Introducing the Volfefe Index

Quantifying the impact of presidential tweets on rates volatility

- The president has produced more than 10,000 tweets since taking office, at a pace that has accelerated in recent months to over a dozen non-retweets a day on his personal account.
- The subject of these tweets has increasingly turned toward market-moving topics, most prominently trade and monetary policy. And we find strong evidence that tweets have increasingly moved U.S. rates markets immediately after publication.
- Market-moving tweets exhibit distinct statistical properties, primarily addressing trade and, more recently, monetary policy. In recent months, these tweets also tend to receive fewer likes and retweets than other contemporaneous remarks.
- We leverage these results along with supervised learning techniques to produce a classifier trained to spot market-moving tweets. We then used this classifier to build a "Volfefe index" we can employ to measure the impact of presidential tweets on rates vol.
- Finally, we fold this index into our volatility fair value model, to demonstrate the president's remarks on this social media platform has played a statistically significant role in elevating implied volatility.

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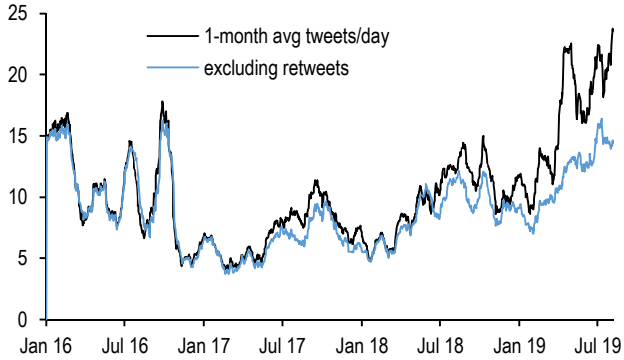
Quantifying the impact of presidential tweets on rates volatility

A common refrain among investors as of late has been the perceived role of the president's Twitter activity on both shorter-term market dynamics and longer-run expectations. **Trade and monetary policy have become an increasing focus for the executive branch, and everything from casual sentiments to seemingly formal policy intentions have been disseminated, globally and instantaneously, via this carefully scrutinized social media platform.** In response, a broad swath of assets from single-name stocks to macro products have found their price dynamics increasingly beholden to a handful of tweets from the commander in chief.

The president has maintained a remarkably consistent daily presence on Twitter since taking office, averaging more than 10 tweets a day to his nearly 64 million followers since the start of 2016—roughly 14,000 total over that timeframe associated with his personal account, of which more than 10,000 occurred after the 2017 inauguration. Average daily activity hit a local low of 5/day heading into his inauguration, and remained somewhat suppressed in his first year relative to the 2016 campaign season. **That said, he has reliably produced at least one tweet on all but a handful of days each year.** Starting in late 2018, however, activity has picked up substantially. **The highest volume of tweets over the past four years has in fact come in recent months,** though a substantial fraction of this rise in activity comes from an increased propensity to retweet others (**Exhibit 1**).

Exhibit 1: The president's Twitter activity has increased substantially through 2019, though a substantial fraction of this rise has been driven by a higher propensity to retweet other users

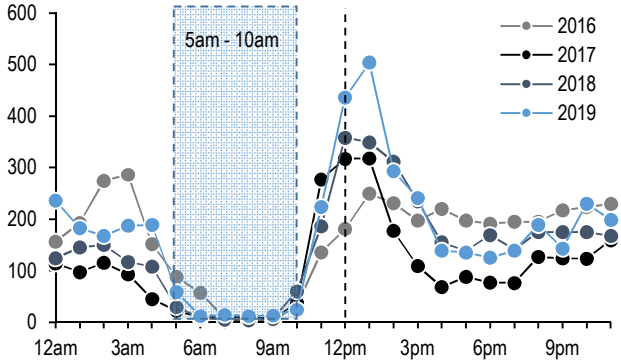
Rolling 1-month average of daily tweets from the president's personal account, both including and excluding retweets; count



