FX Derivatives Research Note

Mahalanobis distance measure proves forward looking for FX vol

- A simple rule base trading exercise that leverages Mahalanobis distance to find historically similar periods and stratify returns conditional on that similarity measure proves forward looking for trading FX vol.
- By inherently incorporating PCA and thus automatically suppressing the impact of highly correlated time series, Mahalanobis distance has an edge over simpler measures such as Euclidean distance or out-of-box clustering methods.
- The details confirm that it is redundant to PCA original inputs as Mahalanobis already efficiently incorporates PCA and that dimensionality reduction is undesirable, at least in context of vol trading.
- Applying the framework to the latest data, we find a defensive lean.

Global FX Strategy

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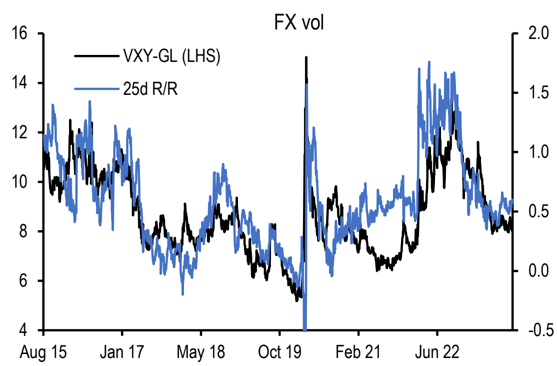
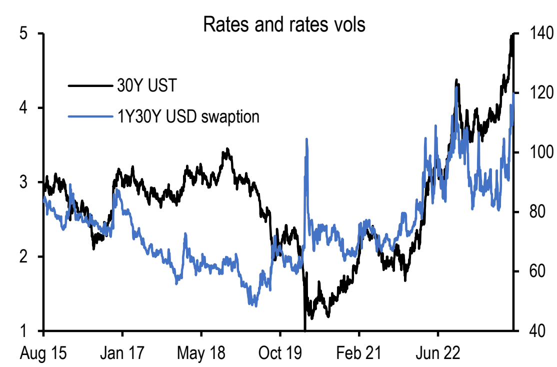
VXY has been lingering around the 8vol handle in a narrow range (~0.5pts) even as the broad USD TWI bounced 4% from the July low. FX vol emerged early on in August but that proved non-game changing. The ongoing FX vol malaise can be justified by the notion that central banks are at / near the point of being done and markets are starting to have a fairly good idea what the terminal rates are going to be. On the other hand the rates markets continue to be highly volatile and geopoliticals are becoming increasingly complex though both mostly sparing FX for now.

Figure 1: FX vols have been trapped at depressed level and in a narrow channel ...



Source: J.P. Morgan.

Figure 2: ... at odds with US rates vol.



Source: J.P. Morgan.

At the current levels, FX vols are in the middle of the narrow channel. A question is if they are going to continue to linger there, or grind higher, and if that answer is consistent when comparing the current FX vol backdrop (**Figure 1**) with the one in rates markets (**Figure 2**) or even broader markets that incorporate also e.g. broader economic, positioning and risk indicators. It's a perpetual dilemma, a complex question that incorporates one's expectations -- which historical periods are similar to the current one and thus provide the most meaningful insight into what to expect.

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We started to tackle that question in an earlier note where we introduced a notion of a distance measure for quantifying market regimes for FX vol trading. Namely, the framework calculates Mahalanobis distance as a measure of similarity between two market backdrops, that contain multitudes of market and economic variables.

Mahalanobis similarity metrics

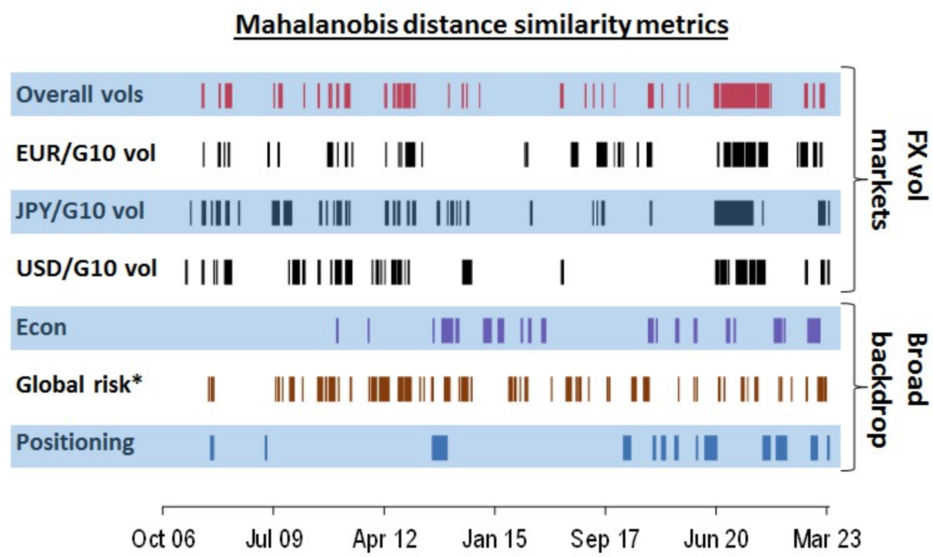
The framework states that market conditions for two time periods are similar if the Mahalanobis distance between them is small. It is a distance between two N-dimensional vectors, where each dimension is associated with one input. A 4-D case would be for example a representation where the dimensions are: USD swaption pricing, silver-to-gold price ratio, USD positioning, JPMaQS leverage ratios. The distance measure is expressed as:

