FX Viewpoint

Predict FX Vol with PCA

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G10 FX Strategy
Global

Howard Du, CFA
G10 FX Strategist
BofAS
+1 646 855 6586
yuhao.du@bofa.com

Vadim Iaralov
FX Strategist
BofAS
+1 646 855 8732
vadim.iaralov@bofa.com

Revisit PCA framework for G10 FX implied vols

We revisit the predictive capability of our PCA framework for G10 FX vols, after initially launching it in 2016. Analysis of the subsequent implied vol data shows that for various tenors and most currencies there is clear negative correlation between implied vol deviations from PCA fair value versus future change in implied vols. In other words, FX implied vols trading at a discount versus the PCA framework fair value tend to rise while implied vols trading at a premium tend to fall. In addition, using 3-factor principal component decomposition of G10 FX implied vols on a 5y rolling basis to predict 10-day ahead implied vol changes shows the most significant out-of-sample correlation.

Better signals to fade vols at a large premium

Further analysis shows the out-of-sample correlations are more significant for currencies that are at a premium than at a discount to estimated fair value. Among major G10 pairs in vol market, AUDCAD, USDJPY and USDNOK vols at a premium have the most significant out-of-sample correlations. EURCHF has the most significant correlation for when implied vols are at a discount to estimated fair value. Moreover, we also find implied vols trading at a large spread to estimated fair value tend to yield better signals.

Summarizing FX vols with principal components

The first principal component vector is highly correlated with the VIX index at 79% since 2017 and 91% since 2019, meaning FX vols are highly correlated with equity vols and the sensitivity has been rising in recent years. The second principal component shows notable pre versus post-Covid shock regime change for FX vols, and is correlated with US 10y real yield at 65%. The third principal component is correlated with JPY strength at 39%, capturing risk-off drivers of FX vol. Due to its so-called "safe-haven" currency status, JPY appreciation tends to lead to higher FX vols.

PCA framework for EM FX vols

Extending the framework to major EM FX vols shows the out-of-sample correlation is more significant for a 1-factor decomposition at a 3m lookahead window. The first principal component for EM FX implied vols also shows a notable correlation with VIX.

Latest signals favor higher 3m NZDUSD vol

The latest PCA signals show 3m NZD-based implied vols are broadly underpriced, with NZDUSD implied vol below estimated fair value by -0.58. The Q4 CPI release for New Zealand at end of January could be a catalyst for higher NZDUSD implied and realized vols. The rates market currently expects 5 RBNZ rate hikes in 2022, one of the most aggressive among developed countries. Amid negative Q3 growth rate for New Zealand, the quarterly CPI release could lead to a re-price of the RBNZ rate path, subsequently contributing to higher NZDUSD vol. The risk to this view is lack of options response to the upcoming NZ CPI release and the Jan FOMC meeting.

Revisiting the PCA framework for G10 FX implied vols

We first launched the principal component analysis (PCA) framework for G10 FX implied volatility in 2016. Now in a post-Covid world, we revisit the predictive power of the framework for G10 FX implied volatility and extend to EM FX vols.

How do we apply PCA to G10 FX volatility?

We first aggregate historical implied vol time series data for all 45 G10 FX crosses. By applying principal component decomposition to the historical implied vol data, we can obtain 45 orthogonal principal components (PCs). The 45 PCs altogether can explain 100% of the variance in the implied vol data, but majority of the variance can be attributed to a select few PCs. We then regress the top principal components with the historical implied vols for each currency pair; the residuals of the regressions capture how much the actual implied vols are mispriced from the so-called PCA estimated "fair values".

A negative residual would suggest the current implied vol is cheap and should revert higher in the near-future; while a positive residual would suggest the current implied vol is expensive and would likely decline in the near future. Moreover, the principal component vectors also allow us to identify macro variables that drive fluctuations in FX vols.

