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Global FX Strategy
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Currency hedging with options

Can options help mitigate the cost-of-carry problem for Euro-denominated FX hedgers?

Global FX Strategy
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- **For European asset managers, hedging short Euro exposure will remain a portfolio management necessity over the next few quarters as the common currency is poised for further gains due to a hawkish shift in ECB policy, best-in-class flow support from a hefty basic balance and unchallenging long-term valuations.**
- **The FX hedging challenge in 2018 is that EUR forward points have climbed to their widest on record since the inception of the Euro, prompting interest to explore options as potentially lower cost / lower negative carry alternatives to traditional FX forward hedges. This note tries to answer some frequently asked questions about hedging short EUR exposure with options.**
- **EUR call spreads and seagull structures (long call spreads financed by selling puts) screen as the historically best-performing systematic hedge overlays on traditional stock/bond investments in US and UK markets over a 2002- 2017 sample period.**
- **Preferred option maturities are shorter (3M) rather than longer (6M or 1Y) given the limited upside nature of call spread and seagull structures that realize most of their P/L towards the back-half of their lives. Preferred strikes are long ATM vs. short 25D or further out-of-the-money.**
- **In terms of notional sizing, matching option deltas to the underlying currency exposure i.e. 100% delta-hedging at inception is significantly more effective than matching option notionals.**
- **Even accounting for realistic transaction costs, the best delta-matched option hedges can increase average portfolio returns by 50bp - 100bp annually over and above forward hedges which themselves materially improve the risk-reward of FX unhedged investments.**
- **Optimal option-based hedge ratios are quite close to 100% for both EUR/USD and EUR/GBP, and this result is fairly invariant to the composition of the underlying portfolio within a broad 30% - 60% equity allocation. Given greater transaction costs of options, optimal option-based hedge ratios are ~10% points higher than forwards.**
- **Relative cost-of-carry of options vis-à-vis forwards can be evaluated by examining the static decay profile of forward delta-hedged option structures. Relative value between volatility and forward points at present is highly favorable for option-based hedging vis-à-vis forwards in EUR/USD, less so in EUR/GBP where forward points are narrower.**

See page 13 for analyst certification and important disclosures.

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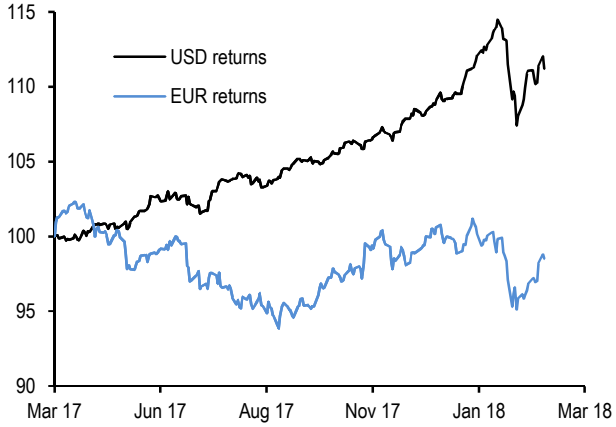
The cost-of-carry headache for Euro-denominated currency hedgers

The 10% rally in the trade-weighted Euro from last year's French election trough has come as a mixed blessing for European asset managers and corporates. On the one hand, the synchronized global growth upturn it ushered in boosted local currency portfolio returns and earnings, but on the other hand translation losses on FX-unhedged investments detracted significantly from EUR- denominated returns (Exhibit 1). Needless to mention, hedging short Euro exposure has been a portfolio / revenue management necessity over this period, and that is likely to remain the case over the next few quarters as the common currency is poised for additional gains due to an impending hawkish shift in ECB policy later this year, best-in-class flow support from a hefty 6% of GDP basic balance and unchallenging long-term valuations; JPMorgan's 4-quarter ahead spot target is 1.29 (*Key Currency Views*, Chandan et al, March 20). The FX hedging challenge in 2018 is that EUR forward points have climbed to their widest on record since the inception of the Euro (Exhibit 2) thanks to the 100 bp sell-off in 2Y Treasuries from their 4Q17 lows. EUR/USD 1Y points are now a punchy 378 points, implying a steep forward outright north of 1.26 at the time of going to print. Neither are hedging expenses likely to shrink going forward if our Fed forecast of four hikes in 2018 is realized and US – Euro area short-end rate differentials do push another 85bp higher by this time next year per our Fixed Income Strategists' projections.

Perhaps as a result of these concerns, we have encountered client interest in recent weeks to explore options as potentially lower cost alternatives to traditional FX forward hedges. *Ex-ante*, this is not an unreasonable line of investigation even absent steep forward points since the non-linearity of option payoffs and the degrees of freedom available in terms of choosing structures, notional, strike and tenor combinations raises the possibility of finding a construct that delivers similar or better hedge protection than forwards for lower net spend. The current market set-up may be especially favorable for considering a forwards-to-options switch on relative value grounds: the sharp increase in Euro forward points has not been met with a commensurate increase in volatility, resulting in static carry / premium ratios of EUR/USD ATMF straddles climbing to all-time highs on record (Exhibit 3). For instance, Exhibit 3 shows that the static terminal payout / premium ratio of a EUR/USD 1Y ATMF straddle is 0.5 currently, meaning 50% of the option premium can be recouped by virtue of the carry on the EUR put/USD call leg of the straddle even if

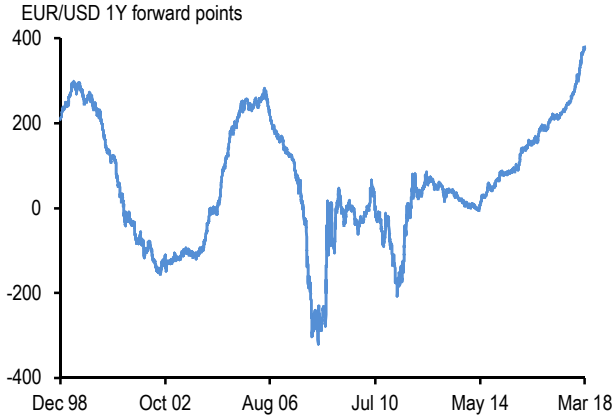
Exhibit 1. The 10% + rally in the Euro over the past year led to steep translation losses on FX unhedged asset portfolios

Total returns of a FX unhedged 60/40 equity / bond portfolio over the past 1-year in US dollars and Euros from the viewpoint of a European investor. Equity returns assumed to be total returns inclusive of dividends on the MSCI World ex-Europe index. Bond returns assumed to be total returns on GBI Global ex-EMU.



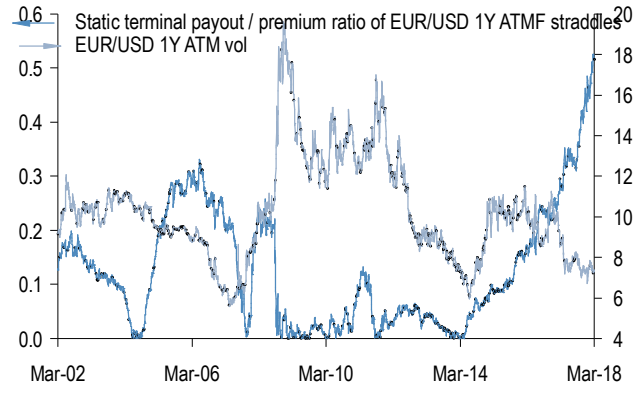
Source: J.P.Morgan, Bloomberg

Exhibit 2. EUR/USD forward points have climbed to their highest since the inception of the Euro….



Source: Bloomberg

Exhibit 3. …without a commensurate increase in volatility, resulting in carry / premium ratio of EUR/USD ATMF straddles climbing to all-time highs



Source: J.P.Morgan

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spot were to remain unchanged at the expiry of the option[1]. The mix of benign vol levels (10th percentile of 20-year history) and record carry / vol ratios indicates a strong preference for option ownership over forwards, since potential upside from mean-reversion in vol comes with reduced decay costs.

