Big Data and AI Strategies

Systematic FX Option Portfolios

- We develop a framework for optimal sizing of vanilla options across strikes. We show that constructing a portfolio of FX options through a utility maximization approach which uses the historical distributions of the underlying leads to systematically significant positive returns.

- The optimization framework suggests that AUD wings should underperform, it sees value in NZD capped topside participation, too much premium baked in CAD options, yen skew pricing still too excessive, expects EUR spot to underperform, muted GBP spot price action and that NOK and SEK options pricing hasn't caught up yet with the more positive sentiment.

- Instead of trying to determine if an individual option is 'rich' or 'cheap', this approach is more general in that it attempts to determine if the option-implied distribution is mispriced and, furthermore, how to take advantage of it in an optimal way given a fixed utility function. We find that this approach yields favorable results with essentially no parameter fitting. These results are comparable to the results we saw with the same technique applied to equity derivatives in our recent report (How to Systematically Design Optimal Hedging Portfolios, Jan 2019).

Global Quantitative and Derivatives Strategy

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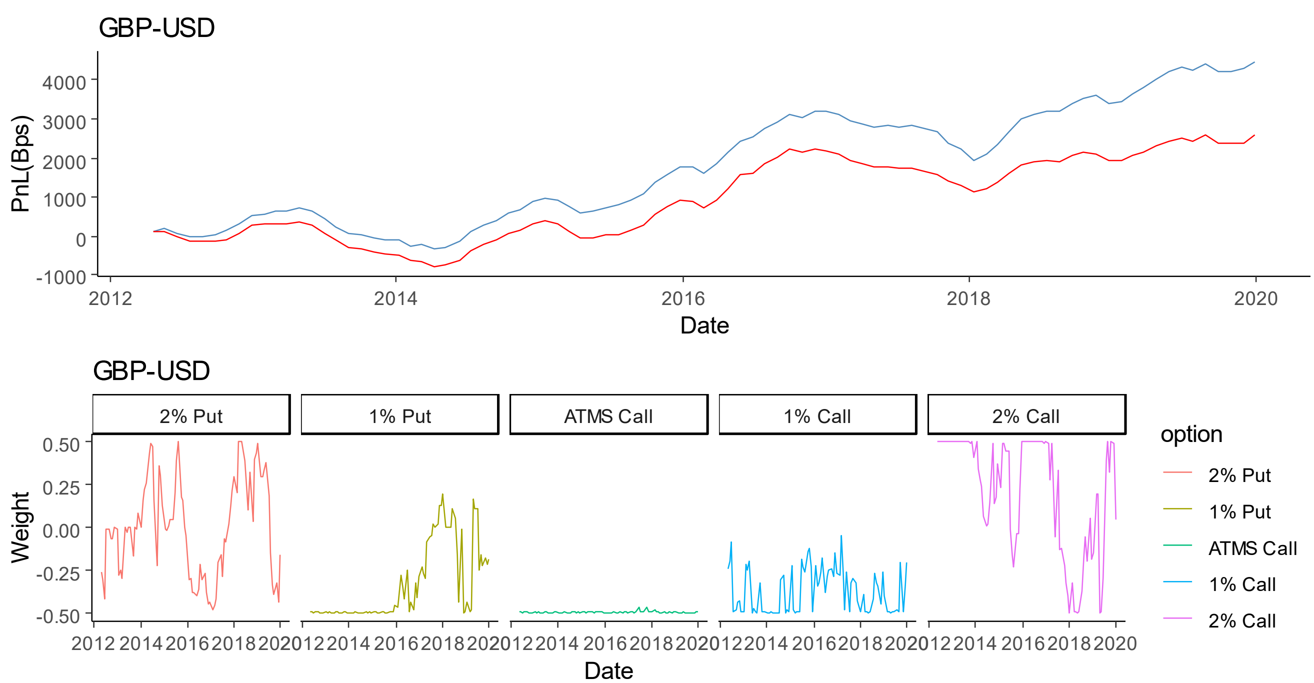
Figure: Optimized portfolio outperforms, demonstrating a clear benefit in directional trading

(Strategy, Naked Forward) = (Blue, Red), 3M tenor. Strategy = optimal composition of live vanilla options (5 strikes) and a forward currency. Options held to expiry. New trade entered monhtly.



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Introduction

Determining the "best" structure for expressing a given macro and FX vol backdrop is one of the most common inquires we receive. We routinely do piecewise backtesting such as in All weather vol ratio spreads excel when primed with risk on/off filter, April 2020 that analyzed return statistics, currency selection and trade timing for delta-hedged ratio spreads and in Pick your best FX hedges: A scorecard approach for selecting FX hedging instruments, May 2019 that provided a rule-based formula for efficiently mixing various FX options structures and forwards (commonly used by corporate hedgers and for directional trading).

