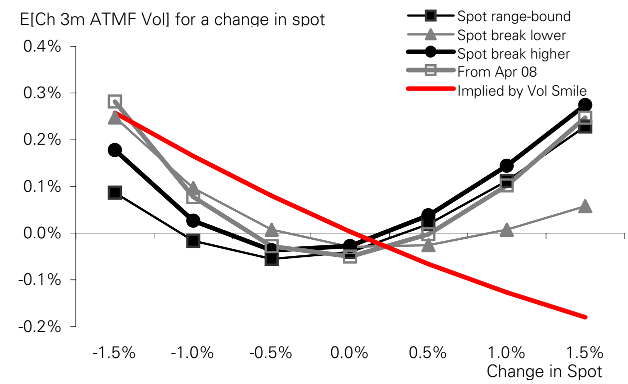


Source: Deutsche Bank

In order to identify where the skew seems most over-stretched, we look at the options smile and compare it with the empirical relationship between EUR/USD and its respective volatilities. The smile (a plot of implied volatility as a function of each delta) gives a reflection of how traders think ATMF volatilities will behave when FX spot is moving. A skew that favours the puts (low delta puts more expensive than low delta calls) typically implies that ATMF volatility will be negatively correlated to the spot rate: it will rise if the spot rate falls, and fall if the spot rate rises. A skew that favours the calls usually implies the opposite.

The solid red line in the chart on the right shows the market expectations of future 1-day ATMF volatility moves based on potential 1-day moves in EUR/USD. The other lines provide an empirical proxy for how the ATMF will move as a function of FX spot, each based on a different environment for EUR/USD since its inception. The chart shows a rather clear discrepancy between the pricing of EUR puts (the portion relating to spot moves < 0), and EUR calls (spot moves >0), or in other words, that they are heavily skewed towards the puts. The high price of low delta (downside) volatilities compared to ATMF volatilities can be justified by the empirical behaviour, especially when EUR/USD falls abruptly. The low price of the EUR calls, however, doesn't seem justified. Current pricing suggests 3-month ATMF volatilities will fall by 0.2% for a 1-day upward correction in EUR/USD, which we believe is unreasonable based on the empirical evidence.

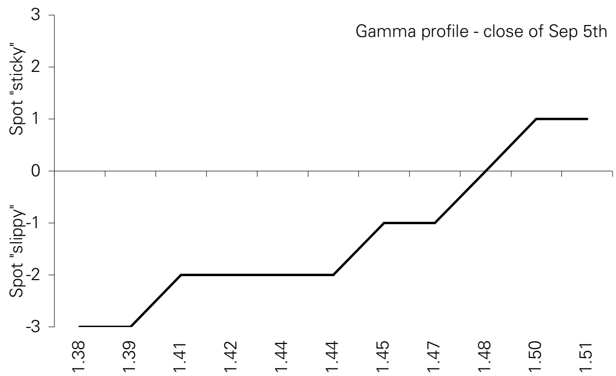
Figure 150: Sensitivity of ATMF vols to EUR/USD spot



Note: we fit a cubic spline to the data, modified to take proportionality and stationarity issues into account. Data from 1999. Source: Deutsche Bank

But while the empirical behaviour is at the core of our argument, it is not the sole component. Our intuition also suggests ATMF volatilities are unlikely to fall if EUR/USD rises. Upward spot market corrections can be aggressive in light of traders' (bearish EUR) positioning, which is near all-time extremes according to our DB Positioning Indicators. Acute upward corrections will keep realised volatility high, and hence also impact implied volatility. Traders' positioning in the options market can also be a factor: according to our traders, market makers are generally short gamma unless FX spot rises more than 5%, beyond which they become flat. Hedging short gamma positions can lead to acceleration in EUR/USD spot.

Figure 151: Gamma profile – EUR/USD



Please refer to our weekly Global FX Gamma Report for further information. Source: DB FX Trading.

As a conclusion, we believe low delta EUR upside volatilities should rise relative to the current ATMF, especially in the 1-month and 3-month tenors. This view can be capitalized upon via delta-hedged curve trades, such as being long a modified risk reversal (ATMF vs 25-delta or 10-delta). The current ATMF-25C spread in the 3-month tenor is approximately 20bp (bid-ask adjusted). We believe those spreads can easily triple over the coming weeks.

Expressing a bearish view on US banking through FX options (31/07/08)

- We look at ways to express a bearish view on US banking stocks using FX options. We find ATMF calls in CHF/SEK and EUR/AUD, and puts in NZD/CHF, particularly attractive.

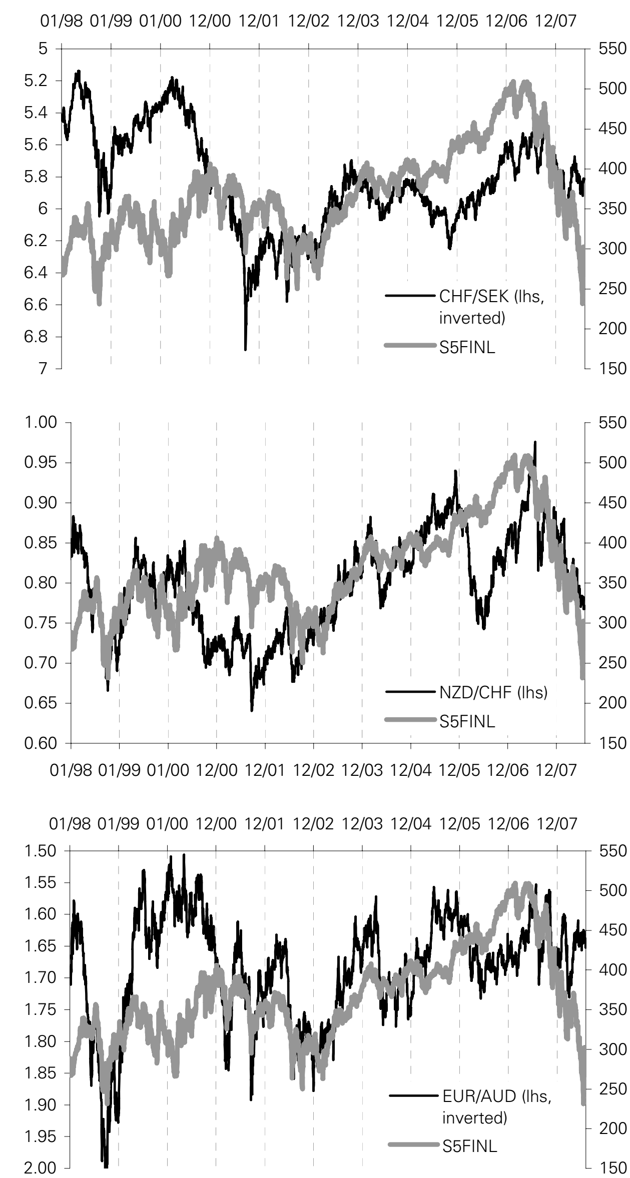
So you're bearish US banking shares but cannot - or do not want - to go short the index directly. You're searching for other ways in which to express that view, and are happy to consider other asset classes. This report describes a simple approach to identify how that view can be expressed through vanilla currency options. Through a combination of standard econometric and scenario analyses, we identify "sweet spots" in FX volatility surfaces in which this bearish view can be effectively expressed.

Our exercise was divided into two portions - evaluation of strength and scenario analysis. In the evaluation portion of our analysis, we isolated draw-down periods in the index over the past 15 years, and checked which FX data - spot and implied volatilities for 79 currency pairs - had been most statistically linked to the index. The identification process included de-trending the data, changing the regression parameters to incorporate non-linear behaviour, verifying how robust the link has been over different time horizons, and giving more weight to the more recent observations. This process generated a short-list of 5 qualifying currency pairs, whose spot and implied volatility have been closely linked to the S&P Financials index over time. These are: NZD/CHF, GBP/AUD, AUD/CHF, EUR/AUD and CHF/NOK.