This note tries to answer some frequently asked questions about hedging short EUR exposure with options:

- Are there any 'dominant' vanilla option constructs that systematically outperform passive long forwards?
- Does option outperformance, if any, survive transaction costs that are typically quite a bit higher than forwards?
- Should option-based hedge ratios be lower than those for forwards given the potential for convex payoffs from the former?
- How to decide whether timing is opportune to choose between forwards and options based on relative points and vol set-up?

This still leaves unanswered questions on how to manage fluctuations in hedge ratios (deltas) of options in real-time with moves in spot, volatility or simply the passage of time; we will address risk management questions in a follow-up to this note.

The generic European asset manager portfolio

The first step in simulating FX hedging strategies is to identify the overseas allocation of a representative asset manager portfolio at a granular currency level. Fortunately, the ECB provides quarterly data on aggregate holdings of Euro area investment funds broken down by asset type and geography[2], a sample of which is reproduced in Exhibit 4. The latest available numbers for 4Q17 shows that European fund managers own over €12 trillion in total assets, of which €4.5 trillion is in bonds and €4 trillion is in stocks. 55% of the bond holdings are in foreign debt, of which the US and EU ex-Euro area (which we assume to be primarily UK) make up 2/3rd of the allocation. Of the equity share of investments, 63% of holdings are in overseas securities, with the US and the UK once again accounting for more than half the share of assets.

Exhibit 4. A generic European asset manager portfolio

EUR billions; not seasonally adjusted; outstanding amounts at end of period. Aggregated portfolio statistics as of end-January 2018, issuer-level breakdown as of end of quarter, hence the small discrepancy in total holdings of debt and equity between aggregate and issuer level data.

Aggregated portfolio

	Total	Deposits and loan claims	Debt securities	Equity	Investment fund shares	Non-financial assets	Remaining assets and financial derivatives
Total	12,473	821	4,490	3,906	2,037	364	857

Debt securities broken down by issuer

	Total	Euro area	Rest of the world				Share of foreign debt			
		Total	Total	EU outside of Euro area	US	Japan	Other	EU-ex Euro area	US	JN	Other
1Q17	4,319	1,979	2,340	665	917	42	717	28%	39%	2%	31%
2Q17	4,384	2,010	2,374	677	926	41	730	29%	39%	2%	31%
3Q17	4,468	2,031	2,438	686	945	46	761	28%	39%	2%	31%
4Q17	4,505	2,032	2,473	710	930	53	780	29%	38%	2%	32%

Shares and other equity broken down by issuer

	Total	Euro area	Rest of the world				Share of foreign equity			
		Total	Total	EU outside of Euro area	US	Japan	Other	EU-ex Euro area	US	JN	Other
1Q17	3,512	1,285	2,227	301	925	189	812	13%	42%	8%	36%
2Q17	3,526	1,311	2,215	306	899	197	813	14%	41%	9%	37%
3Q17	3,664	1,384	2,280	315	924	194	847	14%	41%	9%	37%
4Q17	3,818	1,394	2,424	328	982	219	897	14%	40%	9%	37%

Source: ECB

Given the outsized share of the US and UK in overseas allocation of European investors, this note will focus only on hedges for EUR/USD and EUR/GBP exposures. Using the relative weights of debt and equity holdings for those jurisdictions in Exhibit 4 –51% stocks vs. 49% bonds for the US given €982bn and €930bn holdings respectively, similarly 68% bonds vs. 32% stocks for the UK – we simulate historical return streams from bond/equity portfolios holding asset allocation constant. The assumption of constant portfolio weights may be questionable over a long time series sample, but they have not changed dramatically over the past four quarters and can be reasonably expected to approximate portfolio composition over the next few quarters. Bond returns are proxied by those of JPM Global Bond Index (GBI) country level indices denominated in Euros, and equity returns by total returns (inclusive of dividends) of S&P 500 and FTSE in Euro terms sourced from Bloomberg.

[1] Previous JPMorgan research has found that such *ex-ante* carry / vol ratios are economically significant predictors of *ex-post* straddle returns (see *Extracting vol alpha using carry-to-risk signals*, Jankovic, May 27, 2016) and are also useful components of composite vega buying signals (see *Systematic long vega using straddles*, Jankovic, November 21 2017)

[2] See Investment funds balance sheets: Holdings of securities by issuing sector http://sdw.ecb.europa.eu/reports.do?node=1000003528

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Exhibit 5 shows return statistics for the FX-unhedged return streams from US and UK market investments since 2002, a date restriction imposed by constraints on the availability of reliable option return data that we shall later use to backtest hedging strategies, and the cumulative monthly return streams are plotted in Exhibit 6. It is striking that USD investments did little more than tread water during the boomy years of the early 2000s when S&P delivered double digit annual returns but alongside a stronger Euro. GBP assets fared better but were hit with the sharp collapse in the pound during the GFC that exacerbated losses. The QE-era Euro debt crisis years were kinder for FX-unhedged investing, but with ECB QE on the way out, the dollar on potentially a multi-month downtrend and European political stress effectively neutered for a while over the past year through mainstream electoral wins and/or marginalization of the Euroskeptic fringe, a repeat of the heady mix of foreign asset reflation and a weaker Euro appears unlikely and the need for currency hedging seems unavoidable. The rest of this note will attempt to answer the option hedging related FAQs listed earlier by overlaying various rule-based currency hedge programs on these reference return time series.

Benchmark hedge: FX Forwards

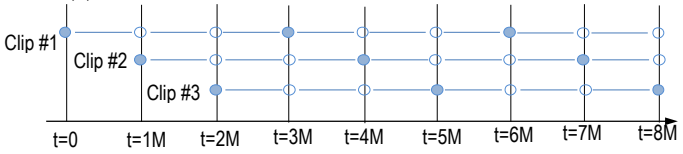
Before exploring option strategies, it is necessary to institute a baseline forward hedge that can act as a control for evaluating the efficacy of more complex instruments. Anecdotal evidence suggests that rolling 1-month and 3-month forward hedges are the most commonly used by institutional investors. Corporate treasuries with disciplined FX hedging programs often resort to layering forwards of various quarterly maturities (3M, 6M, 9M and 1Y) with varying notional amounts (near quarters are hedged to a much greater degree than those further out) that are rolled and notional-rebalanced every three months. For simplicity, we assume only a single-maturity (3M) instrument in our analysis, but do incorporate an element of layering and rolling by assuming that the hedge book consists of three parallel streams of 3M forwards with maturity dates staggered by a month (see schematic in Exhibit 6), each held to expiry and rolled thereafter, and assigned 1/3rd the notional that would have been allocated to a single forward stream. In addition to smoothing performance, this scheme allows monthly marked-to-market portfolios to re-adjust hedge notionals to the desired ratio without having to wait 3-months for a single 3M forward to expire and bear the tracking error in the interim. In fairness, this can also be achieved by rolling a single stream of 3-month forwards every month, but that suffers from the drawback of being more transaction cost expensive on two counts: (a) more frequent rolls –12 monthly transactions in a year – on the entire hedge notional, as opposed to a total of still 12 monthly transactions but each on only 1/3rd the full notional in the quarterly staggered scheme in Exhibit 6; and (b) having to cross bid-offer spreads on both entry and exit, while holding to maturity entails paying only 50% of the

Exhibit 5. FX-unhedged Euro returns of a typical European asset manager's US and UK investments
Monthly data, 2002 – 2017. US investment assumed to be 49% bonds, 51% equities. UK portfolio assumed to be 68% bonds, 32% equities.