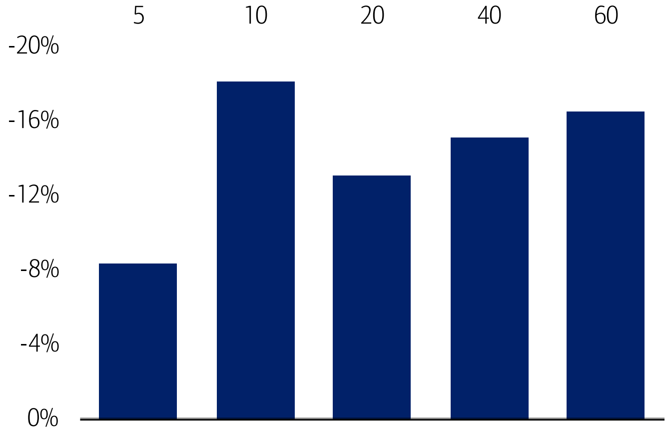
We first assess and determine the appropriate historical lookback period, the impact of additional principal components in regressions, and the forward looking horizon with suitable explanatory power.

Assessment of the PCA framework

We compared 1y to 10y lookback periods, 1-week to 3-month lookahead periods, 1-PC to 5-PC decompositions, and 1m to 1y implied vol with FX implied vol data going back to 2009. For each combination of parameters, we conducted PCA decomposition to historical data on a rolling lookback basis, and calculated the out-of-sample rolling correlations between the estimated regression residuals and the future actual change of implied vol at the given lookahead period. We then looked at the average sensitivity to different parameters. For example, we ran a rolling 3-PC decomposition to historical daily 3m implied vol data at 1y lookback windows, and calculated the rolling correlation between the regression residuals and future 1-week actual change in implied vol.

Exhibit 1: Out-of-sample correlation is more significant for 10d look-ahead

Average of correlations for PC regression residuals vs. future implied vol changes at different look-ahead periods



Source: BofA Global Research

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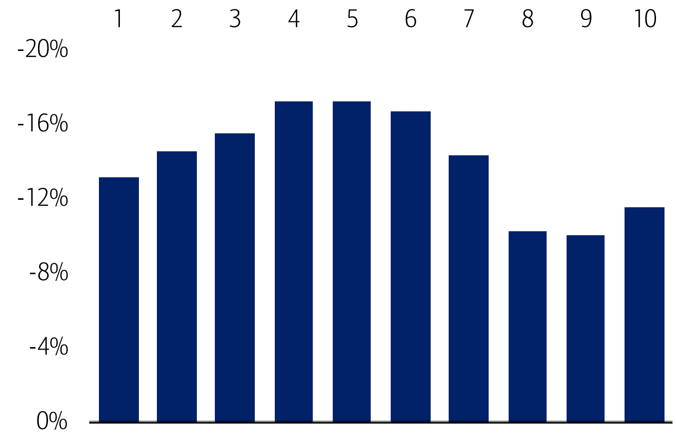
Exhibit 2: 5y historical lookback yields more significant correlation

Average of correlations for PC regression residuals vs. future implied vol changes using different lookback periods of historical data



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G10 PCA vol fair values significantly correlated with 10-day future vol changes

Across all of the parameters we have experimented, we find a negative out-of-sample correlation between the regression residuals and future change of implied vol. The result confirms framework validity because implied vols below estimated fair value tend to rise and implied vols above estimated fair values tend to fall. Exhibit 1 and Exhibit 2 show the backtest correlation is most significant at 10-day lookahead and about 5y lookback periods. The out-of-sample correlations are comparable across tenors, with moderately more negative correlation for the 1y tenor and correlation closer to zero for the 3m tenor (Exhibit 3).

The out-of-sample correlations are also comparable between results for the 1-PC decomposition and the 3-PC decomposition, but the correlation drops notably for the 5-PC decomposition (Exhibit 4). Compared to using a single principal components which explains 72% of the in-sample variance of implied vol data, using 3 principal components can increase the explained variance ratio to 91% (Exhibit 5). The results of the analysis confirm that the **3-PC** decomposition is suitably applied to historical implied vol data at **5y** rolling lookback windows, and use the regression residuals as signals for future **10-day** change in implied vols, in our view.