$$d(x,y) = \sqrt{(\boldsymbol{x}-\boldsymbol{y})^T \boldsymbol{S}^{-1}(\boldsymbol{x}-\boldsymbol{y})}$$

where S is the covariance matrix, and x and y are N-dimensional vectors representing the markets and/or economy. The resulting distance is winsorized at +/- 3 sigma (an arbitrary level). By inherently incorporating PCA and thus automatically suppressing the impact of highly correlated time series, Mahalanobis distance has an edge over simpler measures such as Euclidean distance or out-of-box clustering methods.

Figure 3: Mahalanobis similarity metrics marks the past most similar market regimes to the current backdrop.

Baskets: 1) global risk basket; 2) positioning basket which comprises major IMMs (in form of z-scores) as well as FX correlations; 3) economics/broad market backdrop basket, which contains global PMI (level and 3-mochange), three economic sentiment indicators, CPI, major EASIs and FRIs(1-yr z-score of 3-mo change) and adds a component of FX by including IMMs, 4) Three FX vol baskets: granular market characteristics such as currency level vols, RR, RR/ATM ratio, BF and BF/ATM ratios. The "spectral lines" designate most similar historical periods to the current backdrop as measured by Mahalanobis distance (10%-ile). Global risk category is now including JPMaQS signals for FX tail risk premia, FX volatility risk premia, Duration volatility, and CDS index volatility.



Source: J.P. Morgan, JPMaQS

Figure 3 illustrates an output from the framework where the lines mark the most similar past market periods to the current one. The input variables space is sliced across various

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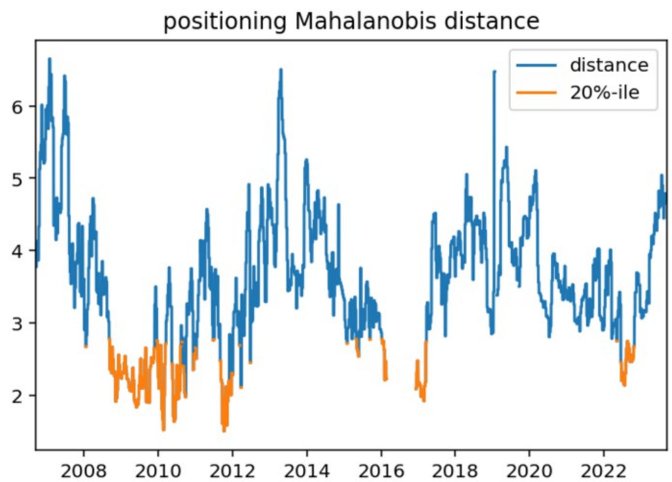
baskets for the benefit of granularity. The construction of the baskets aims to group similar variables together along three vol baskets, economic series, positioning and market risk sentiment.

Distribution of returns conditional on Mahalanobis distance sets the direction for trading

The choice of the baskets is intuitive but ad-hoc. Note that Mahalanobis framework is not predictive by design. It merely tries to take advantage of tendency for history to repeat itself. **Figure 4** illustrates the process in case of the Positioning basket. The distance shown corresponds to the distance of historical periods to a reference period which is this specific case is 2016 Feb. Since there tends to be autocorrelation we exclude 3month window around the reference against which the distance is measured, and even a bit wider window may be needed as evidenced by the adjacent highlighted (20%-ile) region in the distance chart.

Figure 4: Mahalanobis distance for the positioning data basket. Lowest distance to 2016 Aug highlighted.