Source: J.P. Morgan, trumptwitterarchive.com

Exhibit 2: The president's account activity by time-of-day has remained rather consistent since taking office: 12-2pm is the top hour for a tweet, and his sleep schedule appears to run from 5-10am

Total tweets per year grouped by hour of the day; count



Source: J.P. Morgan, trumptwitterarchive.com

The president's Twitter activity displays some strong intraday cyclicals. While tweets can and will arrive at any hour of the day, noon to 2pm Eastern Time is the most likely window within which a new remark will hit the tape (**Exhibit 2**), a time fortuitously coterminous with some of the best intraday liquidity in U.S. rates markets. This cyclical has been especially prominent in the past year, where **a 1pm tweet is roughly three times as likely as one arriving at any other hour of the afternoon or evening.** Activity persists well into late evening, with 3am tweets more common than 3pm—a nuisance for rates markets, as market depth tends to be quite thin during the overnight session. In contrast, the morning (from 5am to 10am)

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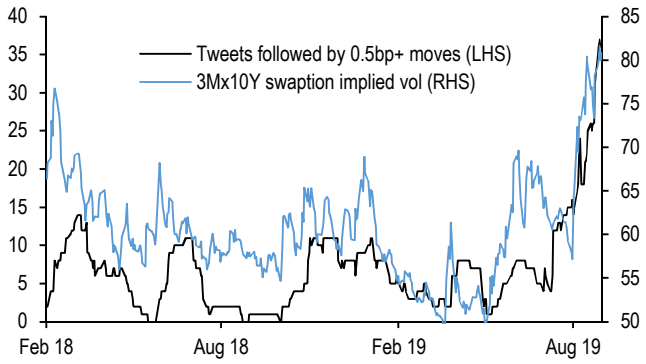
represents a lull in the president's tweeting activity, presumably as the president is sleeping.

Twitter has frequently served as the forum of choice for delivering novel remarks—occasionally even impactful new policy intentions. And Twitter is a platform that allows market participants across the globe to react in real time to its flow of information. **Such a high volume of policy developments made available instantaneously to financial participants en masse thus provides an unprecedented look into how markets could react to the inner workings of the executive branch.** In this note, we take a rough first pass at leveraging this dataset to quantify the president's Twitter-delivered impact on markets. In particular, **we build a "Volfefe" index[1], which analyzes a rolling sample of recent tweets to judge how impactful the president's remarks have been on volatility in U.S. interest rates.** Such an exercise is necessarily quite approximate, but nonetheless gives insight into to what extent the president's candid remarks contribute to market uncertainty.

Exhibit 3: "Market moving" tweets—which we define as those immediately followed by a substantial move in Treasury yields—have increased in dramatic fashion of late, coincident with a spike in vol

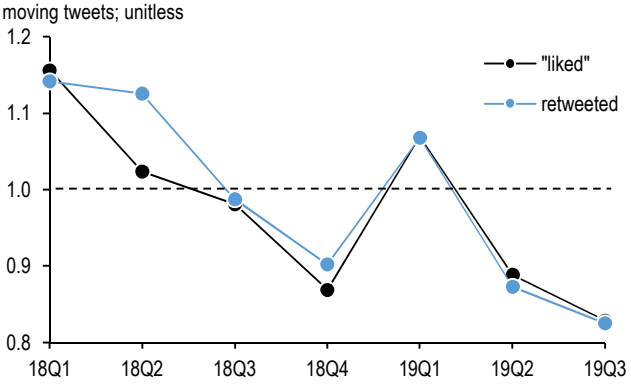
Rolling 1-month count of tweets from the president's personal account immediately followed by a 0.5bp+ net move in 10-year Treasury yields within 5 minutes of publication (LHS; count); 3Mx10Y ATMF swaption implied vol (RHS; abp)