Exhibit 3: Comparable correlation significance across tenors

Average of correlations for PC regression residuals vs. future implied vol changes at different implied vol tenors

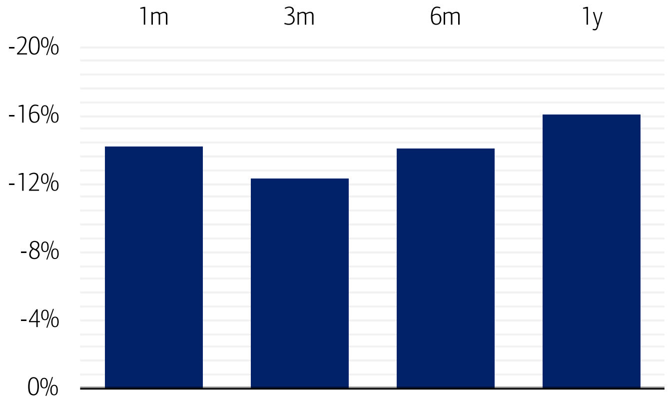

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Exhibit 4: Correlation significance is reduced at 5-PCs

Average of correlations for PC regression residuals vs. future implied vol changes using different number of principal components

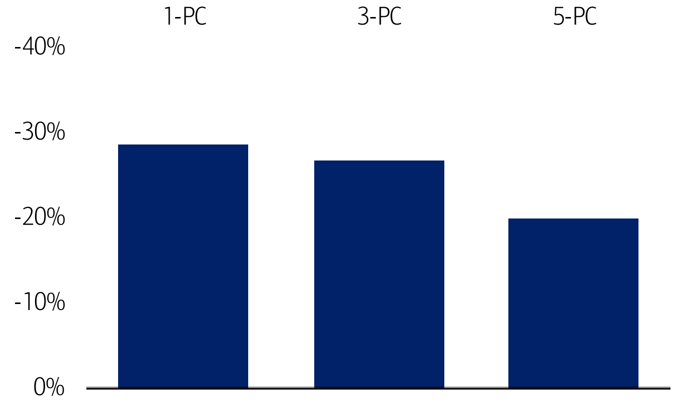

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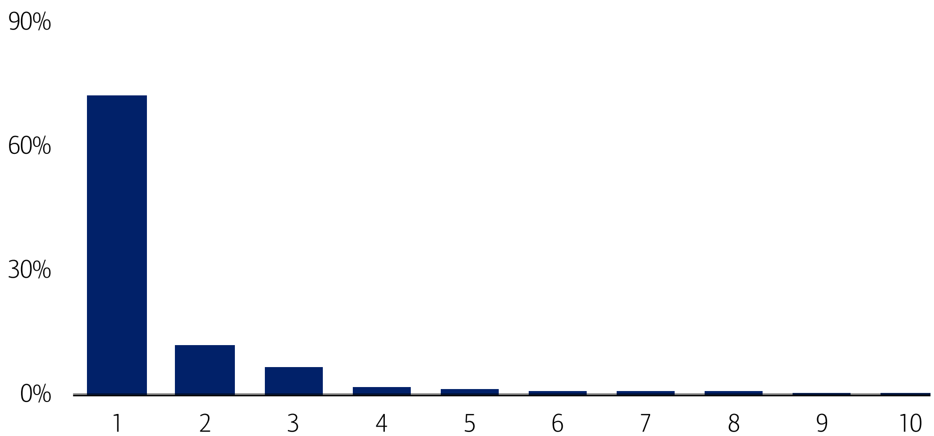
Exhibit 5: 1-PC explains 72% and sum of top 3 PCs explains 91% of the implied vol data variance

Explained variance ratio for the top 10 principal components



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Underpriced vs overpriced implied vols

Implied vols above estimated fair value are more likely to fall

Focusing only on the positive residuals yields more significant out-of-sample correlations, which means implied vols that are rich versus estimated fair values are more likely to fall (Exhibit 6). **AUDCAD**, **USDJPY**, and **USDNOK** are the major pairs in vol market that tend to see implied vols revert lower after trading at a premium over estimated fair value.

By contrast, results for only the negative residuals yields correlations that are closer to zero (Exhibit 7). But in case of **EURCHF**, the implied vol is likely to rise when its level trades at a discount to estimated fair value.