In this note we provide and test a generic and flexible framework that constructs optimal multi-legged option structure (optionally including FX forwards in the basket) based on mispricing between historical and option-implied distribution. Ideally the historical distributions are derived from statistically similar past macro / vol episodes, a refinement that will be addressed in future studies.

The approach was first introduced by Faias and Santa-Clara[1] for equities and motivated by the fact that traditional asset allocation methods such as mean-variance optimization are inadequate for option portfolios because of the non-normality of the return distributions. We have recently implemented this framework in equities in How to Systematically Design Optimal Hedging Portfolios, Jan 2019.

The setup and inputs

We test the option portfolio optimization framework on 3M expiry G10 currency pairs options. The trades consist of five options and a forward with the portfolio mix fixed at initiation and held till expiry. While the portfolio is held till expiry, we add new positions monthly, effectively creating three staggered portfolio streams spaced by a month at any given time (#1: T, T+3M, …; #2: T+1M, T+4M, …; #3: T+2M, T+5M, …). At this stage we avoid using a fair value model for spot (such as the ones based on REERs, FRIs or some other alternative) as we are primarily interested in testing the optimization framework only. Only EOP P/Ls are reported. The following inputs are used in determining the daily portfolio weights:

- FX forwards, FX spot rates and ATM volatility
- Somewhat arbitrarily but to keep the relative comparison straightforward, the 5 FX option prices given by 3M maturities and strikes set to 2% OTMS USD put, 1% OTMS USD put, ATMS USD put, 1% OTMS USD call and 2% OTMS USD call.
- The historical distribution of 3M risk adjusted returns for each FX pair over the past 2 years (ATM volatility is used in calculating risk adjusted returns, see details in the next section).
- A power utility function $u(x) = \frac{x^{1-c}-1}{1-c}$ where c is the risk aversion parameter, and set to 10 to ensure a reasonably high degree of risk aversion. This particular utility function accounts for all the moments of the distribution (not just the mean and variance) and strongly penalizes negative skewness and high kurtosis. As we show later in the report, results are robust on selection of c.

[1] "Optimal Option Portfolio Strategies: Deepening the Puzzle of Index Option Mispricing," J.A. Faias and P. Santa-Clara, Feb 2017, Journal of Financial and Quantitative Analysis.

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The optimization framework

On each trading day we take the inputs above and compute the so called optimal portfolio weights, i.e. the weights that result in the highest utility using the historical distributions.

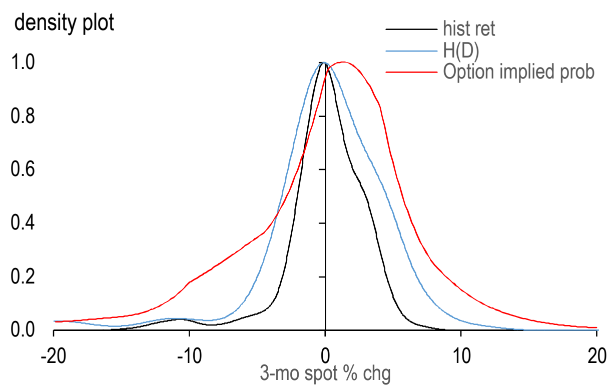
In more detail, for a given a trading day D, we use the historicals from the 2-yr interval *I(D) = (D-2Y-3M, D-3M)*, where e.g. *D-2Y-3M* represents the day 2 years and 3 months prior to *D*. For each day *d* in the 2-yr interval *I*, we consider the normalized 3M return to form the historical distribution for the day *D*:

$$H(D) \coloneqq \{normalized\ ret \times ATM(D), \text{for each } d \text{ in } I(D)\}$$

where *normalized ret* refers to 3-mo realized return from day *d* to day *d+3M* normalized by *3M ATM* at the day *d* with the mean return over the period subtracted off. This subtraction of the mean is used to deal with issues with high correlation to momentum. The expression *normalized ret×ATM(D)* effectively converts prior historical returns into the market backdrop as of the day *D*.

Figure 1: AUD/USD options implied probability of future 3-mo returns is clearly at odds with *H(D)*

AUD/USD option implied probability backed out from 3M AUD/USD option princings. Mean removed from historical returns as per above discussion.



Source: J.P. Morgan.