Local Ccy	Avg. return (ann.)	Stdev. (ann.)	IR (ann.)	Sort-ino Ratio	5% Monthly Tail Loss	Avg. DD	Max DD	Avg. Ret / 5% Tail Loss	Avg. Ret / Max DD
USD	4.0%	9.4%	0.43	0.67	-4.1%	-11.4%	-27.0%	1.00	0.15
GBP	3.2%	8.3%	0.39	0.53	-3.6%	-6.1%	-29.1%	0.91	0.11

Source: J.P.Morgan

Exhibit 6. A schematic of a staggered forward hedging strategy
Colored dots denote expiry/roll dates, and blank dots represent intra-life mark-to-market dates. So Clip #1 rolls at t=0, 3,6, ..., Clip #2 at t = 1,4,7….and Clip #3 at t=2,5,8…….

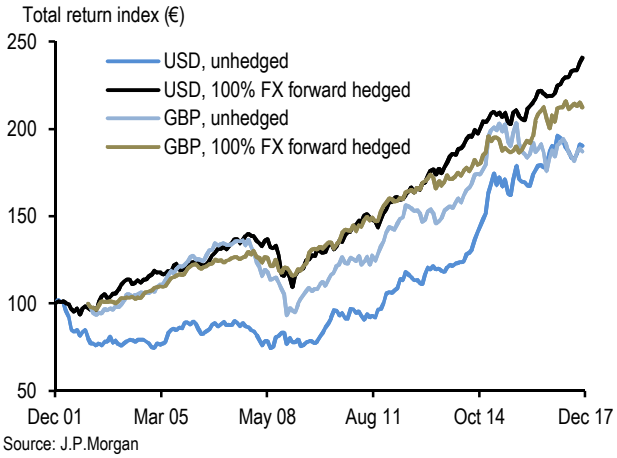


Source: J.P.Morgan

Exhibit 7.FX hedging using forwards has significantly improved risk-adjusted returns of overseas holdings over the past 15 years

EUR/USD	Avg. return (ann.)	Stdev. (ann.)	IR (ann.)	Sort-ino Ratio	5% Monthly Tail Loss	Avg. DD	Max DD	Avg. Ret / 5% Tail Loss	Avg. Ret / Max DD
Unhedged	4.0%	9.4%	0.43	0.67	-4.1%	-11.4%	-27.0%	1.00	0.15
FX Hedged	5.6%	6.3%	0.89	1.12	-2.5%	-2.2%	-21.9%	2.18	0.25

EUR/GBP	Avg. return (ann.)	Stdev. (ann.)	IR (ann.)	Sort-ino Ratio	5% Monthly Tail Loss	Avg. DD	Max DD	Avg. Ret / 5% Tail Loss	Avg. Ret / Max DD
Unhedged	4.2%	8.6%	0.49	0.65	-3.9%	-5.8%	-31.8%	1.08	0.13
FX Hedged	5.0%	5.7%	0.88	1.42	-2.2%	-1.5%	-11.1%	2.24	0.45



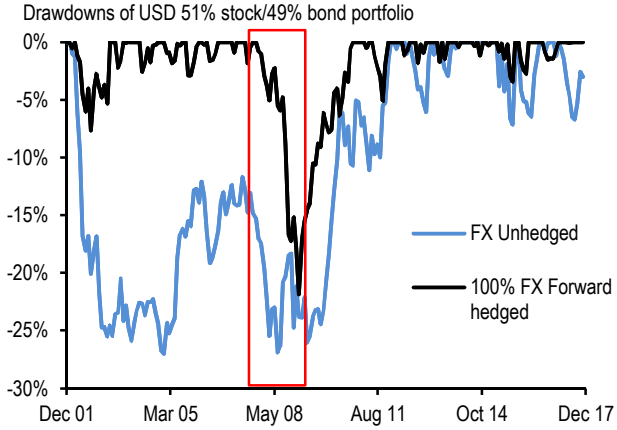
Source: J.P.Morgan

spread at entry. We pay attention to economizing on transaction costs at the very outset since they are a much bigger concern for options than for forwards and have the potential to negate a good part of the benefit of convex payoffs if handled carelessly. Less frequent (quarterly instead of monthly) option rolls that are made possible by staggering expiries also bring certain kinds of option structures into play that would otherwise not survive more frequent rebalancing, for instance call spreads that by their very nature realize most of their intrinsic value in the back half of their lives (more on this in the next section).

How effective is currency hedging in mitigating portfolio risk? Exhibit 7 plots returns of the 51% stock / 49% bond US securities portfolio on an unhedged and 100% FX forward hedged basis. The daylight between the two return streams tells its own story: the gap of 50% points in cumulative P/Ls at the end of 2017 can be explained by the 35% total returns on EUR/USD FX over the '02-'17 sample period, plus compounding benefits of increasing hedge notionals as the core asset portfolio grew over time. Sharpe ratios of the FX hedged construct are more than double the unhedged one, and there are also significant savings on tail risk metrics (37% reduction in monthly 5 percentile tail loss, 81% reduction in average drawdowns and a 20% drop in maximum drawdown). The one negative – something that should not come as a surprise – is that twin crashes in EUR/USD and SPX during GFC amplified rather than muted drawdowns during the 2008/'09 period (Exhibit 8). Absent currency hedging altogether – which does not look advisable based on the historical evidence – there is no way to circumvent this positive Euro vs. US stocks correlation; the only mitigator can be a strategic decision to run less-than-100% FX hedge ratios.

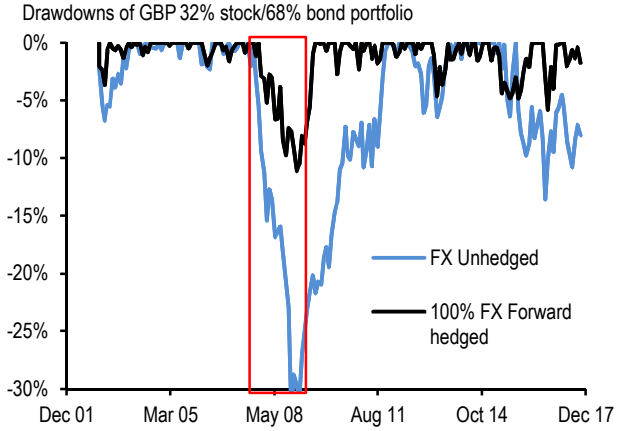
The experience of FX-hedged GBP assets – the jump in returns and the near doubling of Sharpe Ratios vis-à-vis the unhedged portfolio – is similar in many respects to that of USD assets. The one notable difference is the **much larger drawdown reduction** (65%) and hence a much larger commensurate jump in return/tail risk ratios thanks to the lower (in fact, negative during stress) correlation between the FTSE and EUR/GBP. Exhibit 9 shows that GFC-era drawdowns of the currency hedged UK portfolio were only 1/3rd of the naked one, as the 40% drop in the FTSE was offset to a significant extent by the 25% spike in EUR/GBP between May- December 2008. The Brexit experience was qualitatively different in that the pound bore the brunt of the anticipated weakening in the UK's basic balance following exit from the customs union, while stocks remained by and large well-supported against a decent global growth backdrop except for a short-lived 9% drop in the immediate aftermath of the referendum. FTSE rose 15% between May-October of 2016 even including this blip while EUR/GBP rallied an even larger 20%, with the net result that FX-hedged portfolio once again handsomely outperformed the naked one, but somewhat unusually via currency alpha.

Exhibit 8. GFC-era drawdowns of the USD portfolio are amplified by FX hedging due to the simultaneous SPX and EUR/USD declines….