The second and final portion of our exercise was to identify which instrument would best express that view. In other words, which option presents the most attractive investment characteristics - the highest potential return (the "beta") per cost of investment (measured in units of market-implied volatility). In order to do that, we analysed the performance of each type of option as a function of i) different (potential) changes in US financials, ii) different strikes across the volatility smile, and iii) different option tenors. The short list was further reduced to 3 currency pairs - NZD/CHF, CHF/SEK and EUR/AUD - as the other 2 did not provide sufficiently attractive betas per (volatility) cost of investment, and hence would require too much of a drawdown in US financials to break-even.

There is an intuitive explanation behind the 3 currency pairs that ultimately qualify as ways to express a bearish view on US banking stocks, in that all of them generally correlate strongly (either positively or negatively) to global equity appetite. The Swedish krona, for instance, is highly vulnerable to equity flows in and out of Sweden and has therefore historically been highly driven by global equity appetite. The New Zealand and the Australian dollars, and the Swiss franc, have historically been used as FX carry trade instruments (either as funding or investment currencies), and given that the risk appetite factors that drive the carry trade also tend to influence global equities, the historical performance of NZD, AUD and CHF have generally been linked to that of international equities, and by extension, US banking shares.

Figure 152: CHF/SEK, NZD/CHF and EUR/AUD and S&P Financials over time

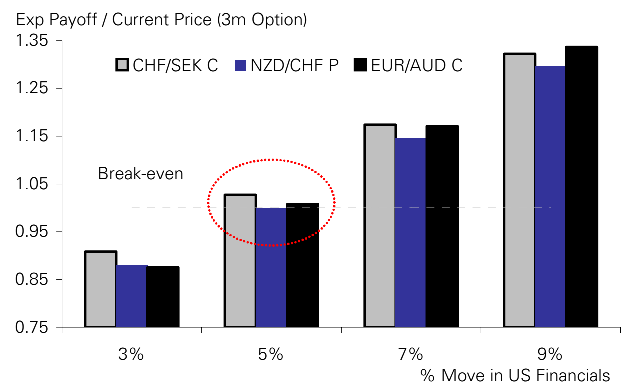


Source: Deutsche Bank

Of these remaining currency pairs, our conclusions are as follows:

- **One needs to expect US banking stocks to fall by at least another 5%** in August in order for the ATMF options with a 3-month maturity to be profitable. That threshold falls for 6-month options (3-4%), but rises for options of 1-month tenor (6-7%). In other words, one needs a relatively strong conviction; the average 1-month change in the index has been 3% during draw-down months, and one-month drawdowns of 7% or more have only occurred in 30% of the draw-down periods since 1995.

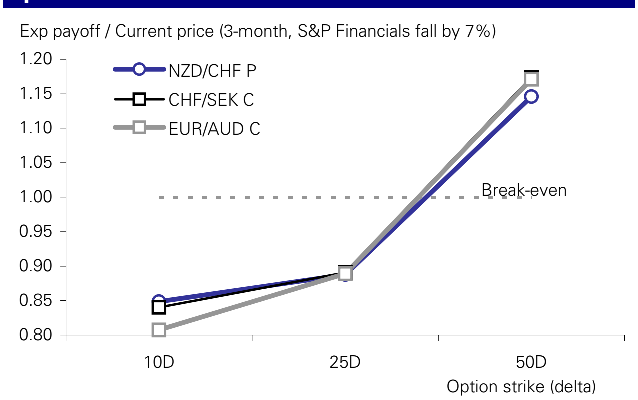
Figure 153: Expected sensitivity of payoffs to move in US banking stocks



Source: Deutsche Bank

- **Stick to the at-the-money-forwards.** They are more expensive, though most likely to work in an environment of small to medium-sized weakness in US financials. The types of changes we would expect in FX spot in the event of a 7% fall in US financials (between 1% and 2%), and the equivalent changes in implied volatility, will not be enough to circumvent the loss from time decay in the lower delta options.

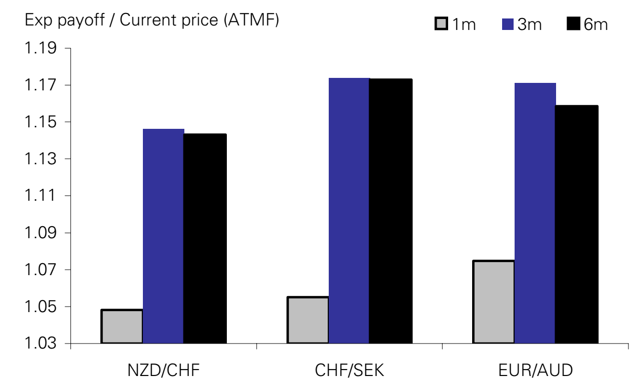
Figure 154: Expected sensitivity of payoffs to different option deltas



Source: Deutsche Bank

- **Look for medium-term (3-month) options.** The cost associated with closing the trade before maturity is well circumvented by the extra return from the rise in volatility, especially in the case of 3-month options. The contribution of moves in volatility to the P&L of a 3-month ATMF CHF/SEK call (its vega), for instance, is 65% greater than the equivalent in the 1-month call. However, a higher vega doesn't necessarily mean greater expected returns, as shorter dated volatilities tend to move by more than longer-dated volatilities. As the chart below shows, the "sweet spot" in the term structure is located in the 3-month tenor.

Figure 155: Expected sensitivity of payoffs to different option tenors



Source: Deutsche Bank

Our analysis suggests that the best vehicles to trade the view that US banking stocks will continue to fall in August are, therefore, 3-month ATMF calls in CHF/SEK and in EUR/AUD, and puts in NZD/CHF. Current pricing for CHF/SEK calls is 1.52%, 1.7% for EUR/AUD and 2.5% for NZD/CHF. We expect the final payoffs to be approximately 20% greater than the premium paid for these simple vanilla structures, though they can be greatly enhanced if one uses second generation-type options with comparable characteristics.

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What Seasonality? Intra-year, intra-month and intra-week volatility patterns (26/06/08)

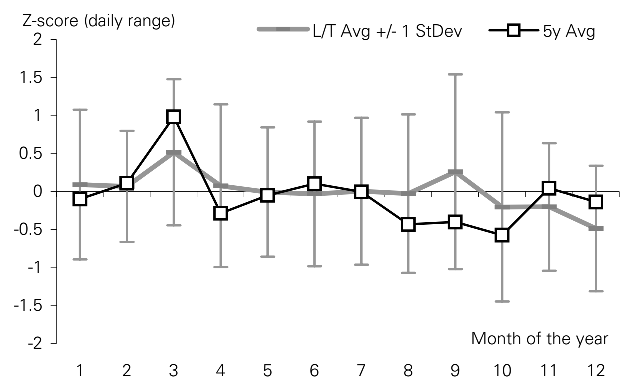
- We investigate seasonality patterns in the empirical volatility of EUR/USD, USD/JPY and GBP/USD, and identify patterns at monthly, weekly and daily time periods. These include the March-September effect in USD/JPY, the start and end-month impact in EUR/USD, and the low volatility on Mondays in the three currency pairs.

It's summer time and the topic of seasonality is back in vogue. With the aim of identifying broad patterns in FX volatility over time, we analysed 18 years' worth of data on daily ranges in EUR/USD, USD/JPY and GBP/USD, de-trended by their respective regimes[115]. While no pattern originated constant excess returns (through straddle trading) over time in our backtest, a few seemed consistent enough over the years and are thus worth mentioning. These include intra-year, intra-month and intra-week patterns.

Monthly seasonality: the March - September – December effect

As we investigated seasonality patterns in FX volatility over the course of the year, USD/JPY exhibited the clearest pattern over time. That is, realised volatility tends to be consistently above the regime average in March and September, and below average in December. This dynamic is intuitively corroborated by structural issues; March and September coincide with the fiscal year-end and half-year end in Japan and have historically been associated with capital repatriation by residents, leading to the underperformance of carry trades and higher volatility. The September effect has been mitigated over the past few years, likely due to causes such as heavy supply of volatility and recovery from a large market drawdown - but the persistence of such seasonality over the years suggests it is definitely worth paying attention to. Finally, the ability of the options market to capture this pattern has been mixed; consistent buying of straddles[116] in March and September would've yielded a hit ratio of 43% and 65% over the past 5 years, suggesting September volatility is "underpriced" compared to that of March. Conversely, selling USD/JPY straddles in December is not necessarily a good idea - the hit ratio has been only 33%.