Next we define the expectation $E_{H(D)}$ of a portfolio *P* to be the average of the portfolio returns over the historical distribution *H(D)*. For vanilla (not delta-hedged) options, such as in our test, the portfolio payoff *P = P(w,r)* is determined by the option weights *w* and the FX returns (note that we fixed the five strikes to ±2%OTMS, ±1%OTMS and ATMS). Correspondingly the expected utility for a given weight *w* is:

$$\mathrm{P_D}(\mathrm{w}) \coloneqq \mathrm{E_{H(D)}}[\mathrm{P}(\mathrm{r},\mathrm{w})] = \frac{1}{|H(D)|} \sum_{r\ in\ H(D)} [U(P(r,w))]$$

where *U* is the earlier defined utility function and |*H(D)*| is the number of observations in the historical distribution. For each trading day D, we optimize:

$$\max_{w\ in\ S} P_D(w)$$

where S is the constraint set:

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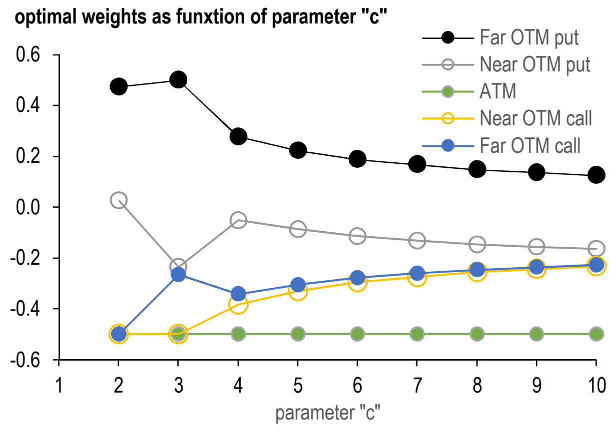
$$S = \{w\ |w\ in\ [-0.5, 0.5]^5\ and -1 \leq\ sum(w) \leq\ 1\}$$

The figure below shows the optimization process to be robust and well behaved with respect to the choice of the utility function *u(x)* parameter *c*.

Figure 2: Optimal weights are robust on the choice of utility function *u(x)* parameter *c*

AUD/USD option portfolio as of May 11. Weights are constrained to [-0.5,+0.5].

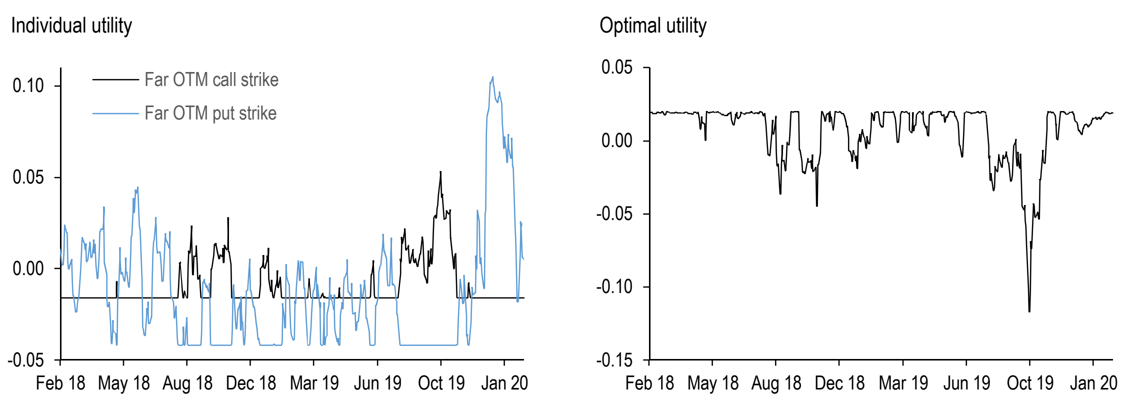


Source: J.P. Morgan.

The optimal weights ***w**** which solve this maximization problem are then used as the portfolio weights. The AUD/USD example below demonstrates the key aspect of the framework.

Figure 3: AUD/USD optimal utility example shows that optimization naturally converges to a portfolio that shows positive utility most of time, with only occasional negative episodes

AUD/USD option portfolio as of May 11. (LHS) Only Far OTM Call and Put strike utility functions shown. Optimal utility achieved for w = 0.13, -0.16, -0.5, -0.23, -0.23 for 2% OTM Put, 1% OTM Put, ATM, 1% OTM Call and 2% OTM Call, respecitvely.



Source: J.P. Morgan.

Namely, the optimization naturally converges to a portfolio that as its baseline has positive utility (and P/L) and it attempts to minimize impact from occasional negative episodes.