Source: J.P. Morgan, trumptwitterarchive.com, BrokerTec

Exhibit 4: And in recent months, such market-moving tweets have seen fewer favorable responses (likes and retweets) from the president's followers compared to other, contemporaneous remarks

Ratio of the average number of likes and retweets for market-moving vs non-market moving tweets; unitless



Note: market moving defined as in the previous figure as tweets immediately followed by a 0.5bp+ move in 10-year Treasury yields within 5-minutes of publication

Source: J.P. Morgan, trumptwitterarchive.com, BrokerTec

To begin with, we try to understand under what circumstances a tweet will "move markets." We limit the discussion to U.S. interest rates, although such an exercise is easily transferrable to equity or currency markets. **We then leverage high-resolution, intraday data from the interdealer Treasury market to try to isolate a causal relationship, by tagging each tweet with the subsequent net move in traded 10-year Treasury yields over a 5-minute horizon.** Our data reports the tweet's timing to an accuracy of a second, and we time the measurement to that precision as well. We also explored 1-minute, 30-minute and 1-hour horizons, with similar success. **Exhibit 3** shows the rolling 1-month prevalence of tweets in which 10-year yields moved by a half basis point or more in this interval. **By this metric, "market moving tweets" have ballooned in frequency this August**. **Importantly, a few episodes have been associated with a sharp rise in implied volatility**, as measured from swaptions.

[1] To provide context for the meaning Volfefe, we direct the reader here.

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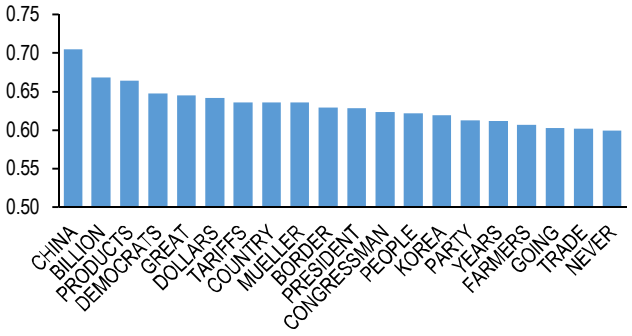
One caveat to mention here is the possibility that the president tweets about markets when markets under- (or out-) perform. From a high-level perspective, it's true that his Twitter activity has risen dramatically in recent months, as volatility has likewise popped. That said, **we find scant evidence that tweets occur at higher frequency on days when implied vol pops higher relative to its recent range.** Another concern worth noting is that we happen to catch large market moves post-tweet by coincidence on days when realized volatility is elevated for other reasons. We can estimate just how many tweets would be randomly captured by bad luck, taking the sample of recent intraday (5-minute) market moves and multiplying that by the president's daily Twitter activity. From this simple exercise we estimate you'd erroneously tag roughly 30 tweets in this fashion in 2018-19, with that number perhaps doubling or tripling if volatility in subsequent 5-minute periods experiences strong autocorrelation (if tweets are indeed timed to large moves). **In fact, we find nearly 146 such tweets in 2018-19, suggesting the effect of tweets on the market is a real one.**

We find market-moving tweets are quite distinct, on average, from the broader population of presidential tweets by several important metrics. **First**, in recent months they have been less well received by followers of his account (**Exhibit 4**) as measured by the average number of "likes" and retweets. **But second, and more important for our purposes, market-moving tweets tend to focus on a subset of topics and themes related to trade and monetary policy.**

Exhibit 5: Ranking words by how frequently they appear in market-moving tweets versus the account's broader corpus reveals, unsurprisingly, trade (and monetary policy) as key topics…

Top ranked words by ratio of the frequency of occurrence between market-moving and non-market moving tweets; unitless