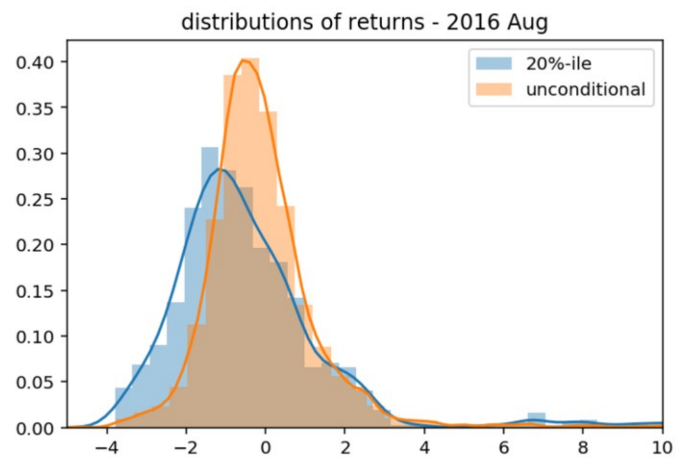
2016 August reference. The gap in the distance timeseries is centered around the ref period (Aug 2016) and stretches 3M on either side of it.



Source: J.P. Morgan.

Figure 5: Returns conditional on Mahalanobis distance tend to underperform long-term returns.

Returns correspond to 1-mo holding of a VXY weighted basket of delta-hedged 3M straddles



Source: J.P. Morgan.

Next we compare the historical returns vs the subset corresponding to the periods where distance with smaller (20%-ile). The returns that we monitor here correspond to 1-mo holding of a VXY weighted basket of delta-hedged 3M straddles. Performance of the trades from during the highlighted 20%-ile historicals result in a distribution of historical outcomes from similar periods and thus forms a basis for assessing if the same trades are suitable for the current backdrop. The conditional distribution is compared to average (un-conditional) distribution via a simple trading rule or a regression model for e.g. mean, peak returns, skewness or some other measure of the difference in the distribution of the returns.

Figure 5 and **Figure 7** show two quite extreme examples of such comparisons, corresponding to 2016 Aug where the data suggests underperformance vs the long term returns, and 2019 Feb where Mahalanobis historicals suggests outperformance. An ad-hoc rule suggests being short delta-hedged straddles in 2016 Aug and long in 2019 Feb. More typically Mahalanobis based and the long-term distribution look more similar.

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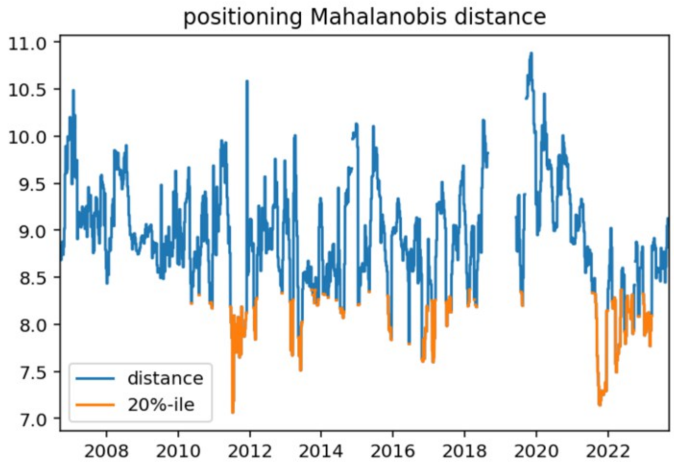
Figure 6: Mahalanobis distance to 2019 Feb reference period.

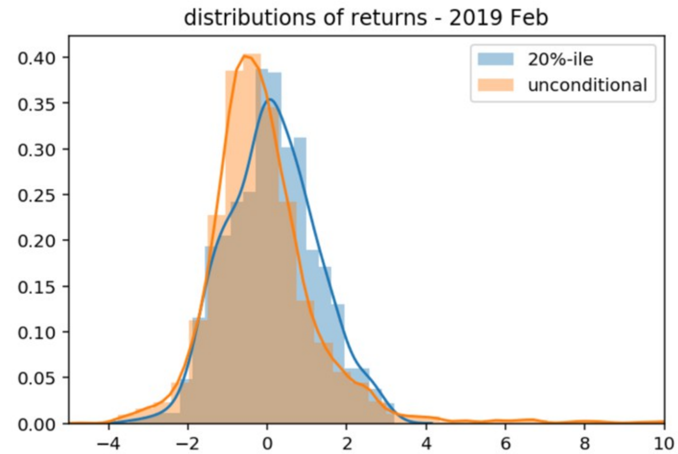
The gap in the distance timeseries is centered around the ref period (Feb 2019) and stretches 3M on either side of it.



Source: J.P. Morgan.