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Results

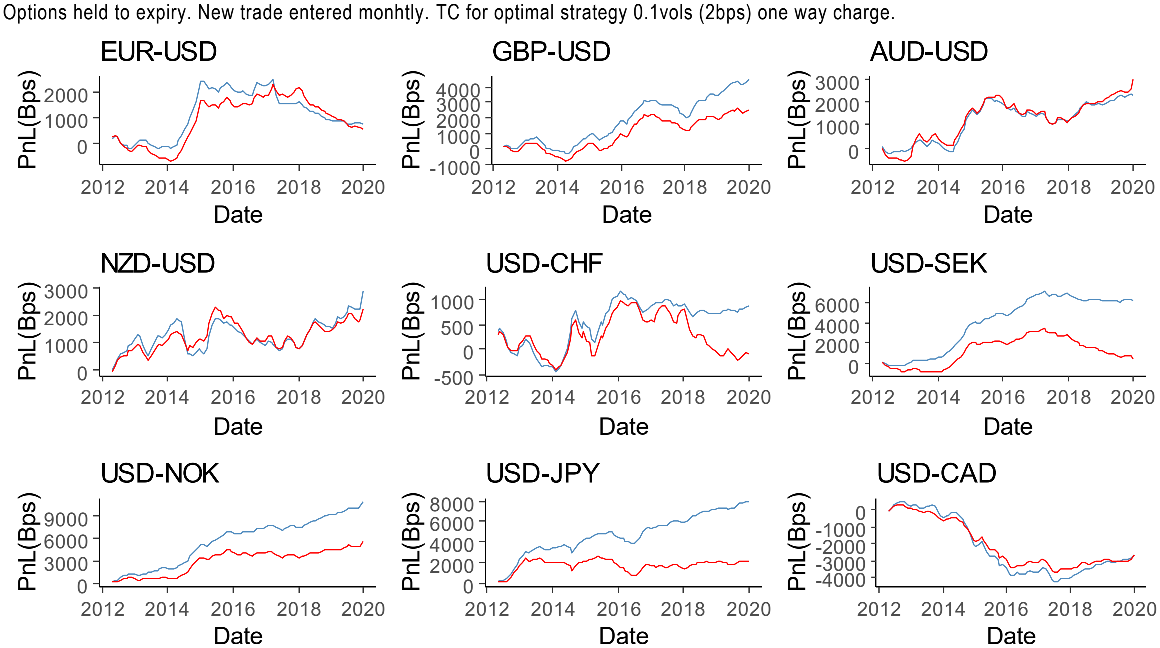
Maximizing P/L on trailing historical distributions does not necessarily guarantee a good forward looking performance. In this section we analyze the performance of the optimization framework on G10 USD pairs and show that the framework indeed has strong predictive power.

We track the returns from the following two portfolios:

- Optimization Strategy which uses the optimal weights calculated by the detailed method above. We add the weighted options package to a long or short forward.
- Naïve long or short forward only

Figure 4: Optimized portfolio outperforms, demonstrating a clear benefit from optimization framework in directional trading

(Strategy, Naked Forward) = (Blue, Red), 3M tenor. Strategy = optimal composition of live vanilla options (5 strikes) and a forward currency. Options held to expiry. New trade entered monhtly. TC for optimal strategy 0.1vols (2bps) one way charge.



Source: J.P. Morgan.

The results of the analysis (Figure 4) show that the optimization strategy performance keeps up and/or materially outperforms across G10 pairs. That is particularly the case for GBP, CHF, SEK, NOK and JPY.

While source of performance can be hard to pinpoint it is clear that the optimization strategy aims, as designed, to monetize excessive premium. By examining the portfolio compositions, we find that the strategies range from being seller of near strikes but long far strikes, as in NOK and SEK via ratio put spreads pre 2016 and ratio call spread after. Or long near strikes and short wings as in NZD and AUD. Or as is the case in CHF where 2015 was a clear cut regime change as there was a major shift in pricing of CHF vol surface following the 2015 de-peg. Namely, CHF risk reversals got bid for CHF and remained so despite the skew underperformance and the optimizer subsequently after 2016 started selling those risk reversals. **Recall that because the utility function is concave, the optimizer must be 'confident' that a**