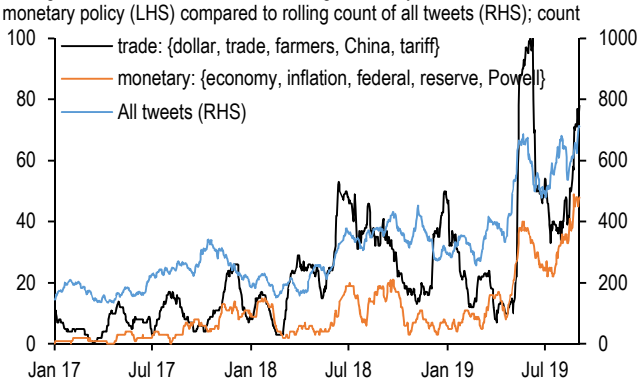


Notes: **Market moving tweets** defined as a 0.25bp+/5min move in 10-year Treasury yields immediately following the tweet's publication. **Ratio of frequency of occurrence:** we define frequency of occurrence based on how often a word or "token" appears in each sample of tweets versus the total number of words in the sample. This is done after excluding tokens of 4 characters or fewer, along with a list of standard "stop words" such as "because" and "shouldn't" etc. We then form a ratio of the logarithm of this frequency from market-moving tweets versus the logarithm from all tweets. Market moving tweets are limited to 1/1/18-present and necessarily occur during Treasury market hours (22/hrs per weekday), whereas "all tweets" are from 1/1/16-present and include weekends and off hours. We also exclude words that appear in the test corpus fewer than 10 times.

Source: J.P. Morgan, trumptwitterarchive.com, BrokerTec

Exhibit 6: Tweets containing such market-moving language have risen in frequency as of late, particularly Fed-related tweets

Rolling 1-month count of tweets containing select key words related to trade or monetary policy (LHS) compared to rolling count of all tweets (RHS); count



Source: J.P. Morgan, trumptwitterarchive.com, BrokerTec

We can be (a bit) quantitative in this assertion by appealing to some rudimentary tools from natural language processing (NLP). **To start, we can identify words associated with market-moving tweets by appealing to their relative frequency of occurrence.** The 14,000+ tweets since 1/1/16 represent a rich "corpus" of language data from which to form statistics about the president's Twitter vocabulary

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and grammar. Thus to aid in building our tweet-volatility index, we start by looking at the frequency of words in market-moving tweets divided by their frequency among the broader corpus of the president's tweets. Here we intentionally introduce a recency bias, limiting ourselves to market-moving tweets from 2018-present. For the "denominator" (broader corpus) we include all tweets from 2016-present, including weekends and the few hours of the day when the Treasury interdealer market is powered down (and thus yield data is unavailable). Our "words" (or more broadly, "tokens") included hashtags and mentions of other users, but we limited ourselves to tokens more than four characters in length and we eliminated a list of common "stop words"—verbal joinery like "because" and "shouldn't". **From this exercise, we find the top-ranked "market moving words" found within impactful tweets dwell on trade, and, to a lesser extent, monetary policy** (**Exhibit 5**): *china*, *billion* and *products* top the list. Not much further down are *dollars*, *tariffs and trade.* Admittedly further down the list are *inflation, economy and reserve.*. Toward the top are also words associated with the Mueller investigations, which our rudimentary NLP metrics have identified as indeed market-moving over the past 20 months.

This ranking was somewhat crude (for a more comprehensive and detailed review of NLP techniques applied in finance, see *Extracting sentiment from news*, R. Smith & B. Hlavaty, 10/9/17). **That said, it provides us with a dynamic and automated way to keep track of topics the market has deemed important within the president's far broader array of subjects. As a result their utility in scoring any given tweet is somewhat limited. We can, however, use them to construct statistical aggregates—a Twitter-vol index—with which to monitor and quantify shifts in the market environment**. To do this we specifically employ the top 75 words identified from market-moving tweets using yield-moving thresholds over 5 and 30 minutes (as in Exhibit 5). We also fold in a set trained on only the past 6 months of data, where words like "inflation" and "economy" bubble closer to the top of the list.