Figure 7: Returns conditional on Mahalanobis distance tend to outperform long-term returns.

Returns correspond to 1-mo holding of a VXY weighted basket of delta-hedged 3M straddles.



Source: J.P. Morgan.

Returns conditional on Mahalanobis are systematically positive

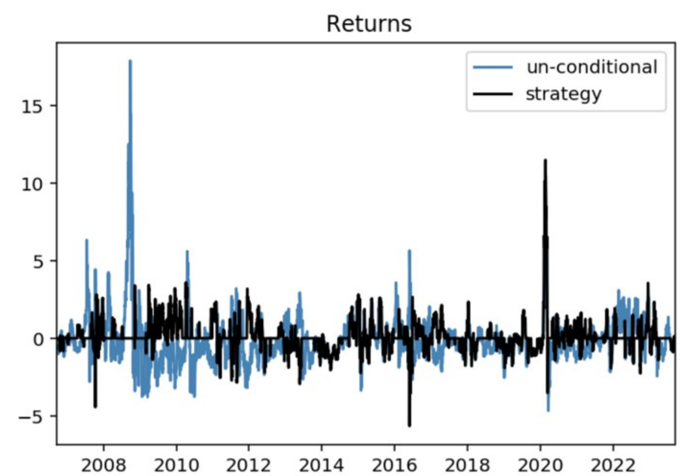
By repeating the same process of finding 20%-ile shortest Mahalanobis distance and extracting the corresponding conditional returns, we get trading direction for any given historical date.

Figure 8: Cumulative performance and ...

VXY weighted basket of 3M d-h straddles. Delta-hedged daily. 1-mo holding. No TC.

Source: J.P. Morgan

Figure 9: ... the corresponding returns per trade for rule based trading of 3M d-h straddles based on Mahalanobis distance for positioning and economic data



Source: J.P. Morgan

The results sum up into cumulative performance for Mahalanobis based trading rule (the black line) and the unfiltered, always long, benchmark (blue line) in **Figure 8**. The corresponding details given in **Figure 9** show that in quite a few instances the historicals were too mixed to provide a firm vol direction but in general the methodology mitigated

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quite a few periods of persistent drawdowns. It struggled to position for the high vol episode in 2008, which is understandable considering that there were hardly any periods withing the data analyzed that truly qualify as similar and from which to draw useful lessons.

The analysis in the way it's conducted contains forward bias though the above results look solid enough even under our simplistic rule based trading. About the input variables, should we be more selective? **Figure 3** shows the whole scope of the input variables space with 6 baskets and each containing 10-30 inputs. Intuitively, smaller number of more relevant inputs should be decreasing the clutter and unnecessary noise. However, an attempt in using Random Forest feature importance ranking in selecting the most relevant features turned to be detrimental as it enforced keeping the most correlated features and, in the process, lead to loss of ability to depict newly developing trends.

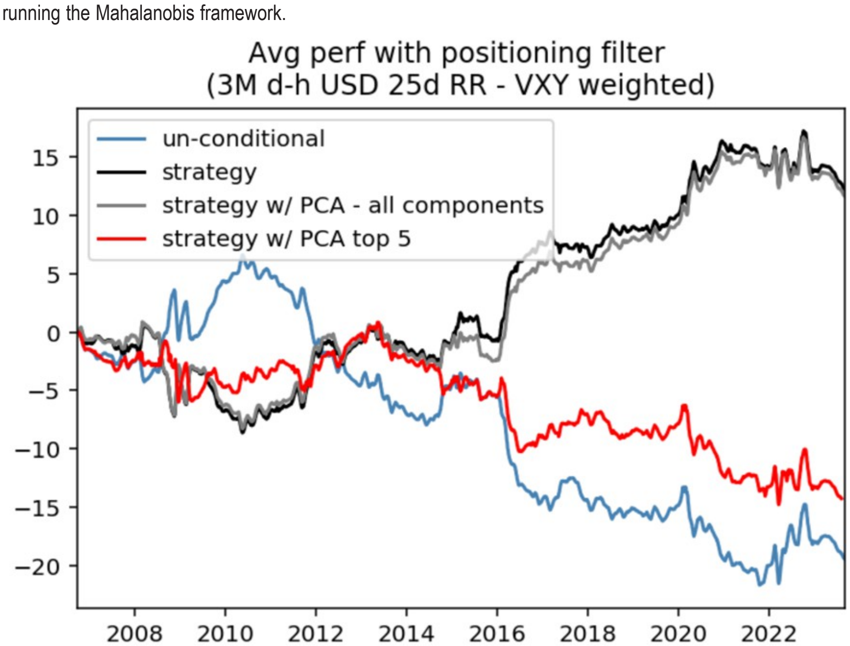
It suggests that less is more is not applicable here, though we don't suggest that a kitchen sink of variables approach should be used, but rather that a meaningful and intuitive set of carefully selected variables should be kept as is, without dimensionality reduction, in this framework.