Exhibit 6: Implied vols at premium are more likely to fall
Top 10 average out-of-sample correlations for implied vols at a premium vs fair value by currency

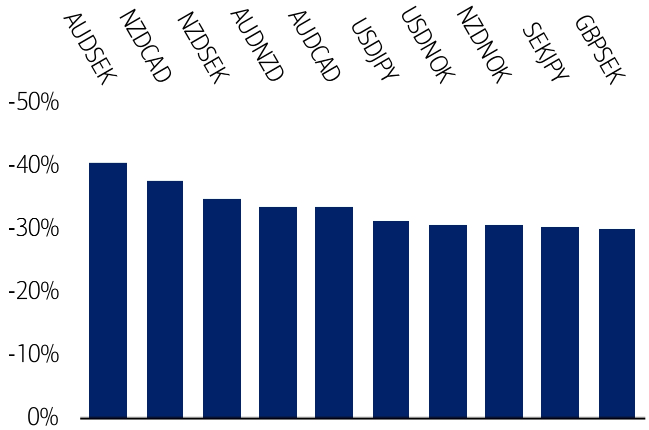

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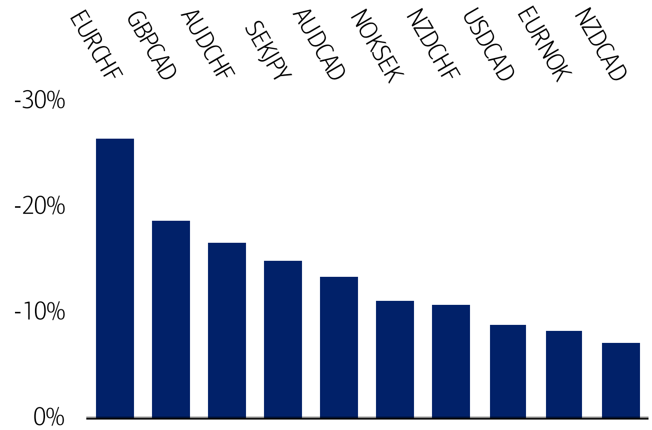
Exhibit 7: EURCHF implied vols at discount are more likely to rise
Top 10 average out-of-sample correlations for implied vols at a discount vs fair value by currency



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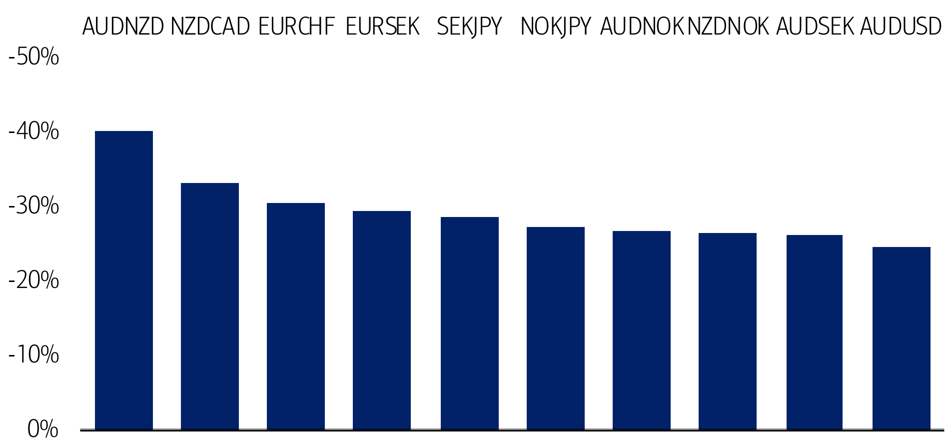
Greater signal strength for large residuals

Exhibit 8 shows the out-of-sample correlation can be more significant for regression residuals that have 1y z-score above +1 or below -1. When implied vols have large dislocation from estimated fair values, they tend to revert back towards these fair values. Among the major pairs in G10, the out-of-sample correlation is most significant for **AUDNZD, EURCHF, EURSEK** and **AUDUSD**.