Briefly, **it's worth noting that the incidence of tweets related to these market-moving topics has been on the rise of late. Trade has been a dominant theme**, averaging out to a higher ratio of total tweets in recent months compared to earlier in our sample. **But the topic that has emerged more recently and grown rapidly is monetary policy (Exhibit 6).**

Our ultimate goal in this note is to provide a daily index we can use to measure the impact of the president's tweets on rates volatility. To do so, we recognize that our technique of flagging tweets via their subsequent moves in Treasury yields has provided us with a labelled dataset of market-impacting and non-impacting tweets. We can use this dataset to performed a supervised machine learning exercise—specifically we can train a classifier to infer how likely each tweet is to move markets. The details of this are left to the appendix at the end of this note, where we also show the model's performance metrics and judge their statistical significance. The punchline: **the model produces firmly statistically significant results** (roughly 99% significant, by most metrics), though its precision is somewhat modest—out of roughly 4000 non-retweets occurring during market hours from 2018-present, only 146 are market moving. **Our model can successfully identify roughly one-third of such tweets that it has never seen before**, which while much better than random chance, is hardly a tweet savant. And even if its precision is limited on a tweet-by-tweet basis, this level of significance suggests significant information content in constructing a lower frequency index to track the overall propensity of the president's recent tweets to drive volatility in rates markets.

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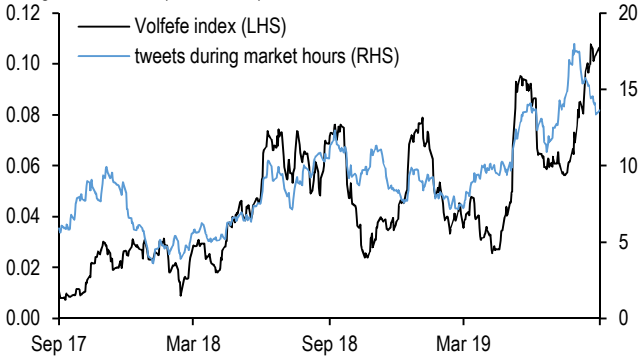
To do this, we use this tweet classifier to compute the market-moving odds of each of the president's tweets, and take a rolling 1-month sum of market-hour tweets to produce an index that measures the relative impact of the commander in chief's Twitter decrees on rates volatility (**Exhibit 7**). Encouragingly, **we find this metric's month-on-month moves is often quite divorced from the sheer volume of tweets,** suggesting our NL-driven classifier technique is providing useful, distinct information. Even more encouragingly, **we find the vol index strongly outperforms the sheer count of tweets in periods heading into substantially elevated implied volatility. Our model was not forced to learn this behavior, being trained on tightly associated, large intraday moves in yields, and not implied volatility itself.**

Exhibit 7: We can build a "Volfefe" index from our trained tweet classifier, to help identify the frequency of market-moving musings…
Our "Volfefe" index, built from rolling 1-month sum of inferred probability that each tweet are market-moving (LHS; unitless) compared to rolling 1-month tweet count during market hours (RHS; count)



Notes: We use the classifier reported on in Exhibit A1 (trained over 2018) to produce an inferred probability that each tweet is market-moving by 0.5bp+ in the next five minutes. We then map these market-moving odds to: max(0,P-0.5) (e.g. zero out tweets less than 50% likely to be market moving), a so-called "move score". Finally we take a rolling 21-day sum of this score across all tweets, to form the index.

Source: J.P. Morgan, trumptwitterarchive.com

Exhibit 8: …and we find this index can measurably enhance our fair-value models for short-dated rates volatility, playing a significant role in front-end rates in particular
3M-expiry swaption implied volatility fair value model, including our Volfefe index