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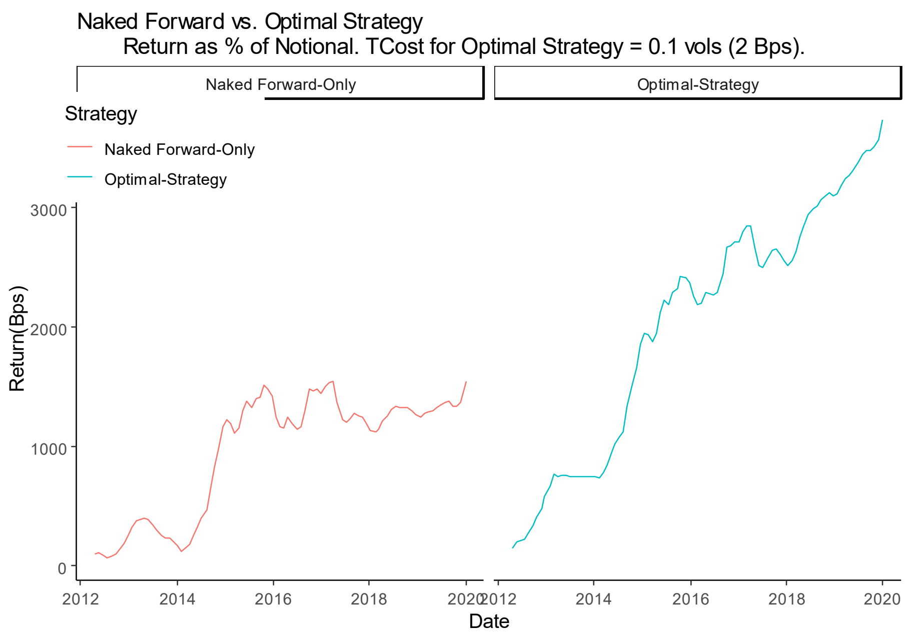
trade has a high expected value before initiating it. In other words the utility function's shape means that we lose more from a loss of 1 unit than we gain from a gain of 1 unit.

Note that the optimizer generated weights are typically quite notably different from zero which implies that in case of e.g. AUD and NZD the implied distribution was efficiently priced or that the optimizer solution was finding a "fair value" of the mix of strikes.

In the figure below, we also show the results from combining the portfolios from Figure 4. We split the currencies into two buckets based on their risk adjusted carry ranking and construct long/short portfolio from top/bottom ranked currencies. Favorably, the Optimal Strategy shows consistently robust performance and outperforms the corresponding long/short Naked Forwards portfolio even during the last 5-yr period when the portfolio consisting of fwds stalled.

Figure 5: Average G10 long/short portfolio Optimal Strategy outperforms the corresponding long/short Naked Forwards portfolio

TC for optimal strategy 0.1vols (2bps) one way charge.



Source: J.P. Morgan.

The next two figures show the statistics for both the average portfolio and the individual currencies' performance given above. The utility statistic is calculated using the same utility function which was used for the optimization procedure, namely the CRRA utility function with parameter 10. We also point out that doing this optimization is an attempt to maximize the utility and not the Sharpe ratio.

A common question at this point is "Why should we maximize utility and not simply maximize Sharpe since what we ultimately want is a high Sharpe anyway?" The reason is that maximization of the Sharpe ratio has many problems when options are involved. Just as how investors desire a low variance in their return profile (and a high mean), they also usually desire a skew which is not too negative. If we replace utility with Sharpe ratio then the optimizer will ignore the skew and have an

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extremely strong bias towards selling deep OTM puts. Essentially this will result in an artificially high Sharpe ratio which is only high because other (higher order) return characteristics get compromised.

Figure 6: Summary stats for Optimal Strategy vs. Naked Forward. Mean and Sdev in Bps (Annual)

Mean and StDev reported in bps. TC for optimal strategy 0.1vols (2bps) one way charge.

Strategy Results

Tcost for Optimal Strategy = 0.1 vols (2 Bps)

Strategy	Mean	Sdev	Sharpe	Skewness	Kurtosis	Drawdown
Optimal Strategy	492	421	1.17	-0.07	0.29	-0.12
Naked Forward Only	203	419	0.49	0.09	0.26	-0.11

Source: J.P. Morgan.

Figure 7: Optimal Strategy vs. Naked Forward

Mean and StDev reported in bps. TC for optimal strategy 0.1vols (2bps) one way charge.