Exhibit 8: Out-of-sample correlation is more significant for implied vols with large deviations from estimated fair value
Top 10 average out-of-sample correlations using regression residuals with 1y z-score beyond +/- 1



Source: BofA Global Research

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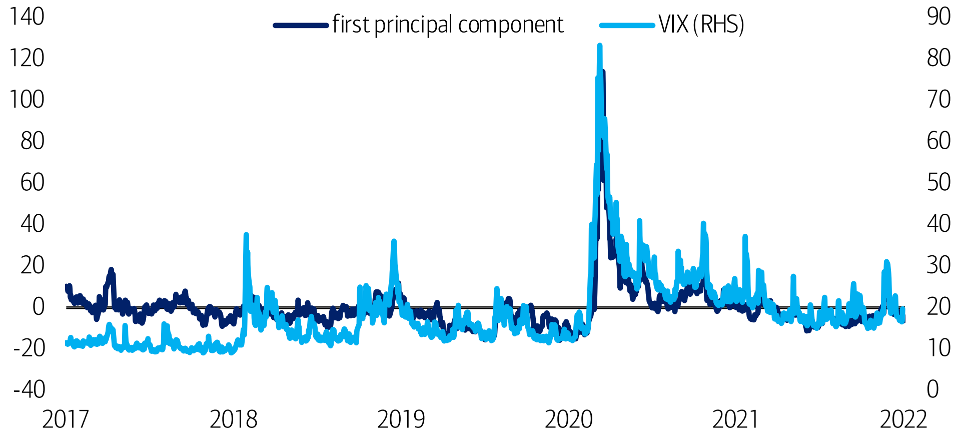
The three principal components

First principal component is highly correlated with VIX

Exhibit 9 to Exhibit 11 illustrate the three principal component vectors for the most recent 5y lookback window. We find the first PC, which explains 72% of the variance for FX implied vols, appears to be highly correlated with the VIX index. The correlation has been 79% since 2017 and 91% since 2019 (Exhibit 9). The result FX implied vols have become more sensitive to risk spillover from the equity market over the years, making FX vol a more suitable proxy hedge for equities than in years past.

Exhibit 9: 1st PC is highly correlated with VIX at 79% since 2017 and 91% since 2019
First principal component vector and VIX index



Source: BofA Global Research

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Second principal component show Covid regime shift for FX vol

The second principal component was positive most of the time before the March 2020 Covid-19 shock, but has since then averaged negative (Exhibit 10). We find the US 10y real rate correlates with the 2nd PC at 65% but not conforming to all of the spikes in the 2nd PC. If the second PC turned positive like it did briefly in Sep and Dec 2020, then we would expect FX vols could broadly move higher in 2022.

Third principal component correlates with JPY strength

Lastly, we find the third PC has a notable correlation of 39% with the Bloomberg correlation-weighted JPY index over the past 5 years capturing risk-off drivers of FX vol (Exhibit 11). Given its so-called "safe-haven" currency status, JPY appreciation tends to occur amid rising FX vols.

Exhibit 10: 2nd PC has been suppressing FX vol since the Covid shock
Second principal component vector correlates with US10y real rate at 65%