Source: J.P.Morgan

Exhibit 9…but the experience is different for the GBP portfolio where a crash in UK assets was offset to some extent by a fall in GBP



Source: J.P.Morgan

Considerations for option-based hedge programs

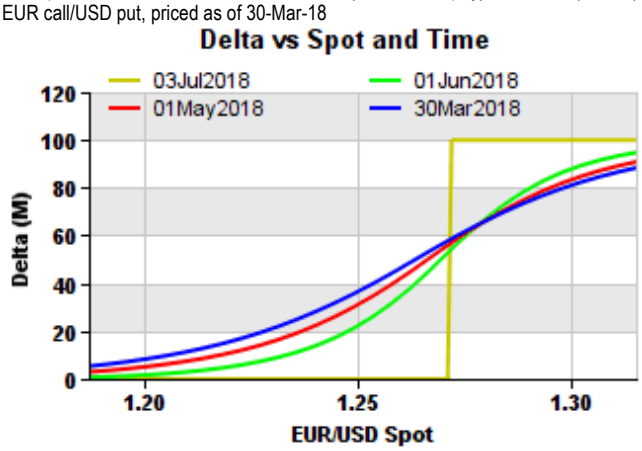
Using options for any purpose, be it for hedging or alpha generation, involves multiple decision parameters such as the choice of structure, tenor selection, strike selection and notional sizing. Before jumping headlong into historical return simulations on option strategies, a few general considerations around these are worth noting:

- **Option structure**: A key stumbling block for asset managers mulling switching to option-based hedging programs is the need for upfront premium commitment that introduces portfolio tracking error relative to benchmark at every option purchase/roll. This naturally influences the kinds of option structures they can pursue, and pushes them in the direction of **zero-cost constructs such as risk-reversals and seagulls**. Premium-

neutrality is not a hard constraint however since the degree of the option premium-induced tracking error matters: for some managers, there may be flexibility to consider lower premium structures such as **call and put spreads**, but standalone premium-heavy calls and puts may be a bridge too far. For corporates, the choice of option structure is a function of hedge effectiveness treatment. Out-of-the-money foreign currency puts and zero-cost risk-reversals are acceptable, with a general preference for the latter over the former. In the light of these limitations, we limit our investigation to the following five vanilla structures: puts on foreign currency, put spreads, risk-reversals (long put vs. short call), seagulls (long put spread vs. short call) and calendar risk-reversals (long put of longer maturity vs. short call of shorter maturity). The last of these is a little unconventional, but included in the set nonetheless since anecdotal conversations suggest some degree of usage within the hedger community, and because some tail-risk hedging literature has found them to be useful in an equity context.

- **Option tenor**: Aside from small differences in liquidity between forwards of different expiries, the choice of forward tenors is largely a strategic one predicated on the need to match portfolio mark-to-market reporting dates and/or the date of the expected cash flow/revenue stream being hedged rather than any material difference in instrument behavior. While similar needs hold for options as well, expiry considerations involve an additional layer of complexity relating to difference in Greek profiles of shorter and longer maturity options (larger theta/gamma and smaller vega on shorter tenor options versus longer tenor ones), which in turn has implications for notional sizing and *ex-ante* cost-of-carry budgeting. For the purpose of this note, we limit ourselves to 3M, 6M and 1Y expiries.
- **Option strike**: The option market uses ATM, 25D and 10D as benchmark or pillar strikes, which may not necessarily accord with how portfolio managers or corporate treasurers set hedge parameters. Our sense is that there is a fair degree of variation in strike selection schemes all of which would be difficult to cover within the ambit of this one-size-fits-all note. We keep our analysis relatively simple by using standard ATM, 35D, 25D and 10D strikes for single strike options and their combinations for multi-legged structures. Using pillar strikes across structures also means that the desired zero-cost condition may not be met for risk-reversals and seagulls in our simulations. This is not a major problem when the intent of the exploration is merely to screen for efficient strategies; specific recommendations will however require more precise strike setting that can be addressed on a bespoke basis.

Exhibit 10. Option delta varies with spot and over time
Delta profile of EUR 100mn notional of a 3M (03-Jul-18 expiry) 25D strike (1.2720) EUR call/USD put, priced as of 30-Mar-18



Source: J.P.Morgan

Option notionals: Sizing option notionals is a tricky task because the extent of hedge exposure (delta) offered by an option is not constant but varies over its life with market swings and passage of time (Exhibit 10).

- A common scheme is to use **100% of the underlying foreign currency exposure** as the option notional e.g. overlaying €100mio/leg of a risk-reversal irrespective of option strike on €100 mn notional worth of foreign assets. This can be potentially problematic since this construct has a net Black Scholes delta of only 50% of the underlying exposure at inception assuming 25D strikes on the two legs i.e. is only half-hedged. Maximum and minimum values of net delta are bounded between +1 and -1, which means that unlike a forward that covers 100% of the exposure at all times, risk-reversals can *at most* hedge 100% but will more likely than not *under-hedge* the underlying.
- The obvious solution that corrects for this is to scale up notionals such that one is **perfectly delta-hedged at inception**. For instance $200mio/leg of 25D risk-reversals have a net Black Scholes delta of $100mn at inception, so exactly offsetting vis-à-vis the core exposure. The disadvantage is that maximum delta of the upsized risk-reversal now ranges between +/- $200 mio, hence periods of over hedging come with the territory.

We test both notional schemes in this study.

Systematic FX option hedging strategies

In this section, we report historical backtest results from systematically running a slew of option hedges for EUR/USD and EUR/GBP and compare their performance to forwards. As with forward hedges, we run three clips of

options with 1/3rd notional allocated to each, with expiries staggered by a month. In addition to economizing on transaction costs which is an important consideration with options, a staggered rolling scheme serves yet another useful function, which is to keep option strikes 'fresh' or close to prevailing spot and thereby serve as effective hedges. [3] All option structures along with the core securities portfolio are marked-to-market at the end of the month for P/L accounting purposes, and either held to expiry for 3M options or rolled every 3 months for options with longer maturities. One could debate the optimality of quarterly option rolls; while it is certainly possible to empirically test different rolling strategies, our take is that the 3-month frequency is a decent starting point as it marks a reasonable compromise between maintaining freshness/staleness of strikes, controlling bid-offer expenses and reducing operational burden in terms of the number of parallel options streams required to be managed if following staggered monthly rolls. Not to mention the convenience of the quarterly frequency often naturally lining up with formal P/L or balance sheet reporting requirements.

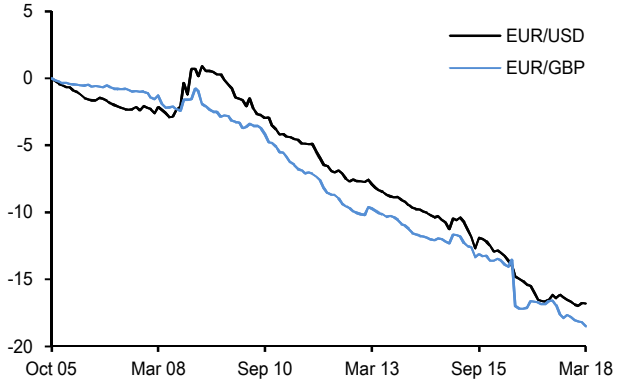
We keep our volatility bid/offer assumptions simple: 0.3 % pts bid-to-offer for EUR/USD options of all strikes and expiries, and similarly 0.4%pts. for EUR/GBP. The numbers correspond to the median bid-offer spreads of 3Mand 1Y ATM vols in these currency pairs over our historical sample as backed out from Bloomberg data ('Bid Price' and 'Ask Price' are attributes one can select instead of the default 'Last Price'). For multi-legged structures, bid-offer is applied to only the leg with the larger vega as is standard practice in option markets.