Figure 156: USD/JPY volatility – higher in March and September, lower in December



Note: the data has been de-trended within each particular volatility regime. Source: Deutsche Bank

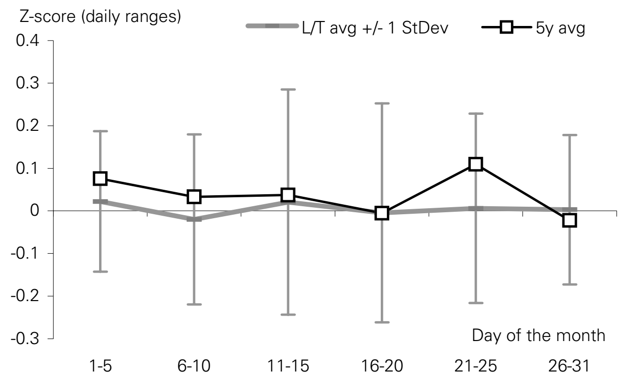
Intra-month seasonality: the impact of economic data

Unlike with the monthly data, intra-month volatility patterns weren't consistent in the 18-year sample. However, a shorter (5-year) history suggests country-specific economic releases have a notable impact on intra-month volatility. In USD/JPY, the tendency for data such as GDP (and WPI) to be released during the second week of the month seems to contribute to a higher volatility in USD/JPY, though we note that this is more a recent event (past 5 years). A similar picture is seen in GBP/USD, with much of the price and activity indicators being released around the middle of the month and hence contributing to a higher volatility in that currency pair around that period. In EUR/USD, the batch of US data released during the first week of the month seems to make an impact, though the cross also sees higher volatility closer to the end of the month (which we suspect to be due to fixings and position squaring). Finally, the intra-month market pricing has been fair - the success ratio of buying weekly straddles to exploit this potential seasonality is slightly below 50%.

[115] We de-trended the data in order to better compare the ranges within different volatility regimes. For further details on the FX volatility regimes used, please refer to "FX Derivatives Focus", February 26th 2008.

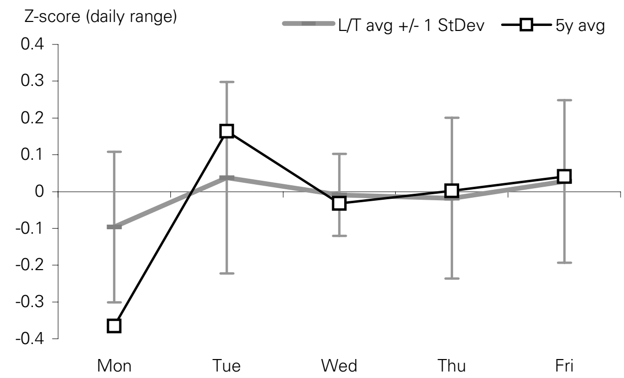
[116] The strategy involves buying 1-month straddles during the first 5 working days of the month. Full transaction costs are taken into account.

Figure 157: EUR/USD volatility – higher at the start and closer to the end of the month



Note: the data has been de-trended within each particular volatility regime. Source: Deutsche Bank

Figure 158: GBP/USD volatility – lower on Mondays, higher on Tuesdays



Note: the data has been de-trended within each particular volatility regime. Source: Deutsche Bank

Intra-week seasonality: low volatility on Mondays?

Digging further into the micro territory, we found some similarities between the three currency pairs. Both long-term and short-term samples suggest that FX volatility is low on Mondays, but rises on Tuesday and goes back to the average on Wednesday, Thursday and Friday. The low volatility on Mondays seems counter-intuitive, as one would think that incorporating all the weekend news should make volatility rise. Perhaps it can be attributed to the fact that volume picks up gradually over the week. The above-average volatility on Tuesday also strikes as interesting, but that effect seems confined to USD/JPY and GBP/USD and has been more evident recently (past 5 years). Regardless of the rationale, market pricing also seems well adjusted for the lower volatility of Mondays: selling overnight straddles would've yielded a success ratio of less than 60% in all three currency pairs over the last 5 years, which is low considering the risk of being short volatility over the weekend.

So what's the final take?

The patterns captured by our study are broad in nature, which likely explains the unfriendly results in our trading rule back-tests. Many of the anomalies also change over time, due to the changing nature of the reaction function of FX market participants. But while these patterns may not be foul-proof, the analysis at least helps de-mystify some "factoids" on patterns that are commonly believed to exist. Summer periods, for instance, are not necessarily associated with low volatility. The USD/JPY, EUR/USD and GBP/USD daily spot ranges in June and July have been above the regime average almost as often as they've been below in the past 18 years. Another example relates to intra-month patterns, as they aren't as consistent among all three currency pairs as one would expect. Finally, the weekend effect doesn't seem to generate much incremental volatility to the price action on Monday; in fact, spot volatility on Monday is typically below the average over the rest of the week.

The changing nature of FX behaviour around economic surprises (20/06/08)

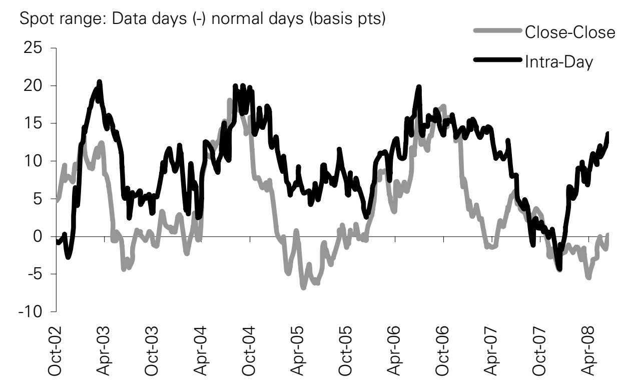
- The impact of US data releases on FX realised volatility is changing: the spikes are greater, but the influence dissipates over the course of the day. Options markets seem yet to adjust to this dynamic, and discrepancies can be witnessed in certain types of economic releases.

Data releases seem to be back at the spotlight of FX volatility markets due to growing uncertainty around policymaker behaviour and the respective impact on G-10 economies. This article addresses the changing nature of this relationship as it observes the progression of intra-day volatility (and its market price) in light of economic news[117]. We conclude that the growing impact of data on FX is felt more intra-day rather than at the day's end, and that market prices are generally yet to adjust to that.

More intra-day, but less close-close volatility

Economic data seems to have generated more intra-day volatility in 2008 compared to prior, as shown by the growing spread between high-low ranges during data days and normal days over time. Nevertheless, much of this impact is dissipating over the course of the day, as shown in the close-close ranges. The intra-day ranges can be attributed, in our view, to the growing uncertainty regarding future policy and economic data, which is reflected in a more vulnerable sentiment, and in the falling accuracy in analyst forecasts of economic data. In line with the general context of risk averse markets, this intra-day volatility impact has been more evident in USD/JPY than EUR/USD or GBP/USD.

Figure 159: More intra-day, less close-close volatility



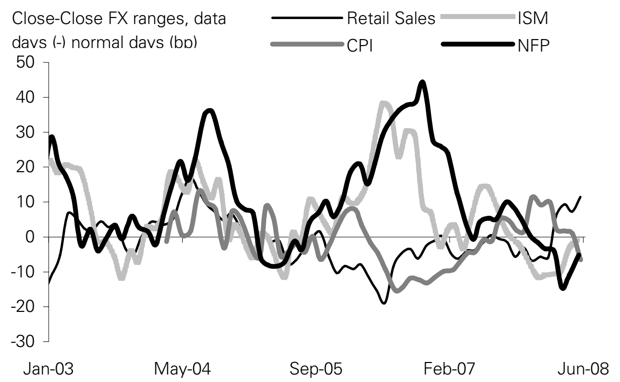
Note: average close-close range between EUR/USD, GBP/USD and USD/JPY. Source: Deutsche Bank

Contrary to initial intuition, though, this incremental volatility has tended to dissipate as the day progresses. In other words, the aggregate impact of data releases seems to be falling over the course of the trading session, and intra-day FX volatility reverts back to the average seen during non-data days. In our view, such diminishing marginal impact is part of a multi-year process of growing market efficiency, which results from improved trading systems and liquidity in currency markets[118], though also seems unusually low at the moment. Another interesting fact is that this dynamic can be witnessed regardless of the nature of the data release. Although it seems clear that the US employment report and the ISM have been of particular relevance in the past, such differentiation seems no longer as evident.