Strategy	Pair	Mean	Sdev	Sharpe	Skewness	Kurtosis	Drawdown
Optimal-Strategy	AUD-USD	303	752	0.40	0.28	0.04	-0.19
Naked Forward-Only		394	906	0.44	0.06	0.02	-0.23
Optimal-Strategy	EUR-USD	101	862	0.12	0.04	0.96	-0.33
Naked Forward-Only		72	810	0.09	0.41	0.25	-0.24
Optimal-Strategy	GBP-USD	591	867	0.68	-0.12	-0.20	-0.17
Naked Forward-Only		340	796	0.43	0.10	-0.21	-0.16
Optimal-Strategy	NZD-USD	379	1109	0.34	-0.09	0.71	-0.28
Naked Forward-Only		291	927	0.31	0.02	-0.04	-0.22
Optimal-Strategy	USD-CAD	-342	957	-0.36	-0.58	0.27	-0.22
Naked Forward-Only		-352	748	-0.47	-0.26	0.09	-0.16
Optimal-Strategy	USD-CHF	114	637	0.18	0.42	0.34	-0.17
Naked Forward-Only		-9	681	-0.01	0.06	-0.04	-0.16
Optimal-Strategy	USD-JPY	1042	1024	1.02	0.15	0.20	-0.27
Naked Forward-Only		283	1014	0.28	0.16	0.18	-0.26
Optimal-Strategy	USD-NOK	1431	1002	1.43	0.23	0.21	-0.25
Naked Forward-Only		750	1041	0.72	0.37	0.32	-0.27
Optimal-Strategy	USD-SEK	807	905	0.89	0.21	0.03	-0.22
Naked Forward-Only		60	935	0.06	0.27	0.04	-0.22

Source: J.P. Morgan.

Historical Weights

We already discussed the performance of the Optimal Strategy. Here we show the historical Optimal Strategy option weights that drive that performance.

Broadly, the optimizer generated weights are quite different from zero. When excessive risk premium is systematically embedded into a vol surface the optimizer leans heavily though conservatively on it, e.g. selling near strikes is often offset by defensively owning far strikes or a part of the skew. Other times, the implied distribution is efficiently priced prompting the optimizer to look for less extreme solution and more to finding a “fair value” of the mix of strikes.

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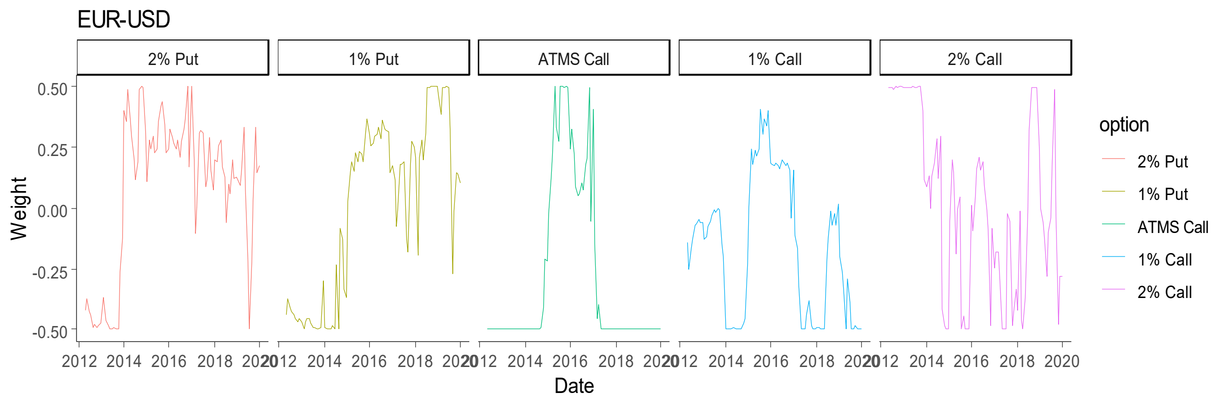
Figure 8: Historical option weights for GBP/USD



Source: J.P. Morgan.

Figure 9: Average of Option Weights for two baskets: EUR, GBP, AUD, NZD/USD basket and USD/JPY, CHF, CAD, NOK, SEK basket

Source: J.P. Morgan.

Current Weights

Knowing that constructing a portfolio of FX options through a utility maximization approach has historically generated significant positive returns validates the framework. But the main output and the key benefit of the framework is in providing the optimal weightings across strikes. Figure 10 shows the most current weightings

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for the 3M G10 USD options based on the optimization framework. Even though we show portfolios with forwards in our backtests, as shown in the previous section, the results are independent of underlying delta positions. Therefore we only show allocations to options.

Figure 10: Optimal weightings for the 3M G10 USD options
Note that only the option weightings are reported.

Current Weights 2020-05-20

cp	2% Put	1% Put	ATM Put	ATM Call	1% Call	2% Call
AUD-USD	-0.32	0.28	NA	0.50	-0.37	-0.50
EUR-USD	0.50	-0.26	NA	-0.50	-0.50	-0.24
GBP-USD	-0.37	-0.38	NA	-0.50	-0.04	0.29
NZD-USD	-0.01	0.50	NA	0.50	0.50	-0.49
USD-CAD	0.00	-0.50	-0.50	NA	-0.50	0.50
USD-CHF	-0.31	-0.31	-0.27	NA	-0.08	-0.02
USD-JPY	-0.25	-0.50	-0.50	NA	-0.25	0.50
USD-NOK	0.50	-0.50	-0.50	NA	-0.50	0.00
USD-SEK	0.50	-0.50	-0.50	NA	-0.50	0.00

Source: J.P. Morgan.