The number of combinations of option structures, expiries, strikes and notional sizing schemes is too large to enumerate in their entirety, hence Exhibit 12 on the following page lists only a selection of entries that demonstrate significant upgrade in hedge performance vis-à-vis forward hedges. The improvement in hedge effectiveness is measured as the average percentage difference between option and forward hedged portfolios along four risk-return dimensions: Sharpe Ratio (avg. return / std. deviation), Sortino Ratio (avg. return / downside std. deviation), Sterling Ratio (avg. return / avg. drawdown) and MAR ratio (avg. return / maximum drawdown). Some general observations from the results in Exhibit 12 are as follows:

- **The best option hedges can increase average portfolio returns by 50bp - 100bp annually** over and above forward hedges, which themselves materially improve the risk-reward of FX unhedged investments as discussed earlier (note the near doubling of Sharpe Ratios and outsized jumps in return/drawdown measures in Exhibit 12).
- **EUR call spreads and seagull structures** screen as preferred hedging instruments. This is not surprising for a few reasons. First, since the Euro has historically behaved as an asset currency (especially versus the dollar) that is bought during periods of strength in risk markets and sold amid stress, declines rather than rallies in the currency have been more volatile, and the resulting lower velocity EUR strength has been well captured by limited upside structures such as call spreads and seagulls. Second, since the sample period of the simulation predominantly experienced a regime of EUR/USD risk-reversal pricing in favor of EUR puts over EUR calls, option structures that sold the relatively higher priced for EUR puts (e.g. seagulls) prove profitable to sell. Price is not the same as value however; the superiority of call spreads and seagulls suggests that OTM EUR options – whether calls or puts – have historically been overpriced. Indeed, Exhibit 11 confirms that owning EUR convexity has been a systematic dud over the years: returns from selling out-of-the-money wing options in EUR/USD and EUR/GBP via delta-hedged, vega-neutral butterflies (short 25D strangle vs. long ATM straddle) has a long track record of profitable alpha generation. Selling deep OTM (10D) puts is preferable to selling higher delta (25D or 35D) puts in the shortlisted seagull structures.

Exhibit 11. Owning EUR convexity has been a dud over the years, implying value in systematically in selling wing options

Cumulative returns (vol pts.) from owning 3M 25D vega-neutral flies, delta-hedged. Options delta-hedged daily using smile forward deltas and option-expiryy matched forwards, and rolled into fresh strikes monthly. No transaction costs.



Source: J.P.Morgan

[3] In order to appreciate this point, consider the extreme case of an option that has become deep out-of-the-money with delta close to zero as a result of spot moving far away from strike. Unlike a forward, this option will not participate in spot moves around the new market level, and hence provide no cover against unfavorable local spot swings. The situation is only remedied by the addition of a new option into the mix with strike closer to prevailing market, which can be achieved either by more frequent rolls (transaction cost heavy) or via less expensive staggered rolls.

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J.P.Morgan

Exhibit 12. Call spreads and seagulls have historically outperformed forwards as systematic hedge overlays on US and UK bond/equity portfolios

A selection of option structures that improves upon risk-reward ratios of forward hedging. Two option notional sizing schemes backtested : (a) €1 notional of options of per leg for every €1 of underlying securities portfolio exposure to Euro, and (b) Option notionals/leg scaled to 100% delta-hedge the underlying Euro exposure at inception. Backtest run across 3M, 6M and 1Y tenor options; ATM, 35D, 25D and 10D strikes and their combinations; and across EUR calls, call spreads, risk-reversals, seagulls and calendar risk-reversal structures. All options held to expiry or rolled at 3-months, whichever is earlier. Three staggered streams of options initiated at t=0, t=1M and t=2M and rolled at t=3M,6M.., t=4M,7M…and t= 5M, 8M...are used to smooth out P/L fluctuations and reduce transaction costs as discussed in the text. Incorporates 0.3 and 0.4 vol pts. bid-to-offer charge on EUR/USD and EUR/GBP vols respectively across tenors; for multi-legged instruments bid-offer charge applied to the leg with higher vega. Monthly data from 2002 – 2017.

EUR/USD

	Unit notional of options / leg							Option notional scaled to provide 100% delta-hedge at inception							Improvement vis-à-vis forward hedge									
															Unit notionals of options/leg					Notionals scaled for 100% delta-hedge				
Hedge Instrument	Avg. return (ann.)	IR (ann.)	Sortino Ratio	Avg. DD	Max DD	Sterling Ratio	MAR Ratio	*Notional scaling for 100% delta-hedge at inception (X) **	Avg. return (ann.)	IR (ann.)	Sortino Ratio	Avg. DD	Max DD	Sterling Ratio	MAR Ratio	Δ IR	Δ Sortino	Δ Sterling	Δ MAR	Avg.	Δ IR	Δ Sortino	Δ Sterling	Δ MAR	Avg.
Unhedged	4.0%	0.43	0.67	-11.4%	-27%	0.36	0.15	---	4.0%	0.43	0.67	-11.4%	-27%	0.36	0.15	---	---	---	---	---	---	---	---	---	---
100% Forward Hedged	5.5%	0.88	1.11	-2.2%	-22%	2.53	0.25	*1.0*	5.5%	0.88	1.11	-2.2%	-22%	2.53	0.25	---	---	---	---	---	---	---	---	---	---
3M ATM/25D Call Spread	4.7%	0.60	0.90	-4.9%	-19%	0.96	0.25	*4.0*	6.4%	0.79	1.23	-2.1%	-12%	3.06	0.52	-32%	-19%	-62%	-1%	-28%	-10%	11%	21%	104%	31%
3M ATM/10D Call Spread	4.9%	0.71	1.05	-3.4%	-15%	1.46	0.32	*2.5*	6.1%	0.85	1.27	-2.1%	-15%	2.86	0.41	-19%	-6%	-42%	28%	-10%	-3%	14%	13%	61%	21%
3M ATM/10D/10D Seagull	5.0%	0.77	1.15	-3.2%	-16%	1.58	0.31	*2.0*	5.9%	0.88	1.22	-2.1%	-20%	2.86	0.30	-12%	4%	-38%	22%	-6%	-1%	9%	13%	18%	10%
3M ATM/35D Call Spread	4.6%	0.53	0.80	-6.3%	-21%	0.72	0.22	*6.7*	6.8%	0.61	1.03	-2.7%	-16%	2.52	0.43	-39%	-28%	-72%	-14%	-38%	-31%	-7%	-1%	71%	8%
3M ATM/25D/10D Seagull	4.8%	0.66	0.99	-4.6%	-18%	1.05	0.27	*2.9*	6.0%	0.79	1.12	-2.1%	-19%	2.85	0.31	-26%	-11%	-59%	6%	-22%	-10%	1%	13%	23%	7%
3M ATM Call	4.7%	0.71	1.17	-3.0%	-14%	1.55	0.33	*2.0*	5.3%	0.76	1.22	-2.5%	-17%	2.08	0.32	-20%	5%	-39%	30%	-6%	-14%	10%	-18%	26%	1%

* A notional scaling factor of 4.0X for instance denotes that €100mn of underlying Euro exposure is fully Black Scholes delta-hedged at inception with €400mio/leg of the option structure

EUR/GBP

	Unit notional of options / leg							Option notional scaled to provide 100% delta-hedge at inception							Improvement vis-à-vis forward hedge									
															Unit notionals of options/leg					Notionals scaled for 100% delta-hedge				
Hedge Instrument	Avg. return (ann.)	IR (ann.)	Sortino Ratio	Avg. DD	Max DD	Sterling Ratio	MAR Ratio	*Notional scaling for 100% delta-hedge at inception (X) **	Avg. return (ann.)	IR (ann.)	Sortino Ratio	Avg. DD	Max DD	Sterling Ratio	MAR Ratio	Δ IR	Δ Sortino	Δ Sterling	Δ MAR	Avg.	Δ IR	Δ Sortino	Δ Sterling	Δ MAR	Avg.
Unhedged	4.0%	0.43	0.67	-11.4%	-27%	0.36	0.15	---	4.0%	0.43	0.67	-11.4%	-27%	0.36	0.15	---	---	---	---	---	---	---	---	---	---
100% Forward Hedged	5.5%	0.88	1.11	-2.2%	-22%	2.53	0.25	*1.0*	5.5%	0.88	1.11	-2.2%	-22%	2.53	0.25	---	---	---	---	---	---	---	---	---	---
3M ATM/35D/25D Seagull	5.1%	0.67	0.81	-3.1%	-26%	1.67	0.18	*2.5*	6.4%	0.72	0.91	-1.9%	-22%	3.35	0.29	-24%	-27%	-34%	-27%	-28%	-19%	-18%	32%	13%	2%