[117] We use 10:00 – 10:00AM NY time for daily ranges. Straddle price data is captured at 10:05 – 10:20AM NY time, and incorporates transaction costs. Intra-day volatility is captured using the period's high and low reading. We look specifically at US economic releases.

[118] For a detailed discussion on structural factors impacting FX volatility, please refer to *FX Derivatives Focus*, February 26th 2008.

Figure 160: Daily volatilities show less differentiation in terms of data type

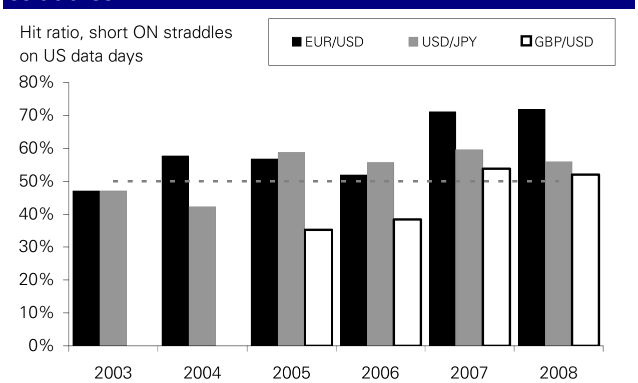


Note: average close-close range between EUR/USD, GBP/USD and USD/JPY. Source: Deutsche Bank

But have market prices adjusted for this changing relationship?

It doesn't seem so. "Data insurance" options have continued to trade at a similar premium to other overnight straddles despite the fact that the spot range around such dates is falling relative to that of non-data days. This can be witnessed in the consistent rise in the hit ratio of a strategy that systematically sells overnight straddles during data days, and especially in EUR/USD.

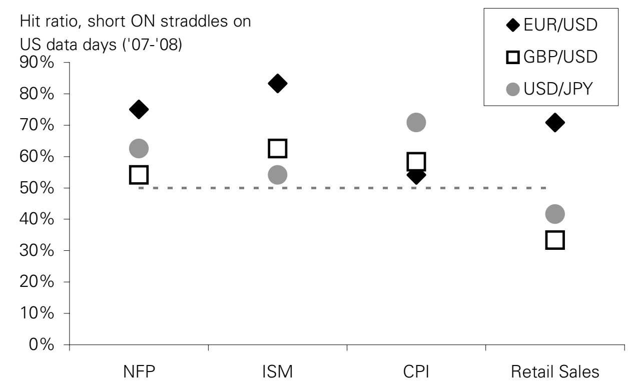
Figure 161: Rising hit ratio for short overnight straddles



Note: transaction costs taken into account (spot and volatility). Source: Deutsche Bank

The historical data also suggests that these discrepancies are more witnessed in certain types of releases for a given currency pair. Our assessment metric - the success hit ratio - suggests overnight insurance in USD/JPY ahead of US CPI, and overnight insurance in EUR/USD ahead of payrolls or ISM, are furthest from such adjustment. In other words, they are the ones where the straddle price is highest compared to the realized range. At the same time, the price of overnight straddles in USD/JPY and GBP/USD encompassing the retail sales release seem low compared to the empirical ranges over the past year and a half.

Figure 162: The type of data matters – and so does the currency pair



Note: transaction costs taken into account (spot and volatility). Source: Deutsche Bank

Is it worth trading volatility around the G-7 weekend? (11/04/08)

- Trading volatility around the G-7 meeting weekend hasn't normally been a profitable strategy in the past, but worth it when certain pre-conditions apply. While straddles may be too expensive at the moment, we believe that a short-dated put on EUR/USD is worth considering, especially for those who are long EUR spot.

Is it worth trading volatility around the G-7 meetings? History suggests that the short answer is, well, it depends. Historical price behaviour suggests unattractive odds in being either long or short overnight volatility ahead of the event. Both strategies - buying or selling straddles shortly after 3:00PM in London on Friday, with expiry at 10:00AM in NY the following Monday, have yielded a hit ratio of less than 50% over the past 5 years.

Short volatility positions have been, on average, more profitable than long positions (44% hit ratio vs 22% in EUR/USD, and 44% vs 33% in USD/JPY). However, and as commonly seen in overnight options, this reflects the fact that the P&L "skew" works heavily against the seller of the overnight straddles. In USD/JPY, for instance, the average loss from a short overnight straddle ahead of the G-7 semi-annual meetings has been 0.33%, over twice the size of the average gain. The skew is more favourable in EUR/USD (the average loss and the average gain are of similar sizes) but, even there, the "tails" of the P&L distribution are unfavourable - the maximum loss is 40% greater than the maximum gain.

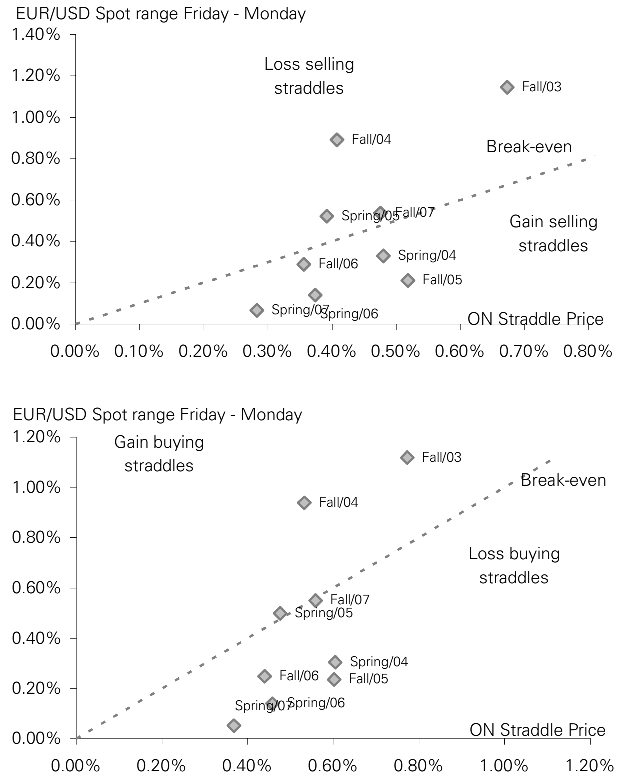
So in what environment does it make sense to trade this event risk through overnight volatility?

In USD/JPY, it is normally worth buying straddles when there is a combination of i) participants being flat JPY, and ii) strong risks of statements relating to global imbalances and the need for surplus countries to let their currencies appreciate. The two most notable G-7 meeting events - Fall/03 and Spring/06 - each had at least one of the two components. In 2006, investors were generally flat yen (our DBFX Positioning Indicator read +2 at the time), and hence the statements on the need for Asian currencies (i.e. CNY) were quite influential to the behaviour of USD/JPY on the following Monday. In 2003, the market was already long JPY, but the indications of less interventions from the Japanese authorities was enough to trigger the highest spot range post-G7 this decade.

In EUR/USD, the best time to buy straddles seems to be when there is risk of strong statements regarding the US dollar, or when there are risks of partial corrections to an underlying trend (as in October 2004). Recent history suggests the Euro is not a "targeted" currency, but such history suffers from a clear "sample bias" problem. This is the first time, over the past 5 years, that EUR/USD is at such extreme in PPP valuations. Previous statements have focused more on Asian (or Middle-Eastern) currencies in the past, but now the Euro could well qualify as recipient of potential statements on "imbalances" - albeit not likely according to our strategists.