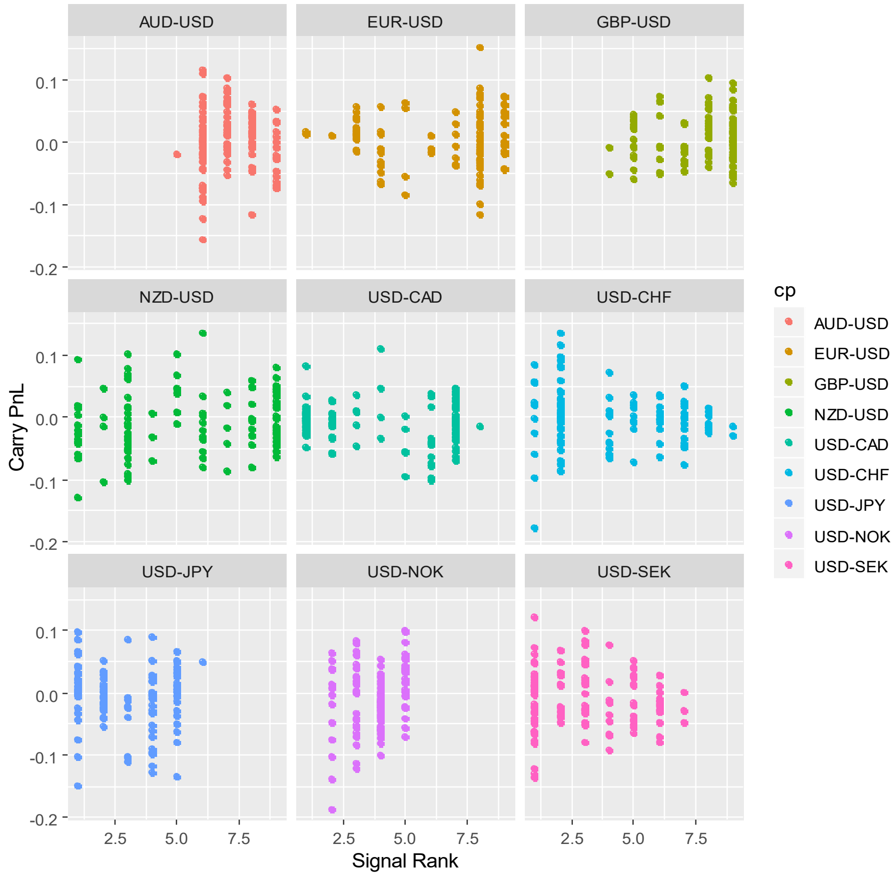
The optimization framework suggests that AUD wings should underperform amid contained spot move, it sees NZD downside fairly priced and value in capped topside participation. CAD has too much premium baked into near strikes though owning a part of skew is not out of question. USD calls are underpriced in USD/JPY and there is still too much residual premium in downside strikes, a leftover from the brutal March episode yen skew pricing. In European region, the optimizer is positioning for EUR underperformance, for GBP spot to be stuck in limbo for the time being and is suggesting that NOK and SEK options pricing hasn't caught up yet with the more positive sentiment.

Appendix

In this appendix we show the results from our carry strategy. We put this in the appendix because the main idea of this report is about portfolio optimization of options and not about specific carry strategies.

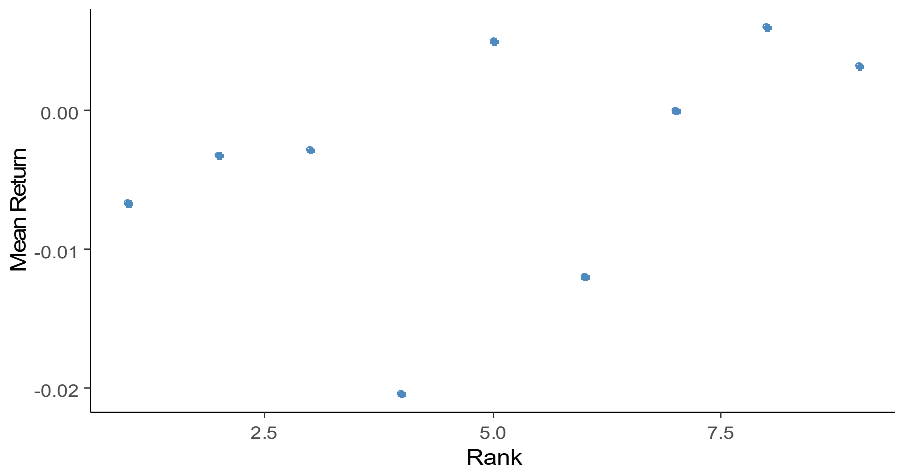
Recall from the carry section above that for each day we consider the values $\frac{(Fwd-Spot)/Spot}{ATM\ Vol}$ over the 9 pairs, take a 2-year moving average, and rank the pairs by this value. Each day we go long the fwd for the bottom half of the pairs (bottom 5) and short the fwd for the top half. The figure below shows the relationship between the mean carry returns vs the pair's ranking. That is, for a given rank R, we compute the mean return from selling the fwd when the pair has rank R. We do this separately for each pair.