* A notional scaling factor of 2.5X for instance denotes that €100mn of underlying Euro exposure is fully Black Scholes delta-hedged at inception with €250mio/leg of the option structure

Source: J.P.Morgan

- **Preferred strikes are long ATM vs. short 25D or further OTM.** The vol out-performance of ATM EUR strikes over OTM ones on flies as illustrated in Exhibit 11 explains why all the call spread and seagull structures in Exhibit 12 contain ATM strikes as the long leg. The short strike in most shortlisted entries is 25D or 10D. EUR/GBP is slightly different from EUR/USD in that there is greater acceptance of selling closer-to-ATM strikes (e.g. 35D) due to it being a non-dollar cross with more contained ranges and limited tail moves in either direction compared to dollar pairs.

- **Preferred maturities are shorter (3M) rather than longer** (6M or 1Y). This is understandable given that 3-months is the chosen roll/re-balancing frequency in our study, and the limited upside and/or vol-selling nature of the chosen structures that realize most of their P/L towards the back-half of their lives. Since option decay is non-linear and greater for shorter maturity options, 3M seagulls for instance monetize most of the bleed on the two short OTM option legs by the time the quarterly re-balancings come along, while those in 6M and 1Y structures still retain a significant portion of their original premium and offer lower mark-to-market benefits.

- **In terms of notional sizing, matching option deltas to the underlying currency exposure is far more effective than matching option notionals.** Notional matching – the practice of buying €100mio of options for every €100mn of underlying currency exposure irrespective of strikes – is blind to the delta or the true amount of directional offset provided by the option hedge. Delta-matching corrects for this flaw by scaling option notionals to the underlying exposure appropriately, but sometimes at the cost of unmanageably large notional numbers (more on this later). From a performance standpoint, 100% notional matching (labeled 'unit notionals of option/leg' in Exhibit 12) does not better forward hedges for any combination of option structures, strikes and expiries in our simulation. In contrast, 100% delta-hedging leads to as much 30% improvement in risk-reward ratios; Sharpe Ratios actually suffer mildly due to continuous option

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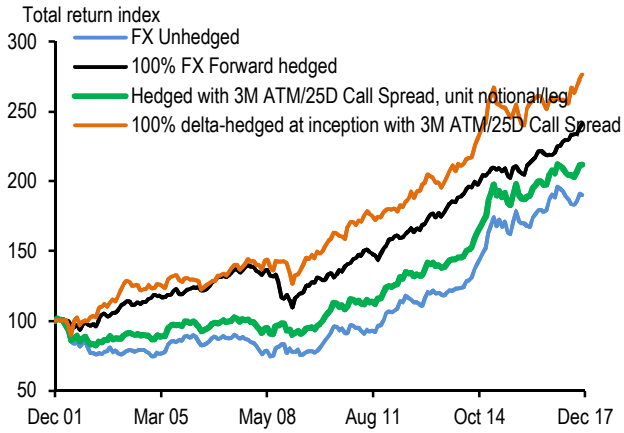
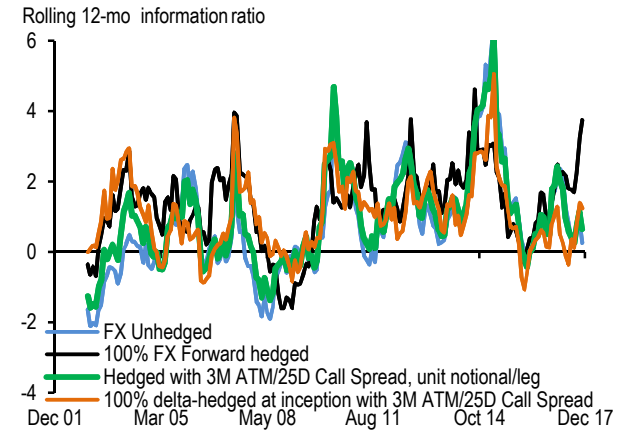
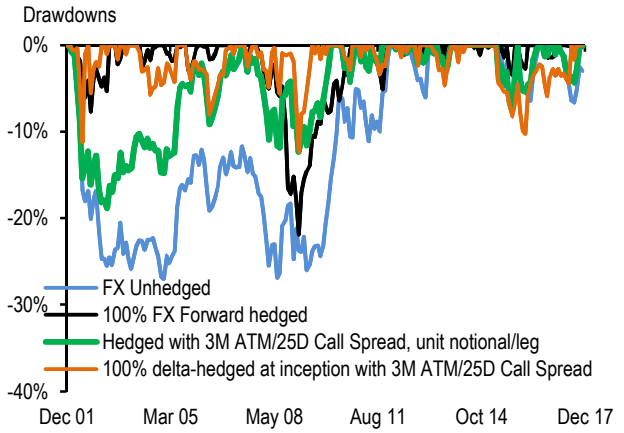
Exhibit 13. Cumulative returns, information ratios and drawdown profiles of unhedged, FX forward hedged and FX option (3M ATM/25D call spread for EUR/USD, 3M ATM/35D call spread vs. short 25D put seagull for EUR/GBP) hedged US and UK securities portfolios