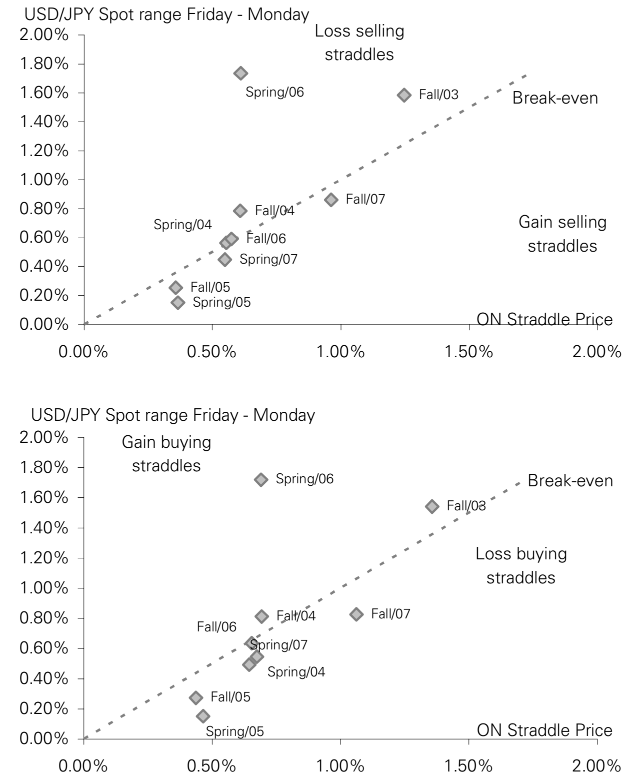
Our analysis suggests there is no "screaming" volatility trade ahead of this event, though the current environment - which includes both flat positioning and extreme valuations in EUR/USD - suggests an "insurance" trade may be worth considering. As much as we believe that the official statements are unlikely to surprise the market, history shows that price action may be very volatile even when the statements are judged to be unsurprising. A full straddle may be too expensive as overnight implied volatilities march above 13%, but a EUR/USD put may be worth considering, especially for those who are long EUR in the cash market.

Figure 163: Historical performance – selling and buying straddles in EUR/USD



Note: full bid-ask spreads taken into account in both the spot and straddle transactions. Source: Deutsche Bank

Figure 164: Historical performance – selling and buying straddles in USD/JPY



Note: full bid-ask spreads taken into account in both the spot and straddle transactions. Source: Deutsche Bank

Volatility in Extremis (09/01/08)

- We look at how PPP and FX volatility relate over time, and conclude that there is a clearer link for volatility risk premium rather than empirical volatility – especially in EUR/USD and USD/CHF.

Relating FX volatility to PPP valuations

A fundamental valuation approach to USD/G10 FX suggests many crosses are highly over/undervalued. Indeed, purchasing power parity (PPP) levels for the main currency pairs are near historical extremes (-18%, -11%, 23%, 25%, 26% and 34% in USD/CAD, USD/CHF, AUD/USD, EUR/USD, USD/JPY and GBP/USD respectively). In light of these over-stretched valuations, we look at how 3-month FX volatility has related to PPP levels since 1971, and conclude with trades that seem attractive given both our directional views on spot and the historical evidence.

PPP Extemes Do Not Change Realised Volatility Path

A key aspect of how empirical (actual) volatility relates to PPP in USD/G10 FX relates to the level of interest rate differentials. Empirical volatility is highest when low-yielding currencies are most overvalued against the USD (> 20%), and volatility tends to fall as they move from over- to under-valued territory. This is mostly a low-yield phenomenon though, as the opposite applies to higher yielding currencies in either mild (medium yielders) or acute (high yielders fashion. Much of this polarized behavior can be explained by the carry trade: lower FX volatility normally goes hand-in-hand with carry strength, which in turn pushes high-yielding FX into overvalued territory and makes low-yielding FX undervalued.

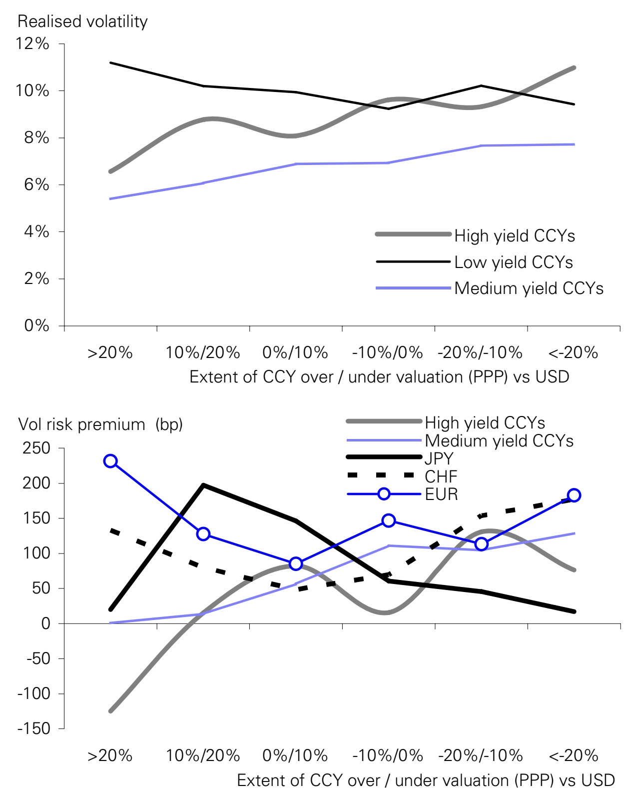
But They Do Impact the Vol Risk Premium (VRP)

When it comes to matched-maturity volatility risk premia (implied over realized volatility) of G10 crosses of similar yield category, they don't necessarily behave as actual volatility does. Of the currencies that exhibit unique VRP characteristics, EUR/USD and USD/CHF are at the forefront: both see a sharp rise in VRP at extreme valuation levels, due to uncertainty over positioning corrections and other forces that typically bring the crosses back to a multi-year range. Risk reversals, though, reflect these "pull-back" forces stronger in EUR/USD than USD/CHF, skewing strongly in favor of the undervalued currency (EUR or USD) at extreme levels. VRP is particularly low at extreme valuation levels in USD/JPY, that the market prices volatility more accurately at the extremes, though such is not shared at less extreme levels (implied volatility is "stickier"). In other higher yielding currency pairs, however, the behavior is more synchronized: the risk premium is high at undervaluation levels (realized vols are high, but implieds are even higher) but falls progressively as the currencies strengthen (realized volatilities fall, but implieds fall even further).

So what are the key takes?

The key conclusion is that realized volatility is not as dependent on particular PPP thresholds, though the VRP level can be – especially in EUR/USD and USD/CHF. Given our view that valuations will remain stretched in both crosses, they suggest short gamma positions will generally perform well over the coming months. Elsewhere, the data suggests volatility and VRP will move in tandem with our spot views, with less clear linkage to PPP levels. Our bullish views on USD/CAD, EUR/USD, USD/JPY spot, cautious on AUD/USD and bearish USD/CHF spot suggest empirical volatility will rise over the coming months in all crosses except for USD/JPY, and the (matched-maturity) volatility risk premium will also rise in USD/CAD, AUD/USD and USD/CHF and fall in USD/JPY.