	3Mx2Y		3Mx5Y		3Mx10Y	
Factor	Coeff	T-stat	Coeff	T-stat	Coeff	T-stat
Intercept	32.4	19.6	44.9	37.4	47.0	48.6
Volfefe Index	**149.7**	**10.2**	**68.4**	**6.4**	**22.2**	**2.6**
Price impact; 32nds per $100mn	57.1	15.5	51.2	19.1	50.0	23.1
Whites/Greens OIS slope; %	-10.5	-12.4	-0.3	-0.6	5.8	11.8
Policy uncertainty; index	-0.3	-1.2	-0.2	-1.1	-0.2	-1.8
Programmatic supply; $bn 10s/25bp	-0.1	-5.1	-0.1	-7.3	-0.2	-9.7
R-squared; %	75%		68%		67%	
Std. error; abp	5.9		4.2		3.3	
Current; abp	80		76		75	
Fair value; abp	80		77		71	

Notes: Gamma fair value model regresses 3Mx2Y, 3Mx5Y and 3Mx10Y ATMF implied vol individually against the Volfefe index, described in Exhibits 7 and 8, Treasury price impact (see *Drivers of Price Impact*, J. Younger et al., 1/13/17), whites/greens OIS slope, monetary policy uncertainty (see *Measuring Economic Policy Uncertainty*, Baker et al., 3/10/16), and programmatic supply absorbed by the dealer community. We model programmatic supply as daily sales of $500mn notional of 1Mx10Y ATMF straddles; to compute the expected impact of a bid for gamma by dealers in a range break, take a probability-weighted average of this gamma profile against the implied distribution of 10Y rates at a 3M horizon and then use the beta from our 3Mx10Y gamma fair value model to compute a support for intermediate tails worth roughly 1.5abp.

Source: J.P. Morgan, trumptwitterarchive.com, policyuncertainty.com, BrokerTec

Finally, we can move toward a rough estimate of how much these market-moving tweets have pushed up volatility pricing in the swaptions market. Exhibit 8 shows an update of our standard fair value model for short-expiry swaptions. Added to the typical list of drivers (market liquidity, Fed expectations, policy uncertainty from broad news sources, and dealer hedging flows from systematic short programs), **we've added our newly christened "Volfefe Index"**. From a regression trained on the past two years, **we find this index can explain a measurable fraction of moves in implieds, particularly in shorter tails (2-year rates, and 5-year rates, as opposed to 10-year rates).** This makes rough sense as much of the president's tweets have been focused on the Federal Reserve, and as trade tensions are broadly seen as, first and foremost, impactful on near-term economic performance and, likewise, the Fed's reaction to such developments. **If anything, this regression is a conservative measurement**, as somewhat covariate factors have been included here (in particular OIS curve slope which via Fed expectations could be cannibalizing some of the index's explanatory power; curiously, with or without Volfefe, the broader policy uncertainty index has little to no explanatory power in recent moves).

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Finally, in a very rough approximation, we can quantify the president's impact on vol pricing. Using the above regression coefficients, and noting the Volfefe index has moved from an average of roughly .05 earlier this year to a high of 0.1 at present, **we estimate (crudely) that the president's tweets are worth roughly 8abp of the recent rise in implieds in the upper-left, and worth roughly 4abp to 5-year tails.** This leaves the upper-left looking surprisingly fair by our model at the moment, with more room for vol to let out steam further out the curve.

Appendix: Model details

To construct our index, we first train a classifier to predict how likely any given tweet is to "move markets." This is a supervised learning exercise where tweets are deemed market-moving when they are immediately followed by a 0.5bp+ move in Treasury yields (higher or lower) within 5 minutes of being published. We obtain tweets form the Trump Twitter Archive, which has captured them roughly in real-time since mid-2017 (our cross-validation sample is 2018-present). This is important since tweets are sometimes deleted and/or revised later in the day.