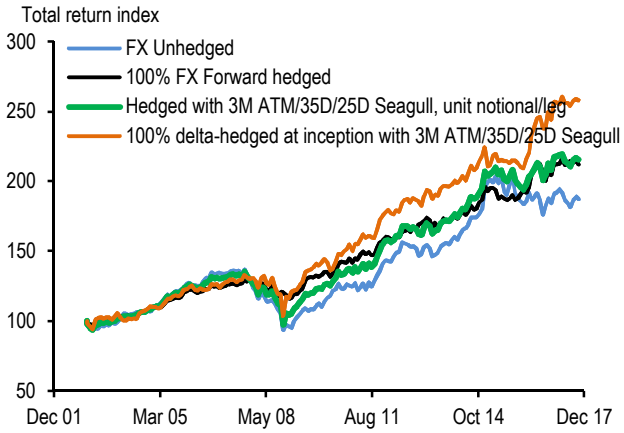
EUR/USD

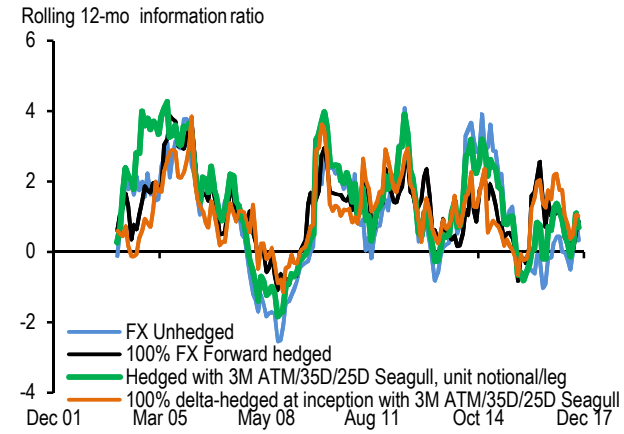


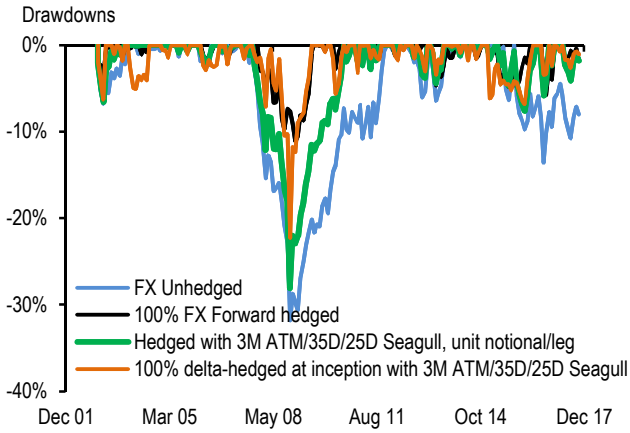




EUR/GBP







Source: J.P.Morgan

premium leakage, but **drawdown statistics experience significant jumps**. As a result, the modest decline in Sharpe Ratios is more than offset by outsized increases in MAR ratios (avg. return / maximum drawdown). The bottom row of charts in Exhibit 13 is a visual depiction of the significant shrinkage in drawdowns brought about by option-based FX hedging. Most notably, call spread structures reduce GFC-era losses that are unavoidable with forward hedges; the latter underperform because large market disruptions are inevitably dollar bullish events that hurt both the underlying securities and the long Euro FX hedge, while call spreads whose exposure to Euro declines is limited to the premium paid do not suffer from the same left tail problem.

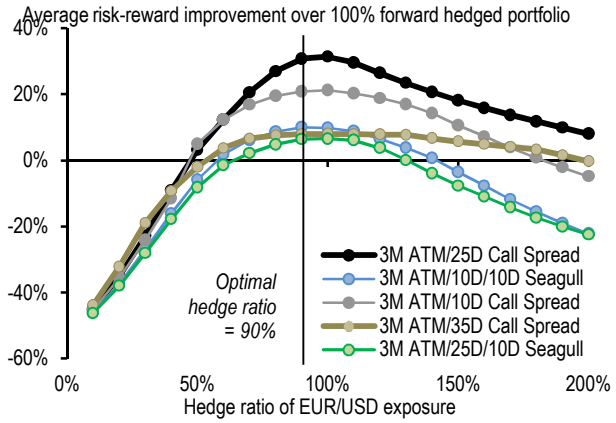
A word is in order about the notional sizes of call spreads and seagulls associated with 100% delta hedging. For simplicity, we use Black Scholes (BS) deltas in our analysis. A 3M ATM/25D call spread, which has a net BS delta of 25 (= 50 for the ATM strike – 25 for the 25D strike) is scaled up by a factor of 4X to hedge 100% of the underlying exposure at inception i.e. €400mio/leg of the call spread per €100mn of EUR/USD spot exposure. There are two implications of using such a scheme. First, tightly spaced strikes become untenable/ impractical for all intents and purposes because notional sizes required for 100% delta-hedging would snowball to unmanageably large amounts (e.g. €1bio/leg of ATM/40D call spreads to hedge €100mn of spot risk etc.), not to mention liquidity issues associated with rolling these large notionals every quarter. Second, this further biases hedges towards shorter rather than longer expiry option structures. Note that the delta math is tenor independent i.e. 100% delta-hedging of €100mn of EUR/USD spot exposure requires €400mio/leg of ATM/25D call spreads, be they 3M or 1Y expiries. However the vega amounts involved are very different in the two cases, and an option market that generally manages risk on a vega basis is more liable to charge wider bid-offer spreads for higher vega option transactions. Hence, where feasible, **our preference for ATM vs. 10D or at most 25D call spread structures that need smaller notionals**.

Optimal option-based FX hedge ratios

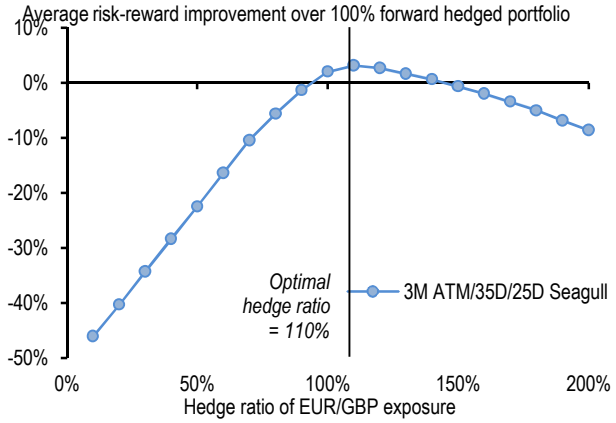
The preceding section establishes that matching option deltas to the underlying currency exposure is much more effective than matching option notionals, *under the assumption that 100% of the underlying currency exposure requires hedging.* Is 100% FX hedging optimal however, particularly for US investments where both core equity holdings and the FX hedge can simultaneously decline in a 2008-style deleveraging shock? In order to answer this question from a backward looking empirical standpoint, this section examines the performance of portfolios FX hedged with option structures shortlisted in Exhibit 12 but with varying hedge ratios. Exhibit 14 presents the results of the analysis. Optimal option-based hedge ratios – measured in this instance by the average improvement in the four risk-reward ratios in Exhibit 12 over and above a 100% forward hedged portfolio – turn out to be quite close to 100%: **90% for EUR/USD and 110% for EUR/GBP.**

Exhibit 14. Hedging ~100% of the underlying currency exposure with options has historically delivered the highest risk-return improvement over forwards across a variety of option structures

EUR/USD



EUR/GBP



Source: J.P.Morgan

Do these optimal hedge ratios vary with the composition of the underlying bond/equity portfolio? A re-examination of the performance of option-hedged portfolios along the lines of Exhibit 14, but this time varying FX hedge ratios as well as the percentage of stock allocation in the underlying bond/equity mix suggests that **optimal hedge ratios are relatively constant around 100% for both EUR/USD and EUR/GBP within a broad 30% - 60% range of stock holdings** (Exhibit 15). This is a comforting outcome that renders the analytical results of this note fairly generic and applicable to a broad spectrum of investment portfolios irrespective of their asset mix.

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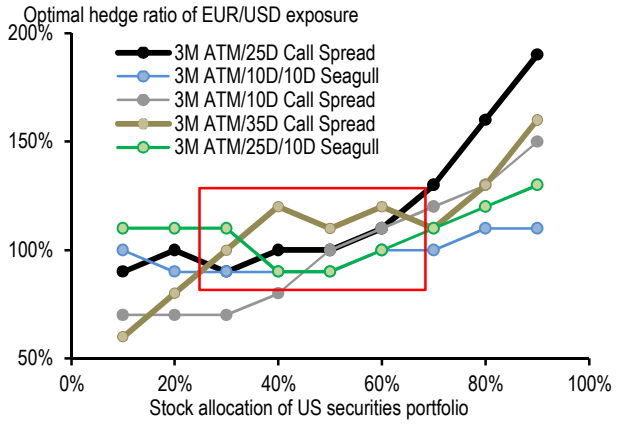
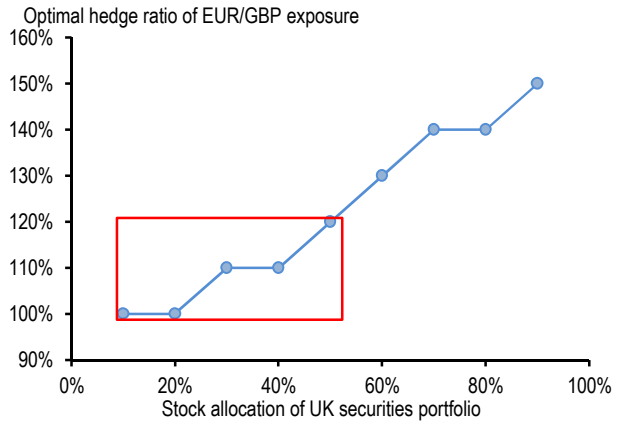
Exhibit 15. Optimal hedge ratios for option-based strategies are relatively invariant to the underlying bond/equity portfolio composition within a reasonably wide 30% - 60% stock allocation