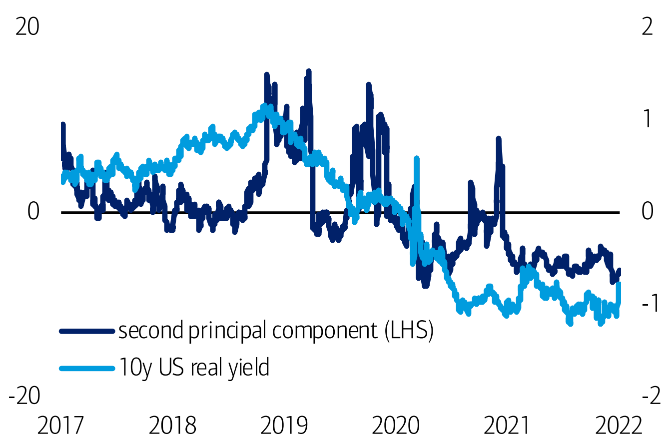

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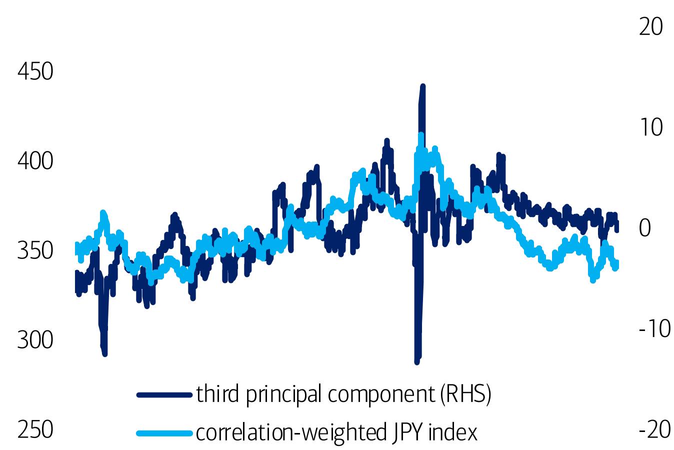
Exhibit 11: 3rd PC correlates with JPY strength at 39%
Third principal component vector



Source: BofA Global Research

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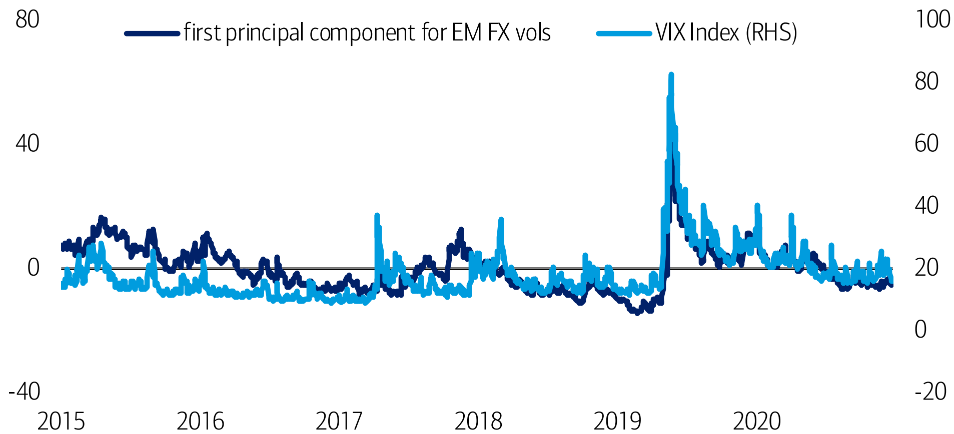
PCA framework for EM FX implied FX vols

Higher correlation for EM FX vols using 1-PC and 3m lookahead

We further extend the PCA decomposition framework to 10 pairs of major EM FX vols across major regions. We find the out-of-sample correlations between PCA residuals and future implied vol changes are most significant for a 1-PC decomposition using 6 years of lookback window and 3-month lookahead window. Additional principal components and applying the framework to shorter lookahead windows tend to notably reduce the out-of-sample correlation for EM FX vols.

The first principal component vector for EM FX vols explains 76% of the historical data variance. It is also correlated with the VIX index at 60% (Exhibit 12), and correlated with the first PC for G10 FX at 81%. These results suggest idiosyncratic local risks affect EM FX vols more than G10 FX vols, and the PCA framework has more explanatory power over medium term than short-term for EM FX vols.

Exhibit 12: 1st PC for EM FX vols has explained variance ratio of 76% and is 60% correlated with VIX
First principal component vector for EM FX vols vs VIX Index



Source: BofA Global Research, Bloomberg. The first principal component is generated using historical FX implied vol values for MXN, BRL, ZAR, HUF, PLN, RUB, KRW, TWD, SGD, and INR.

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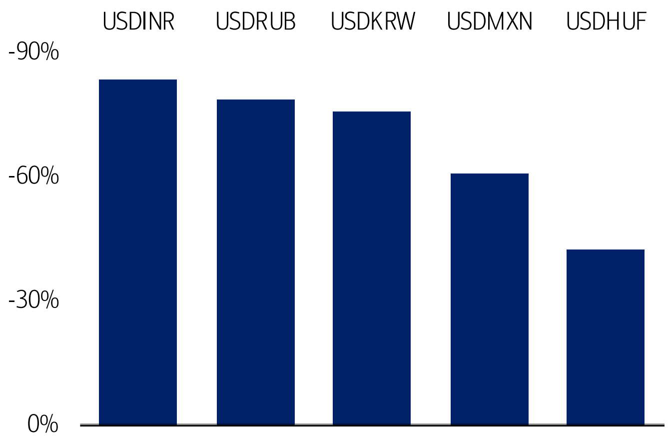
Implied vols at premium are also more likely to fall for EM FX