Our feature set is a set of "one-hot" vectors (zeros and 1s) formed by a list of roughly sixty flag words identified via the logarithm of relative frequencies between market-moving tweets in 2018-present versus all the president's tweets from 2016-present. This intentionally introduces a recency bias. We take the top 30 words identified from 0.25bp+ and 0.5bp+ moves in 5 minutes and 1bp+ moves in 30 minutes, along with a list from just the past six months of tweets. Before forming ratios, we eliminate all words/tokens with 4 or fewer characters and a list of common "stop words". The one-hot vectors then merely specify if the word appears in a tweet or not (one or zero), and do not take into account how many occurrences or where the word sits in its broader grammatical context. A word is "present" regardless of whether or not it appears as a root of a larger word (e.g. "dollars" would count as "dollar", although "Chinese" would not count as "China" under our basic methodology).

With our feature set and data labels (market moving and non-market moving), we are in a place to train our classifier. We employed a handful of methods, including Naïve Bayes, random forests and gradient boosted machines, ultimately settling on random forest as a well-behaved ensemble method suited to our small dataset, capable of capturing interactions between words. We evaluated the models out of sample by withholding 10% of our 2018-present market-hour tweets, training on 90% and testing performance on the remaining, randomly selected bunch. We did this ten times per hyper-parameter choice, averaging performance metrics across the ten trials. These results are shown in **Exhibit A1**. While our model's overall hit rate was quite high (75% was common), this mostly reflected how rare market moving tweets were relative to the broader corpus. Instead, we focused on the rate of "true positives"—the percentage of out-of-sample market moving tweets correctly identified as such by the classifier. Here we captured roughly 1-in-3, with correctly tuning the hyper-parameters providing a modest improvement.

To judge whether or not this methodology was truly adding value, we also randomly scrambled our classifier's decisions and re-scored its performance. We repeated this 1000 times, and noted the various performance percentiles achievable by chance to varying probabilities. From this Monte Carlo exercise we found our out-of-sample performance handily exceeded the 95% threshold by all metrics, and the maximum randomized trial (roughly 99% threshold) by most metrics. This is not a precision machine, but it clearly seems to be adding value.

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Exhibit A1: Our simple model trained on the occurrence of market-moving words can identify market-moving tweets with substantially better accuracy than random chance (though its precision is nothing to brag about)

Out-of-sample performance of a random forest classifier trained on 2018 market-moving tweets vs non-market moving tweets, averaged across 10 trials, withholding 10% of data for testing (cross validation), compared to performance of a scrambled set of classifications run 1000 times (Monte Carlo thresholds) to judge statistical significance; also shown is performance in a global fit (in sample) across all 2018 tweets, which we use to construct the vol index

	Cross Validation	Monte Carlo Thresholds			Statistical Significance	Global fit (in sample)
		Median	95%	99%+		
True Positives	**35%**	27%	30%	32%	**99%+**	40%
Precision	**18**	17	18	20	**95%**	25
Recall	**35**	27	30	33	**99%+**	40
F-Score	**24**	21	23	25	**98%**	31
False Negatives	**65%**	73%	70%	67%	**99%+**	60%

Notes: **Market moving tweets:** Defined as those followed by a 0.5bp+ move in 10-year Treasury rates in the 5-minutes immediately following publication. **True positives:** Percentage of market-moving tweets that are correctly identified as market-moving (only including out-of-sample tweets in cross-validation, including all tweets (in sample) under a global fit). **False negatives:** Percentage of market-moving tweets missed by the classifier. **Precision:** Among tweets we flag as market moving, how often are we correct? **Recall:** Among all market moving tweets, how many did we catch? **F-measure:** harmonic mean of precision and recall, a single statistic you'd ideally like to maximize.

Source: J.P. Morgan

Finally, we used the entire sample to train a final classifier with the best-performing hyper-parameters from cross-validation. This classifier is for use in the final index, which we view as a descriptive tool for use in our vol fair value model rather than a predictive tool (e.g. for calling tweets in real time). With this final classifier in hand, we construct the Volfefe index by computing the probability that each tweet is market-moving, and mapping this to a "score" via max (0,P – 0.5). We then take a 1-month rolling sum of this score using all tweets occurring during market hours. This final result is what's plotted in Exhibit 7 and used in the fair value model in Exhibit 8.

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