EUR/USD



EUR/GBP



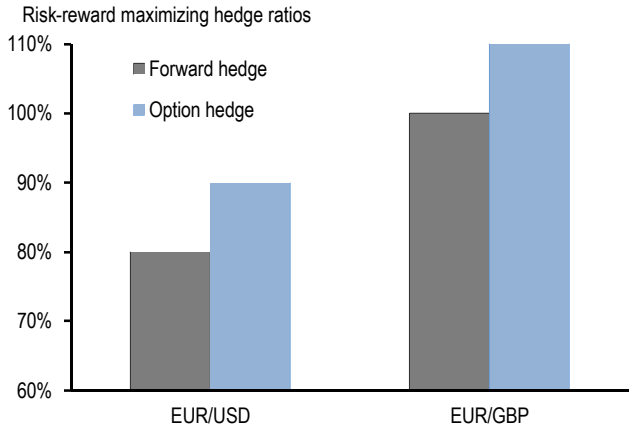
Source: J.P.Morgan

Finally, are optimal hedge ratios for option-based programs higher than those for forwards? This would appear to be the case *ex-ante* given materially greater transaction costs for options compared to forwards, and the limited gain nature of the shortlisted option structures above (call spreads and seagulls) that would require relatively greater notionals to provide the same degree of protection. Indeed, empirical results are intuitive (Exhibit 16), with **optimal forward hedge ratios being 10% pts. lower than that for the option structures** listed earlier. The general positive correlation between EUR/USD and S&P, and the negative correlation between EUR/GBP and FTSE during market downturns also explains why absolute optimal FX hedge ratios are higher for the UK portfolio than the US one.

Comparing cost-of-carry between forwards and options

The starting point of this note was the rising cost of carry on EUR forwards due to widening of US - Europe rate

Exhibit 16. Optimal hedge ratios for option-based hedging programs are higher than for forward-based ones



Source: J.P.Morgan

differentials, which is prompting European asset managers to seek alternative hedge instruments like options. A relative comparison of cost-of-carry between forwards and options is then the nub of the issue: while it is fine for certain varieties of option structures to have systematically outperformed forwards as hedging vehicles over the years, are they a better choice *today* based on *ex-ante* theta/decay considerations?

Our general approach to forwards vs. options carry comparisons is to layer on the theoretical forward delta hedge atop the option structure, and examine the static decay profile of the net package holding spot, forwards and the vol surface constant over the assumed holding horizon. If the delta-hedged construct turns out to be an appealing buy – either because the net *ex-ante* static carry turns out to be positive (rare, but possible in some high-yielding EM currencies depending on the option construct) or presently low compared to long-run historics (more likely) – then options are the relatively better buy, else forwards are to be preferred. For instance, the 3-month bleed of a 3M ATM/25D call spread is $10000* [\max(S_0-K_{ATM}, 0) - \max(S_0 - K_{25D}, 0)] / S_0 - p$ where p is the net call spread premium in bp of EUR notional and S_0 is current spot. $K25D$ is invariably fairly well out-of-the-money, so the second term in parentheses is usually zero. When K_{ATM} is significantly higher than S_0 as is the case currently, the first term in parentheses is zero as well leaving $-p$ as the net option decay, but there have been occasions in the past when negative forward points led to non-zero S_0-K_{ATM}, hence a careful calculation of the full expression above is advisable for long-run historical analysis.

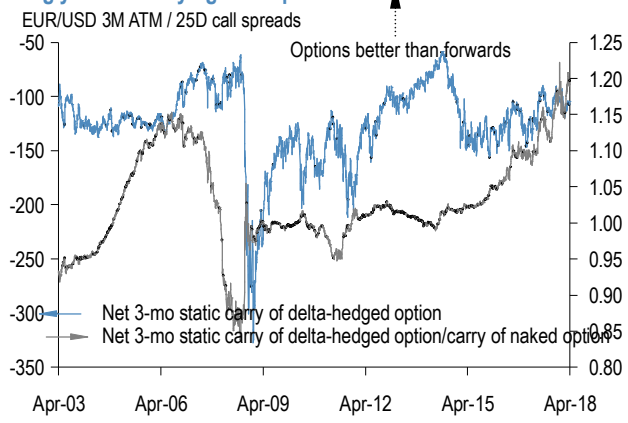
For unit notional/leg of the call spread above that has a net Black Scholes delta of 25, the delta-hedge requires selling 0.25 units of a 3M forward. Given a 3M forward outright level of F and current spot S_0, the 3-month bleed of the

forward in bp EUR is $10000*(S_0 - F)/S_0$. The net static decay of the delta-hedged package held to expiry combining the two expressions above is $10000*[\max(S_0 - K_{ATM}, 0) - \max(S_0 - K_{25D}, 0)] / S_0 - p - 0.25*[10000*(S_0 - F)/S_0]$, which can then be evaluated on a z-score basis or as a ratio to the raw option premium[4] for easier comparability over time and across underlyings. The example above is specific to call spreads, but the approach can be generalized to any option structure as long the option premium ***p*** and static option carry are appropriately computed.

Exhibit 17 and 18 present the results of this relative cost-of-carry analysis across the previously shortlisted option structures for EUR/USD and EUR/GBP. The charts tell their own story: **the relative value between volatility and forward points is highly favorable for option-based hedging vis-à-vis forwards in EUR/USD** based on the >70th percentile historical ranking of the relative carry metric discussed above across almost all option constructs. Given the low absolute level of volatility, it is unsurprising that net vega-buying structures such as call spreads offer better RV vis-à-vis forward points on a historical basis rather than vol selling structures such as seagulls. EUR/GBP options screen worse than EUR/USD on this front since forward points are much narrower, the effect of which cannot be offset by selling some of the lowest vols on record (sub 30th percentile of 15-yr history) through seagull structures.

On the whole, we surmise that the combination of better relative value and a track record of systematic outperformance over forwards strongly points to a preference for option hedges at current market, especially in EUR/USD.

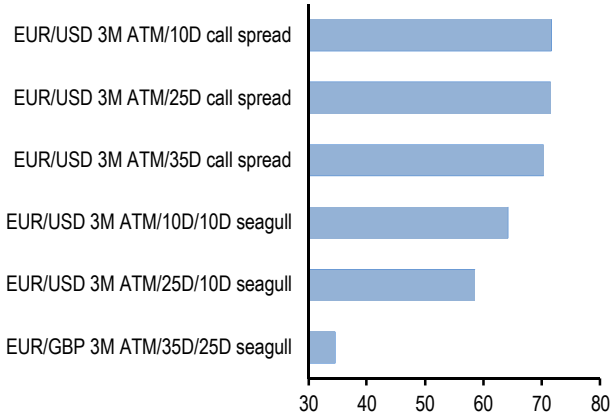
Exhibit 17. Rarely in history has the relative static carry set-up so strongly favored buying EUR options over forwards….



Source: J.P.Morgan

Exhibit 18. ….across option structures, especially in EUR/USD

Full-sample percentiles of net 3-mo static carry of (Black Scholes) delta-hedged option structures (i.e. of the blue line in Exhibit 17)



Source: J.P.Morgan

[4] Ideally, one would like to use the carry of the forward as the denominator of the ratio since a decision to switch to option hedges (or not) is made against the baseline of forwards. The practical issue that intrudes is that forward points can fall to zero, rendering the ratio unusable. Hence the use of option premium – which is guaranteed to be non-zero, at least for purchased option structures such as call spreads – as the deflator. Mathematically, the decision problem simply inverts from having to evaluate if $Carry_{OPTION}/Carry_{FORWARD}$ is low enough to if $Carry_{FORWARD}/Carry_{OPTION}$ is high enough to justify a switch from forwards to options.

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