FX vol and PPP – historical relationships



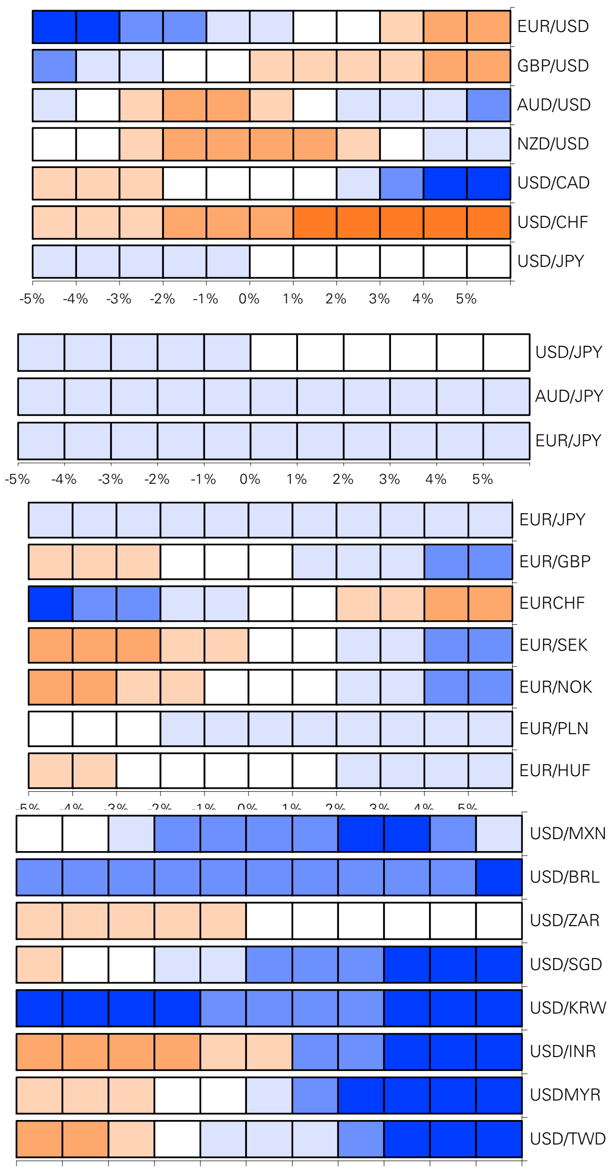
Source: Deutsche Bank Global Markets, Bloomberg. We use exponentially weighted realized volatility and matched maturity VRP (lagging historical volatility by 3-months). We use median levels in our sample.

Section 4: Global FX Gamma Reports

Global FX Gamma Report, (12/09/08)

Market Short Gamma - Spot "Slippy"				Market Long Gamma - Spot "Sticky"		
Strong	Moderate	Mild	Neutral	Mild	Moderate	Strong

Figure 165:Global FX gamma heat-map



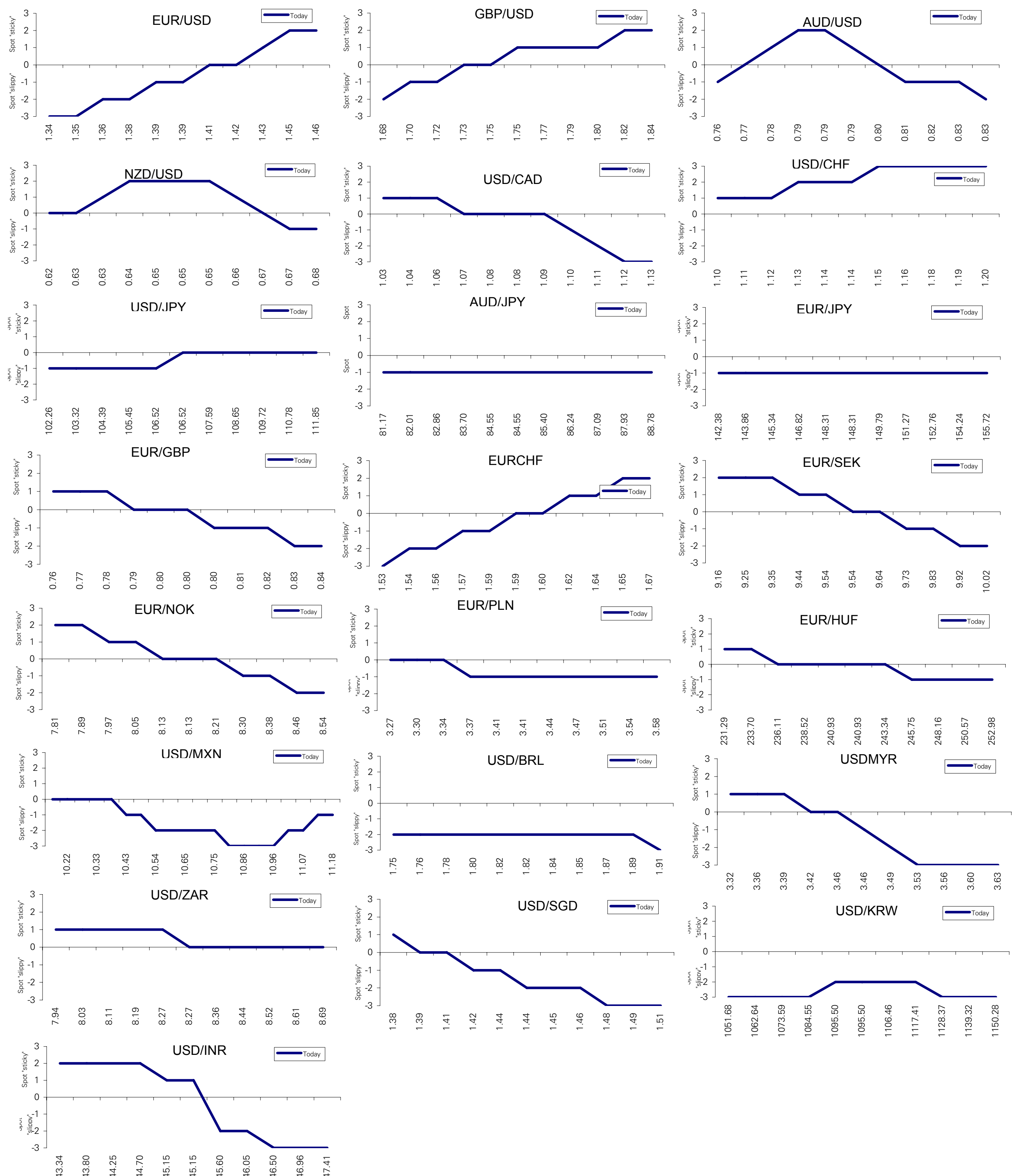
Note: Spot levels (0%) assumed: 1.392 1.751, 0.794, 0.648, 1.077, 1.141, 106.520, 68.972, 84.550, 186.469, 148.308, 0.795, 1.589, 9.540, 8.133, 3.405, 240.931, 10.645, 1.818, 1.260, 1109.500, 1.444, 45.545, 3.468, 32.090, 8.275. Source: Deutsche Bank FX Trading

Figure 166: Levels and commentary

	Barrier Levels / Ranges	Commentary
EUR/USD		The large demand for downside options from customers keeps the market heavily bid for gamma. Note that a large portion of these options are of very short dated maturities.
AUD/USD		Traders are feeling more comfortable after being supplied with gamma for a week by model accounts. Topside strikes look increasingly bid due to what seems to be a generally short risk reversal position by market makers.
NZD/USD		Market makers are long gamma and were given decent amounts of short dated options after the RBNZ surprise cut on Tuesday.
USD/JPY		The rising demand for USD/JPY downside from customers makes the street increasingly short downside gamma.
EUR/JPY		With most barriers been taken out, market gamma has been generally "washed" and the growing short gamma position is purely a function of risk aversion, with customers purchasing a growing amount of EUR/JPY and AUD/JPY downside into the weekend.
USD/BRL	The barrier minefield has been mostly washed out.	The past couple of weeks were marked by different participants "scrambling" for USD/BRL upside - from hedge funds taking a more bearish view on BRL to corporates hedging or re-setting derivatives structures. Unlikely to change anytime soon.
USD/SGD		Market makers were caught heavily short gamma, leading to unprecedented levels (1m volatilities traded at 8.9%).
USD/KRW	Most barriers have been cleaned out, 1160 - 1200 now	The spot market ranges are still very choppy, and liquidity is limited in both spot and options markets.
USD/INR		Our traders expect USD/INR spot to test 46.00 next week, with constant onshore buying from oil companies and gamma remaining well bid.
USDMYR		The Bank Negara remains heavily active in the spot market.
USD/TWD		Expect the spot trend to continue with heavy "smoothing" by the CBC.

Our survey of options traders paints a pretty interesting picture of the current options market. Customers seem increasingly worried and are hence demanding greater amounts of short dated, low delta options in quite a few crosses, which leaves market makers short lower delta strikes (almost) across the board. We still seem to be somewhat far from the Jan-March extremes in G-10, however, due to the growing presence of system-trading accounts, who have been supplying gamma to the market as signalled by their reversion models in JPY, AUD and NZD. There is almost no barrier "minefield" according to our heatmap, except for a few levels in USD/KRW. This follows naturally from the aggressive spot moves from August, and most of the gamma exposure seems linked to vanilla structures. EM is starting to feel the bearish adjustment. Corporates, hedge funds and institutional accounts are heavily bidding for upside strikes in USD/BRL, and in some of USD/Asia. In fact, our gamma report has never recorded (in its short history) such short gamma exposure at 2%+ above spot for USD/EM.