We find no need for using PCA-ed input data as Mahalanobis proves efficient in incorporating PCA

Mahalanobis incorporates PCA by design, but the question is how well? Does the framework benefit from running PCA on the inputs before feeding them into Mahalanobis. We test that on the positioning basket that we apply on 3M delta-hedged 25d risk reversals (USD call - USD puts, VXY weighted).

Figure 10: Mahalanobis proves efficient in incorporating PCA

Here "strategy" = w/o performing PCA first. "strategy w/ PCA" corresponds to running PCA first, then running the Mahalanobis framework.



Source: J.P. Morgan.

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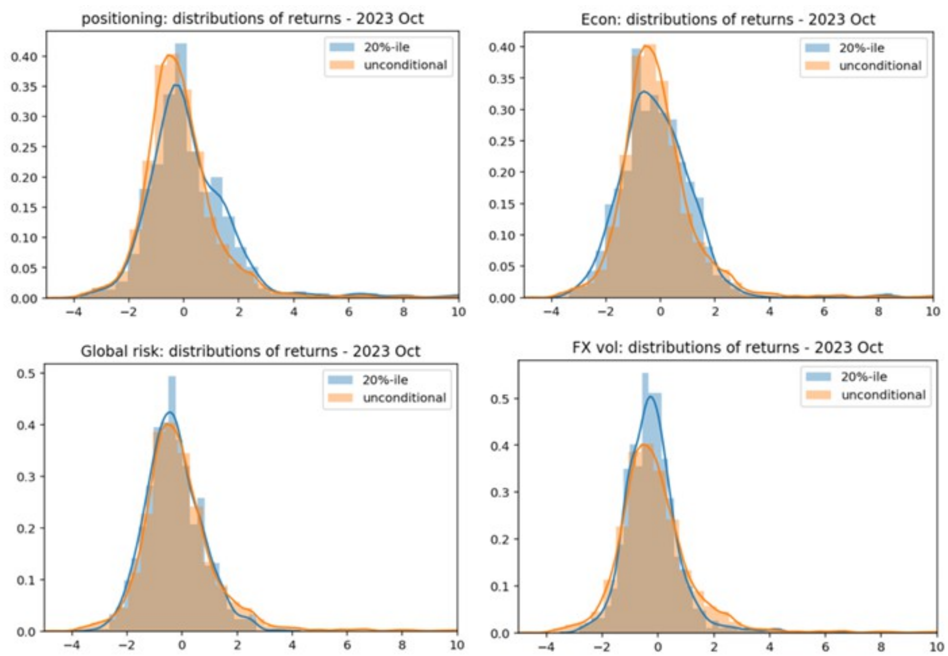
The results in **Figure 10** show that a) PCA has no material effect on the outcome when all components are kept (firmly confirms that PCA is not needed), and b) keeping only the most significant PCA components is undesirable as in that case the framework loses forward looking ability to spot developing trends (similar to what was observed with the Random Forest feature importance ranking approach).

Defensive lean in the latest data

We apply the above-detailed framework on the 2023 Oct data. **Figure 11** indicates a defensive bias, most clearly observed in the positioning & correlation basket and the FX vol baskets. The Econ conditional returns distribution has a topside vol bump while Global risk basket is nominal, expressing a neutral stance on delta-hedged 3M VXY weighted straddles.

Figure 11: Overall, a defensive lean

Returns from delta-hedged 3M straddles (VXY weighted).



Source: J.P. Morgan., JPMaQS

Key takeaways

- A simple rule base trading exercise that leverages Mahalanobis distance to find historically similar periods and stratify returns conditional on that similarity measure proves forward looking for trading FX vol.
- The details confirm that it is redundant to PCA original inputs as Mahalanobis already efficiently incorporates PCA and that a stringent dimensionality reduction is undesirable, at least in context of vol trading.
- Keeping only the inputs that are highly correlated to the historical returns tends to limit the framework's ability to uncover new trends. The framework benefits from having access to wide range of indicators, rather than relying on a narrow, highly focused set, as it was suggested in the past.

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- In this limited scope analysis, we constrained the testing on the macro inputs. Vol markets inputs are another data set that should prove useful for more granular, per currency vol trading. Furthermore, it may be worth supplementing the positioning dataset, which have already shown promise with our new options positioning data. We leave that for a future work.

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