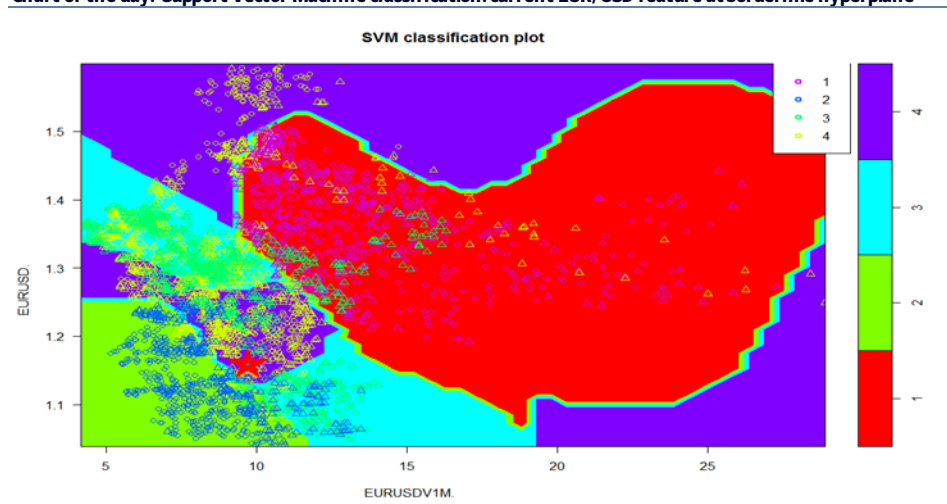


### Key takeaways

- We use machine learning by employing large fundamental data, seeing current uncertainty over Eurodollar via a different lens.
- Unsupervised learning finds state is highly time dependent, with current classification far from previous Eurozone crises.
- Supervised learning sees current feature at borderline hyperplane, with a likely migration suggesting further Euro downside.

By Alice Leng

Chart of the day: Support Vector Machine classification: current EUR/USD feature at borderline hyperplane



Source: BofA Merrill Lynch Global Research, Bloomberg

### A touch of machine learning on EUR/USD

With the Italy bond selloff and uncertainty over political risk having a drastic impact on the Eurodollar, we study the current state via fundamental and survey data, employing both supervised and unsupervised learning on various forms of transformation. We apply a touch of classification algorithms to key data relevant to both sides of the economies, aiming to offer a different perspective on the ongoing uncertainty over the fate of the Eurodollar.

The implications of our analysis are threefold. We find a recognizable pattern in the Eurodollar spot and vol regime and underlying fundamentals via unsupervised learning. Such classification is time dependent with the current environment far from its counterpart during the previous Eurozone crisis. Supervised learning shows the current condition is at a boundary hyperplane. A likely migration to the nearby state sees further Eurodollar downside while volatility is likely to remain range bound.

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## An attempt to use machine learning in FX

Machine learning is a method that uses statistical techniques to learn from data, identify patterns and make decisions. Despite the debate over limitations of such analysis, it can possibly uncover unique insights by devising complex models and algorithms over complex data sets otherwise hard to process by humans.

In this analysis, we study the current state of the Eurodollar via a large set of fundamental and survey-based data relevant to both sides of the economies. We employ various transformations such as first difference, growth rate and de-trend to capture the change and relative strength of underlying economics and sentiment. By employing both supervised and unsupervised learning, we aim to uncover a different perspective to the ongoing uncertainty over the Eurodollar.

### Unsupervised clustering via K-means

We first employ unsupervised learning by classifying historical environments into clustered groups based on the underlying feature over fundamental data. The benefit of unsupervised learning is that it avoids labeling bias by inferring hidden structure from "unlabeled" data. We use a k-means algorithm to classify the state into different groups by including all the fundamental data and its various forms transformation. It is unsupervised as we do not provide any guideline or punishment for how to classify.

Both the k-means clustering over 4 and 10 groups show there is a clear pattern of classification over fundamental data with respect to currency movements (Exhibit 1, Exhibit 2). The fact groups tend to cluster around similar neighborhoods with regards to the level of exchange rate and volatility is fascinating as we throw the data into an algorithm completely unsupervised.