Figure 167: Gamma profile per currency pair

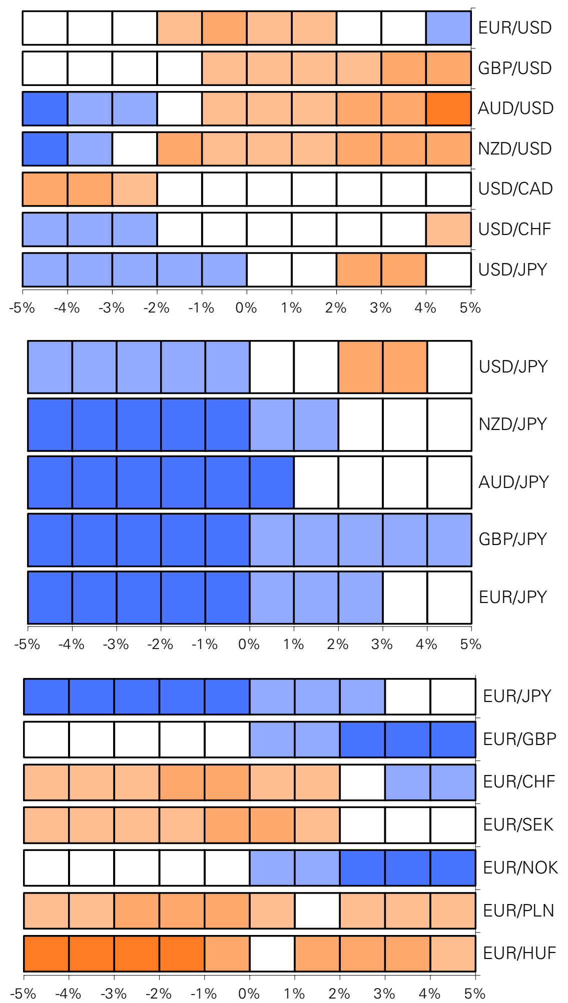


Source: Deutsche Bank FX Trading

Global FX Gamma Report, (18/01/08)

Market Short Gamma - Spot "Slippy"				Market Long Gamma - Spot "Sticky"		
Strong	Moderate	Mild	Neutral	Mild	Moderate	Strong

Figure 168:Global FX gamma heat-map



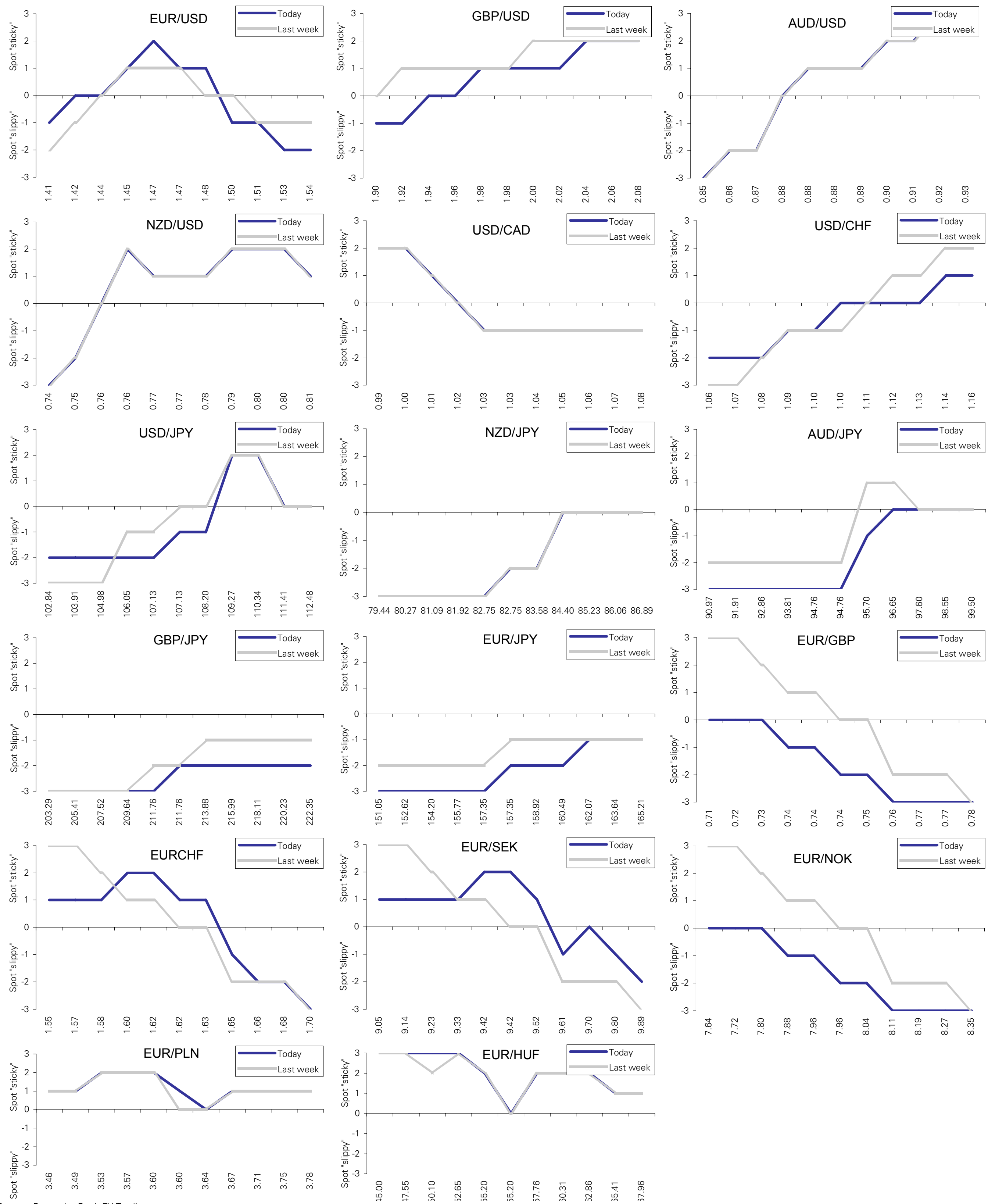
Note: Spot reference, as per y-axis order: 1.469, 1.977, 0.885, 0.772, 1.030, 1.100, 107.13, 82.75, 94.76, 211.76, 157.35, 0.743, 1.616, 9.422, 7.956, 3.602, 255.20.Source: Deutsche Bank FX Trading

Figure 169: FX Barriers and Commentary

FX Pair	Barriers	Commentary
EUR/USD	1.5000 is the only real barrier of note within range.	Large demand for put/call spreads; volatility is bid due to nervous market conditions.
GBP/USD	No barriers in market.	The market is short downside gamma, though comfortable with the 1.94/1.99 spot range.
AUD/USD	Nothing nearby. All barriers washed out by large spot range.	The market is very short front end risk reversals.
NZD/USD	The market is long topside, to continue as spot rallies are capped and decay hasn't built up.	Option decay was covered all week, but we expect selling of gamma if the spot market gets quiet.
USD/CAD		Short vega positions are likely to be covered given next week's batch of economic events.
USD/CHF	Nothing within 2% spot range.	Players are short USD/CHF spot against short CHF calls; the market is vulnerable to a squeeze.
USD/JPY	105.00, 108.25 and 108.55 are the main levels.	The supply of JPY calls is currently scarce given the one-sided nature of market positions.
NZD/JPY		Gamma in short supply, FX carry exerting a large influence on options positioning.
AUD/JPY		Good interest to buy M/T and L/T options given expectations of monetary easing by the RBA.
GBP/JPY	Barriers at GBP/JPY 210 have been knocked; 205 is the next key level.	
EUR/JPY	Notable barriers at the EUR/JPY 155 level.	Volatility is consistently better bid compared to that of USD/JPY.
EUR/SEK	-	Gamma is currently well offered in the market after a period of low volatility.