Figure 11: Cash-Carry Returns by Pair and Cross Section Rank



Source: J.P. Morgan.

Figure 12: Mean Cash-Carry Return by Cross Section Rank



Source: J.P. Morgan.

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Risks of Common Option Strategies

Risks to Strategies: Not all option strategies are suitable for investors; certain strategies may expose investors to significant potential losses. We have summarized the risks of selected derivative strategies. For additional risk information, please call your sales representative for a copy of "Characteristics and Risks of Standardized Options." We advise investors to consult their tax advisors and legal counsel about the tax implications of these strategies. Please also refer to option risk disclosure documents.

Put Sale: Investors who sell put options will own the underlying asset if the asset's price falls below the strike price of the put option. Investors, therefore, will be exposed to any decline in the underlying asset's price below the strike potentially to zero, and they will not participate in any price appreciation in the underlying asset if the option expires unexercised.

Call Sale: Investors who sell uncovered call options have exposure on the upside that is theoretically unlimited.

Call Overwrite or Buywrite: Investors who sell call options against a long position in the underlying asset give up any appreciation in the underlying asset's price above the strike price of the call option, and they remain exposed to the downside of the underlying asset in the return for the receipt of the option premium.

Booster : In a sell-off, the maximum realized downside potential of a double-up booster is the net premium paid. In a rally, option losses are potentially unlimited as the investor is net short a call. When overlaid onto a long position in the underlying asset, upside losses are capped (as for a covered call), but downside losses are not.

Collar: Locks in the amount that can be realized at maturity to a range defined by the put and call strike. If the collar is not costless, investors risk losing 100% of the premium paid. Since investors are selling a call option, they give up any price appreciation in the underlying asset above the strike price of the call option.

Call Purchase: Options are a decaying asset, and investors risk losing 100% of the premium paid if the underlying asset's price is below the strike price of the call option.

Put Purchase: Options are a decaying asset, and investors risk losing 100% of the premium paid if the underlying asset's price is above the strike price of the put option.

Straddle or Strangle: The seller of a straddle or strangle is exposed to increases in the underlying asset's price above the call strike and declines in the underlying asset's price below the put strike. Since exposure on the upside is theoretically unlimited, investors who also own the underlying asset would have limited losses should the underlying asset rally. Covered writers are exposed to declines in the underlying asset position as well as any additional exposure should the underlying asset decline below the strike price of the put option. Having sold a covered call option, the investor gives up all appreciation in the underlying asset above the strike price of the call option.

Put Spread: The buyer of a put spread risks losing 100% of the premium paid. The buyer of higher-ratio put spread has unlimited downside below the lower strike (down to zero), dependent on the number of lower-struck puts sold. The maximum gain is limited to the spread between the two put strikes, when the underlying is at the lower strike. Investors who own the underlying asset will have downside protection between the higher-strike put and the lower-strike put. However, should the underlying asset's price fall below the strike price of the lower-strike put, investors regain exposure to the underlying asset, and this exposure is multiplied by the number of puts sold.

Call Spread: The buyer risks losing 100% of the premium paid. The gain is limited to the spread between the two strike prices. The seller of a call spread risks losing an amount equal to the spread between the two call strikes less the net premium received. By selling a covered call spread, the investor remains exposed to the downside of the underlying asset and gives up the spread between the two call strikes should the underlying asset rally.

Butterfly Spread: A butterfly spread consists of two spreads established simultaneously – one a bull spread and the other a bear spread. The resulting position is neutral, that is, the investor will profit if the underlying is stable. Butterfly spreads are established at a net debit. The maximum profit will occur at the middle strike price; the maximum loss is the net debit.

Pricing Is Illustrative Only: Prices quoted in the above trade ideas are our estimate of current market levels, and are not indicative trading levels.

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