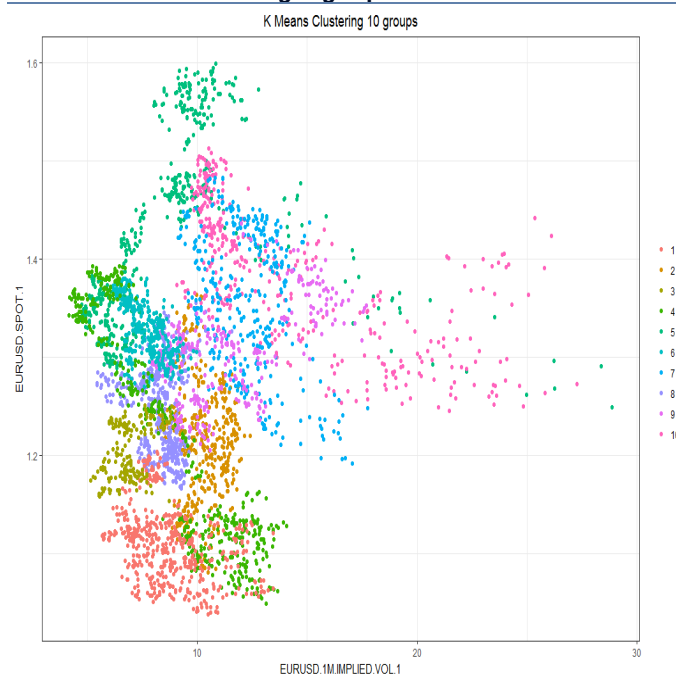
The implication of having a clear clustering pattern over various states with respect to spot vol regime shows various exchange rate and vol regimes over time are supported by the underlying economic fundamentals and sentiment movement.

**Exhibit 1: K-Means Clustering 4 groups**



Source: BofA Merrill Lynch Global Research, Bloomberg

**Exhibit 2: K-Means Clustering 10 groups**

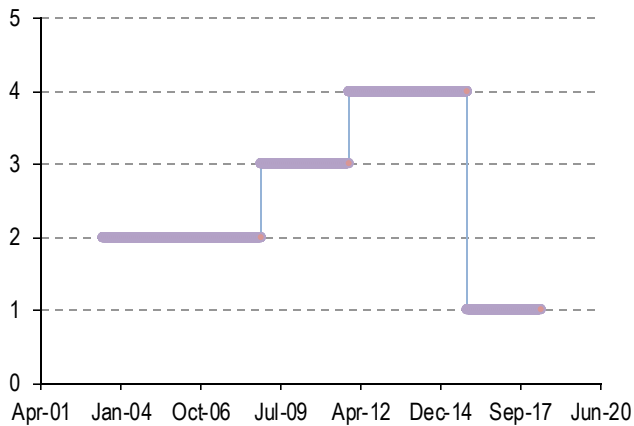


Source: BofA Merrill Lynch Global Research, Bloomberg

### Implications: this time is nothing like Eurozone crisis

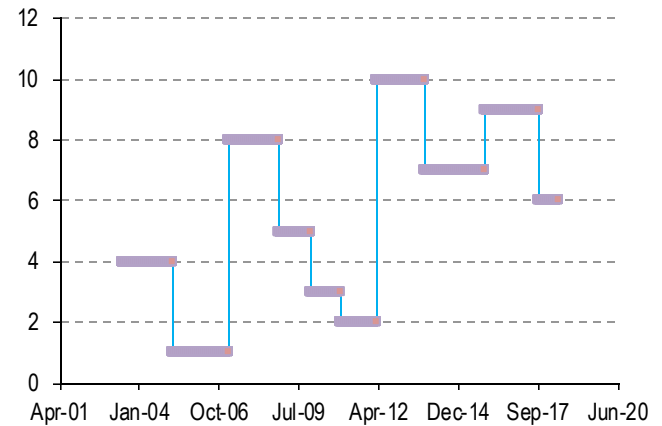
Despite the uncertainty over political risk and Eurodollar selloffs, our analysis suggests the current risk environment is nothing like the Eurozone crisis. By aligning clustered groups over the dimension of time, we find unsupervised clustering is highly time dependent. There is clear separation of state over time with little overlap during separated periods. This is evident for both smaller clusters in the 4-group case and more detailed clusters in the 10-group case (Chart 1, Chart 2). The clear separation provides a unique angle to see the current state is far from previous selloff episodes such as the Eurozone crisis.