Source: Deutsche Bank

Figure 170: Gamma profile per currency pair



Source: Deutsche Bank FX Trading

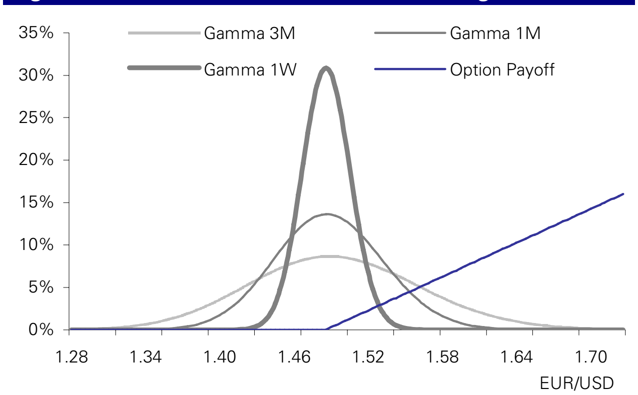
Appendix – Gamma and Gamma Profile[119]

Vanilla options – trading around the strikes

Delta is the sensitivity of an option's value to moves in the underlying spot; its value ranges from close to zero (when the option is far out-of-the-money), to close to one (when it's far in-the-money). The rate of change of the delta, from zero to one, is called the **gamma**. Gamma is not constant across spot; it rises gradually at first, then quicker, reaching a peak around the strike of the option, after which it falls gradually again. A long vanilla option position is long gamma; that is, delta rises as spot rises, and delta falls as spot falls.

As the chart shows, the gamma of an option is always a positive asset. If the owner of an option always gets longer spot as it rises, and shorter spot as it falls, then he (or she) will always benefit from a spot movement regardless of the direction. Hence, when spot volatility rises, option traders recognise the rise in the value of gamma and thus charge more for options.

Figure 171: Gamma of a vanilla call through time



Note: the option described is a EUR/USD call, struck at 1.4850. "Option payoff" relates to the payoff at maturity. Source: Deutsche Bank

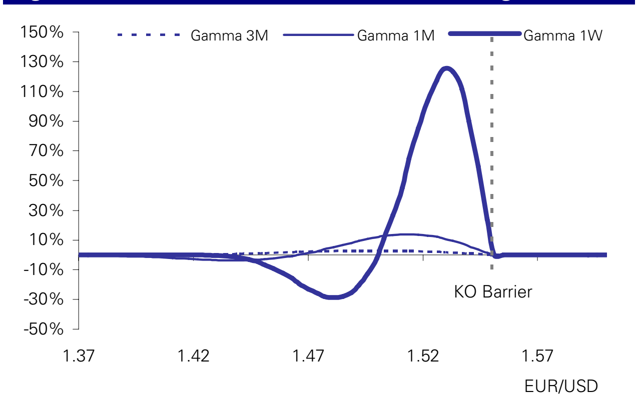
If the long vanilla call position is being hedged, however, the option buyer will sell larger amounts of spot as it rises (to offset the rising delta), and buy spot as it falls (to meet the falling delta hedge requirement). This activity suppresses actual spot volatility at the region in which the rate of change in the delta (i.e. the gamma) is high, or in other words, around the strike of the option. In addition to the strike, the maturity date of the (vanilla) option also plays a key role in determining the impact of this delta hedging on the spot market, in that the gamma of ATMF options rises substantially as time decays. In summary, one can expect the spot market to become **"sticky"** if the option market[120] is long short dated strikes around current spot; conversely, if the option market is short strikes, we can expect the spot market to be choppy, or **"slippy"**.

Exotic options – trading around the barriers

The impact of option market activity on the spot market is exacerbated by the presence of exotic options (OTC), structures whose payoff profile differs from common vanilla options and which are typically more complex in nature. The breadth of exotic FX products traded today is huge, with one of the most commonly traded exotic options being the reverse knock-out (RKO); this is a vanilla option but with an additional feature where it disappears if a specified barrier level (in-the-money) is crossed at any time during the life of the option. This limited upside[121] potential reduces the price of RKOs compared to vanilla options, which in turn makes them popular.

A very realistic scenario would see an acting market maker selling an RKO call option to an investor client, which inherently makes the acting market maker short the RKO. The delta hedging requirement for the acting market maker will change across time and spot, as shown in the chart. At the strike, the trader's gamma position is similar to what it would be if the structure had no knock-out feature – the acting market maker is short gamma and needs to buy spot as it rises.

Figure 172: Gamma of short RKO call through time



Note: the numbers relate to a EUR/USD call, struck at 1.4850 with a knock-out at 1.55. Source: Deutsche Bank

However, as spot approaches the barrier, the curvature reverses and the trader becomes long gamma (after all, the trader is long the barrier – albeit short the call). With his delta exposure becoming increasingly positive, the trader then hedges the exposure by selling large amounts of spot as it approaches the barrier, exerting downward pressure on spot and preventing it from hitting the barrier level. A similar dynamic will be occurring with the acting

[119] (This article is partly based on the "CRVG Special Focus – Option Gamma & the Spot Market", Jan-2003)

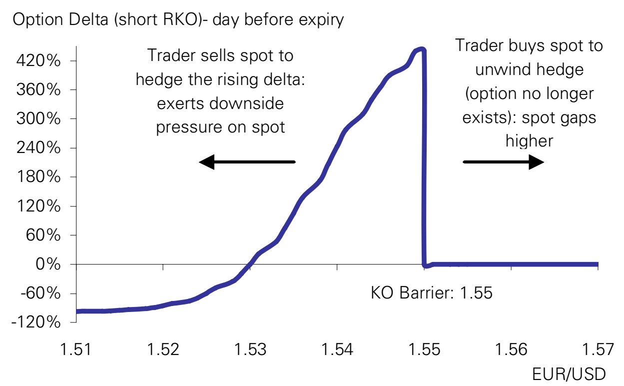
[120] By "option market", we specifically refer to market participants who need to hedge their option exposure – in other words, market makers.

[121] Conversely, RKOs also give limited downside potential for the option seller, a clear difference to vanilla options – such as standard calls – which have unlimited loss potential for the seller.

market maker's vega exposure (short near the strike, long near the barrier), which will induce the selling of short dated options and hence also suppress volatility.

Should the barrier break at any given point, the RKO option ceases to exist and the acting market maker's hedges will have to be unwound. The trader now needs to buy back spot and options to square the position, which can lead to a gap higher in spot and choppy trading – in other words, spot becomes **"slippy"**. Large barrier breaks typically result in substantial gaps in spot.

Figure 173: Hedging the short RKO position – forces at work in the spot market



Note: the numbers relate to a EUR/USD call, struck at 1.4850 with a knock-out at 1.55. The delta is in Euros.
Source: Deutsche Bank

The Deutsche Bank Global FX Gamma Report

In order to evaluate whether the market is long or short gamma, one should have a significant sample of the market's position. Deutsche Bank's leading share of the FX options market, confirmed by recent Euromoney surveys, provides it with a unique level of visibility, which allows us to evaluate the gamma positioning of the market with reasonable accuracy through our Global FX Gamma Report.

The report outlines the main strikes and barriers of relevance in the foreign exchange options market and their likely impact on the behaviour of spot. At levels where our traders believe acting market makers are long gamma, we expect spot to be **"sticky"**; in other words, less volatile and range-bound due to consistent selling above, and consistent buying below, a particular strike. Conversely, ranges in which the "Street" is believed to be short gamma should be associated with **"slippy"** spot behaviour: barrier hedging (and de-hedging) activity may lead to violent moves in spot FX should it trade at the barrier level.

Our traders allocate a subjective measure of gamma intensity for a given currency range, choosing between -3 (very "slippy") to +3 (very "sticky"). These are displayed in the form of currency blocks (USD, JPY and EUR, page 1) or individual currency pairs (17 in total, page 2).

The author of this report wishes to acknowledge the contribution made by Abhijit Gite, an employee of DB GMC, a third-party provider to Deutsche Bank of offshore research support services.

Appendix 1

IMPORTANT

The projections or other information generated by the Gamma Profile per currency pair tool regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results and are not guarantees of future results.

Portions of this report analyze historical data. Past performance is not a guarantee of future results.

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