We break down the out-of-sample correlation between implied vols at a premium versus at a discount for EM FX pairs. Similar to G10 FX vols, EM FX implied vols are also more likely to fall when the levels are at a premium versus PCA fair values than to rise when levels are at a discount. INR, RUB, and KRW vols tend to fall the most when they are richer than estimated fair values (Exhibit 13). When EM FX implied vols are at a discount against PCA fair values, they tend to rise more for BRL and MXN (Exhibit 14).

Exhibit 13: INR, RUB, and KRW vols at premium are more likely to fall
Top 5 average out-of-sample correlations for EM FX implied vols at a premium vs fair value by currency



Source: BofA Global Research

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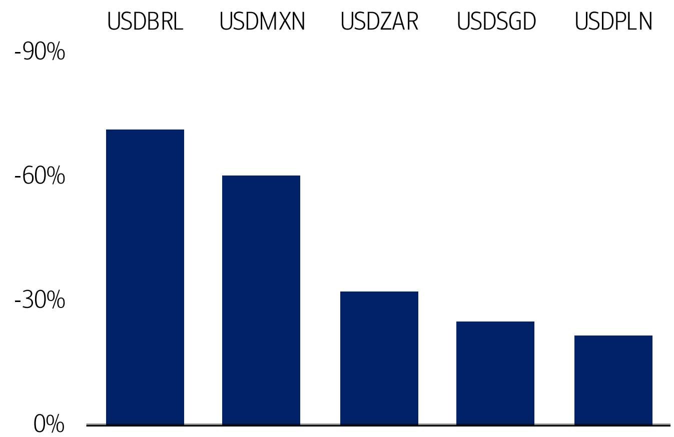
Exhibit 14: BRL and MXN vols at discount are more likely to rise
Top 5 average out-of-sample correlations for EM FX implied vols at a discount vs fair value by currency



Source: BofA Global Research

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Latest PCA signals favor higher 3m NZD implied vols

NZD-based implied vols are broadly underpriced

The latest PCA signals show 3m NZD-based implied vols are cheap relative to PCA estimated fair values. NZDUSD implied vol is the most underpriced by 0.58 vols (Exhibit 15). The actual implied vol minus estimated fair value spread is also below -1 z-scores (Exhibit 16).

JPY-cross volatilities appear at a premium, with CADJPY as the richest at 0.92 vols given imminent Bank of Canada meeting. The premiums are in excess of what can be explained by the variation within G10 FX alone. The JPY-based vol premiums may be a market response to the recent global equity sell-off, in our view.

Exhibit 15: NZD-based implied vol are underpriced by 0.5 spread
3m implied vol – PCA estimated fair value spread

Vols	EUR/	GBP/	AUD/	NZD/	USD/	CAD/	CHF/	NOK/	SEK/
/GBP	-0.14								
/AUD	-0.04	-0.13							
/NZD	-0.30	-0.31	-0.48						
/USD	-0.35	-0.18	-0.29	-0.58					
/CAD	0.50	0.02	-0.38	-0.48	0.20				
/CHF	-0.02	-0.25	-0.35	-0.55	-0.07	0.45			
/NOK	0.30	0.29	-0.31	-0.32	-0.21	0.02	0.24		
/SEK	0.24	0.39	-0.19	-0.55	-0.04	0.17	0.21	0.20	
/JPY	-0.05	0.34	0.64	0.45	-0.02	0.92	0.18	0.23	0.17