Chart 1: K-Means Clusters over time: 4 group case



Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 2: K-Means Clusters over time: 10 group case



Source: BofA Merrill Lynch Global Research, Bloomberg

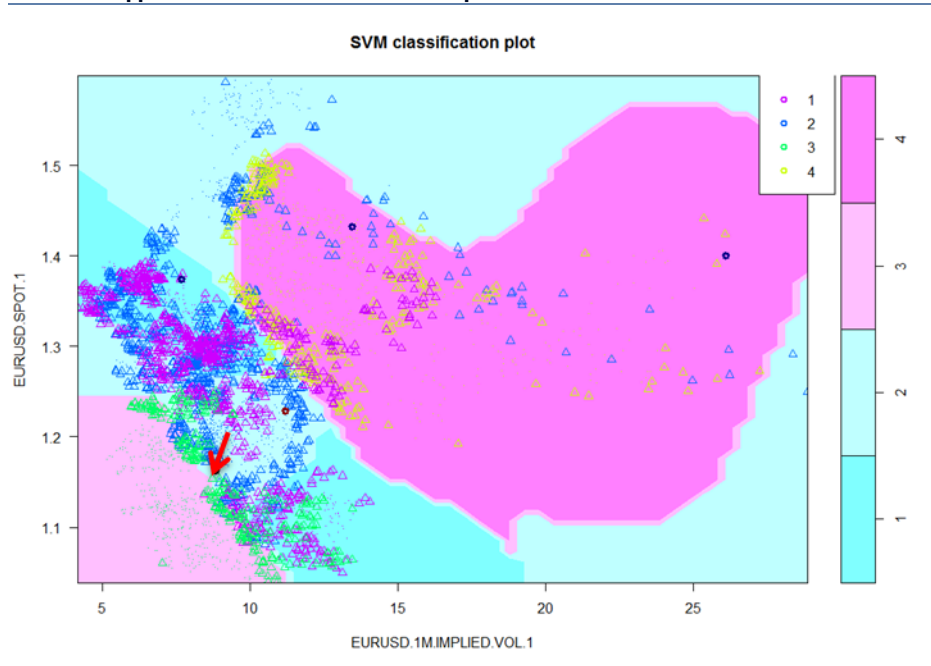
Unsupervised learning has its benefits, but it does not map an input to an output that defines causal relationships. We explore supervised learning in the following analysis, aiming to capture another missing dimension of the puzzle.

### Supervised learning via support vector machine

Supervised learning is a methodology that defines the effect that one set of observations has on another set by providing the training data with supervisory signals. It is supervised as it requires a guideline for training. We apply a support vector machine as a way to disentangle the hyperplane with a separation achieved by the hyperplane that has the largest distance to the nearest training-data point.

We find the current state is at the boundary support vector and the previous risk episodes highlighted by darker dots such as the Greece defaults, ECB president Mario Draghi preparing the market for QE, and the Fed announcing tapering are far from the current state (Exhibit 3).

### Exhibit 3: Support Vector Machine classification plot



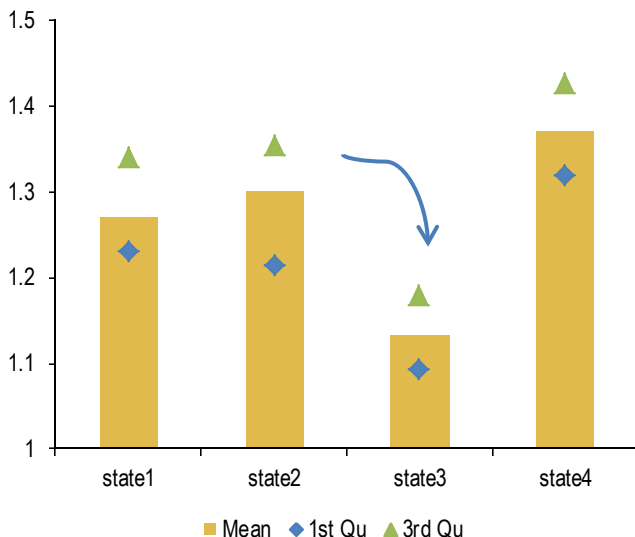
Source: BofA Merrill Lynch Global Research, Bloomberg

#### Implications: boundary support vector likely to migrate

If such analysis becomes valid, we see further Eurodollar downside as the state migrates to the lower level and vol stays range bound. The current state is at the boundary support vector of state 2, likely to transition to state 3. By taking the mean and percentile distribution of spot and vol, we find that state 3 has the lowest spot level whereas state 4 exhibits strong euro (Chart 3). From the volatility angle, euro weakness tends to associate with higher volatility. State 1 tends to see higher dispersion of vol while spot remains range bound (Chart 4).