Source: BofA Global Research

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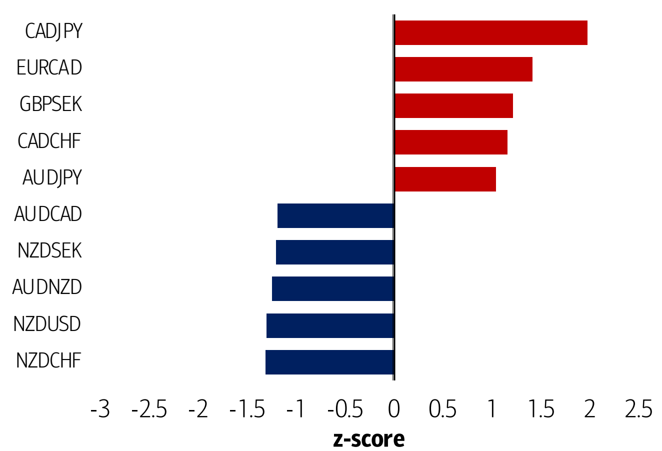
Exhibit 16: NZD actual-PCA estimated vol spreads are below -1 z-score
Top and bottom 1y z-scores of implied vol-PCA estimated fair value spread



Source: BofA Global Research

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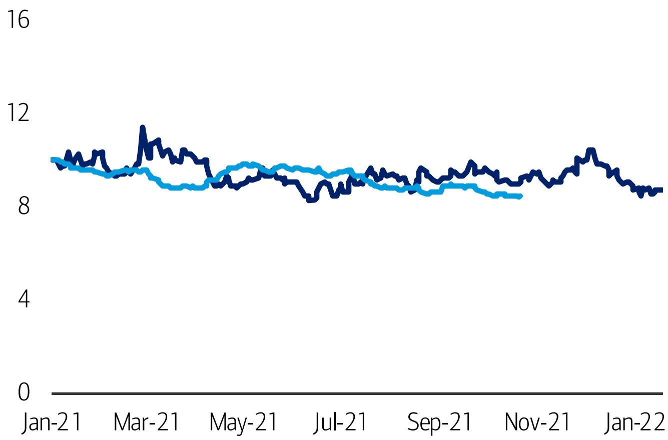
Q4 CPI release amid aggressive 2022 rate hike pricing to move NZD vol higher

3m NZDUSD implied vol is currently trading close to the 2021 low. It has not moved higher largely because NZDUSD realized vol has remained subdued, in our view (Exhibit 17). We expect both 3m NZDUSD implied and realized vols to move higher from current levels, and we see the Q4 2021 NZ CPI release at end of January as a potential catalyst. Unlike the US CPI which has had above 3% YoY monthly prints since June 2021, the NZ

CPI is released quarterly and latest value still only covers data up to Q3 2021 (New Zealand Economic Watch: 18 October 2021).

The rates market currently has priced in 5 RBNZ rate hikes in 2022 (Exhibit 18), which is one of the most aggressive among all developed countries. Most of the hikes are also expected to occur in within the first half of 2022. Any re-pricing of the monetary policy decisions on the back of uncertain Q4 CPI amid contracting Q3 growth (New Zealand Economic Watch: 16 December 2021) would likely lead to a rise in NZD vols. The risk to this view is lack of options response to the upcoming NZ CPI release and the Jan FOMC meeting.

Exhibit 17: 3m NZD implied versus lagged realized vol
NZD implied and realized vols are both at or close to a bottom since 2021



Source: BofA Global Research, Bloomberg

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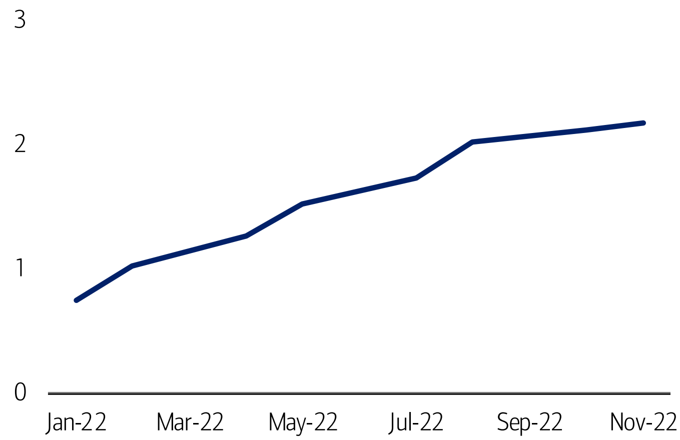
Exhibit 18: NZ OIS market currently sees 5 RBNZ rate hikes in 2022
NZ OIS implied rate in 2022



Source: BofA Global Research, Bloomberg

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