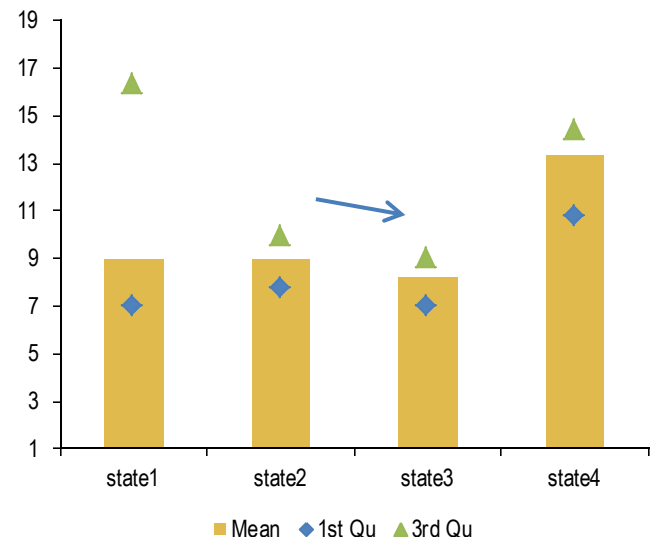
Our surprised learning via SVM indicates we are currently at the boundary of state 2 near the support vector hyperplane. The implication is that it is highly unstable and likely to migrate to a nearby state. If such conjecture turns out to be valid, it would suggest that the Eurodollar has further downside while vol is likely to remain range bound.

Chart 3: EUR/USD spot distribution by state



Source: BofA Merrill Lynch Global Research, Bloomberg

Chart 4: EUR/USD vol distribution by state (1M Implied volatility)



Source: BofA Merrill Lynch Global Research, Bloomberg

## Appendix

We employ fundamental and survey data from both the US and Eurozone side to analyze Eurodollar spot and vol dynamics. Typical data included in our analysis are shown in the table below with various transformations such as difference, growth rate and de-trends.

**Table 1: Data summary**

National Account	Consumer Prices	Producer Prices	Labor Market	Economic Activity	Business Cycle Indicator	Business Conditions	Leading Indicators	Housing Market	Retail Sector	Consumer Confidence	Personal Sector	External Sector	Government Sector	Monetary Sector	Financial Sector
Real GDP	CPI	PPI Final Demand	Unemployment Rate	Industrial Production	Industrial Production Index	ISM Manufacturing	OECD Leading Indicator	Housing Starts	Retail Sales	Confidence Board Index	Personal Income	Current Account	Gov't Budget Balance	Monetary Base	Fed Funds Rate
Personal Consumption	CPI ex-Food&Energy	PPI Final Demand ex Foods&Energy	Initial Jobless Claims	Capacity Utilization	Real Personal Income	ISM Non-Manufacturing	Conf. Board Leading Indicator	Building Permits	Retail Sales ex-Autos	U. of Mich Consumer Confidence Index	Personal Expenditure	Trade Balance	Total Public Debt Outstanding	M1	3-Month T-Bill Rate
Private Investment	PCE		Continuing Claims	Factory Orders		Chicago Fed National Activity Index		Existing Home Sales	Total Vehicle Sales		Personal savings rate	Exports		M2	10-Year Gov't Bond Yield
Government spending			NFP	Durable Goods Orders		Markit PMI		Mortgage Applications			Consumer Credit	Imports		M3	Equity market
GDP Price Deflator			Job openings	Business Inventories		Euro-Area Business Climate Index									MOVE Index
				Manufacturing Inventories		EC Economic Sentiment Index									VIX
						EC Industrial Confidence Index									GFSI
						EC Service Confidence Index									German CDS SR 5Y
						Eurozone Economic Expectations									Italy CDS SR 5Y
															Spain CDS SR 5Y
															ECB Main Refinancing Rate
															3-month Euribor Rate

Source: BofA Merrill Lynch Global Research, Bloomberg

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- [Global Rates, FX & EM 2018 Year Ahead](#), 19 November 2017
- [Summer themes](#), **Global Liquid Markets Weekly**, 29 May 2018
- [The next trigger](#), **Global FX Weekly**, 24 May 2018
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