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Global Quantitative & Derivatives Strategy
23 May 2018

Big Data and AI Strategies

Applications of Machine Learning in Equity Derivatives

- In this report, we illustrate the applications of machine learning techniques to equity derivatives trading strategies. Specifically, we focus on the topics below:
- **Fundamental drivers of option returns:** we explore the relationship between option returns and various factors using non-linear and robust statistical techniques.
- **VIX regime switching model:** we identify volatility regimes by using a Hidden Markov Model, and capture the regime-specific dynamics by introducing the asymmetric Vasicek model.
- **Relative value volatility model:** by applying hierarchical regression cross-sectionally to the US ETF universe, we construct a robust and effective framework for assessing the richness/cheapness of ETF implied volatility.

Global Quantitative and Derivatives Strategy

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See page 37 for analyst certification and important disclosures, including non-US analyst disclosures.

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Fundamental Drivers of Option Strategy Performance

Applying statistical learning techniques to option screening

- We explore and model the drivers of option strategy performance, beyond the well-known implied-realized volatility premium by utilizing fundamental equity factor data over the last ten years.
- Given the non-linear nature of the option payoff, we demonstrate the application of statistical learning techniques such as logistic regression, K-nearest neighbors, and bootstrap aggregation to the analysis of option strategies.
- Our model appears to successfully identify good option buying/selling candidates in out-of-sample testing. Combined with directional signals, our model is capable of **screening for attractive call buying, call selling, put buying, and put selling candidates.**

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Introduction

In this section, we aim to explore and model the drivers of option strategy performance, beyond the well-known implied-realized volatility premium, building on our previous research results on call overwriting strategies[1]. Furthermore, we generalize our findings to a wider range of option strategies (including option buying as well as selling). Along the way, we demonstrate the application of statistical learning techniques to the analysis of option strategies.

To begin, we consider one of the simplest option strategies, call overwriting, which consists of a long position in one share, overlaid with a short position in the stock's call option. We propose decomposing the P&L of an overwriting position into three components:

- **Equity risk premium (ERP):** At inception, the equity delta of the overall position is equal to one minus the delta of the call option.
- **Volatility risk premium (VRP):** the option implied volatility has a well-documented risk premium over realized volatility. The investor would expect to receive the difference between implied and subsequently realized volatility from selling the call option.
- **Mean reversion premium (MRP):** the equity exposure of the call overwriting position changes dynamically. Namely, the delta is lower as the stock price increases, and higher as the stock price decreases. If the stock price tends to mean revert during the life of the option, the call overwriting position would likely outperform a static long delta position. Note that, although in the context of a call overwriting position, the change in delta arises from the short call option, it can also be replicated by dynamically trading the underlying shares. Therefore, the mean reversion premium is separate from the volatility risk premium.

To illustrate how the various risk premia are manifested in the call overwriting strategy, we compare a call overwriting position to two related strategies:

1) **Long one unit of the SX5E index, and sell a 1M ATM call option at the market implied volatility:** this is our benchmark strategy, similar to the SX5EBW2 Index calculated by STOXX.
2) **Long one unit of the SX5E index, and sell a 1M ATM call option at the subsequent realized volatility:** assume the market has perfect foresight and the options implied volatility trade at exactly the subsequently realized volatility. In other words, we remove the volatility risk premium and are left with a strategy that earns only the ERP and MRP.
3) **Long position in half a unit of the SX5E index:** this represents the ERP from the residual delta position, since the 1M ATM call option has about 50% delta at inception.

From the above strategies, we can easily separate out the P&L contribution of the VRP (1-2), MRP (2-3), and the ERP (3).

The chart below shows the behavior of the three strategies through time. Taking the differences between the strategies to arrive at the risk premium returns, we find that

[1] Enhance call overwriting returns with fundamental factors, 27 Jan 2017

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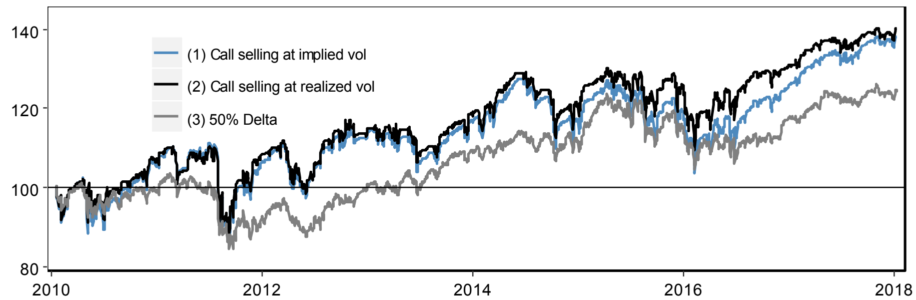
the ERP accounts for the majority of the P&L, at 2.5% per annum; VRP is roughly zero, since the implied and realized volatility averaged similar levels over the last 10 years[2]. In comparison, the MRP accounts for ~1.5%.

Figure 1: Decomposition of SX5E ATM call overwriting strategy



Source: J.P. Morgan Equity Derivatives Strategy

From the above analysis, we can conclude that the MRP is as important in contributing to the call overwriting P&L as the other two risk premia. Therefore, if we simply screen attractive call overwriting candidates by their projected implied/realized volatility spread and fundamental direction, we risk leaving a substantial portion of the performance unaccounted for.

The observations above are shown in our previous research to apply to the indices globally as well[3]. We can equally apply the analysis to single names (in this case the members of the SX5E). In Figure 2, we show the cross-sectional correlation of the three components, and find that MRP displays a negative correlation with the other two. Figure 3 shows the average returns by sector. Once again, we find a substantial portion of returns attributable to MRP.

[2] How much value can we theoretically add to the call overwriting strategy by improving our volatility forecast? Assuming through a combination of skill and luck, we manage to consistently sell implied vol at 1 vega above subsequently realized (which is the average volatility premium of the S&P over the last 10 years), it would translate into approximately 1.4% additional return per year. To arrive at the number, recall that the price of a one-month ATM option can be approximated by the following formula:

0.4 x sqrt(1/12) x Sigma = 0.1154 x Sigma

where Sigma is the volatility input. Therefore, every vega of volatility premium translates to approximately 0.1154% of P&L per month, or 1.4% annualized.

[3] European Equity Derivatives Outlook, 30 Sep 2014

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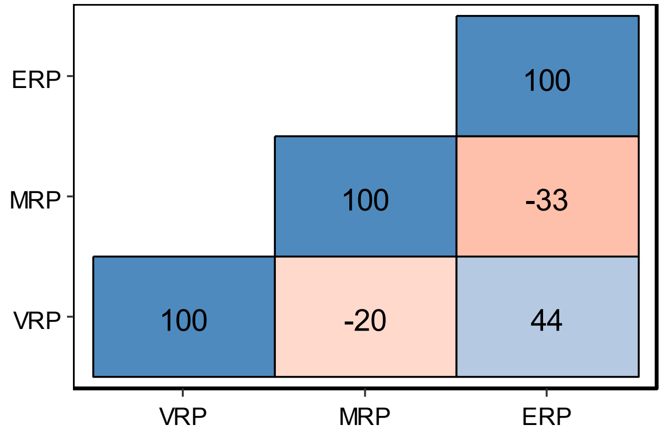
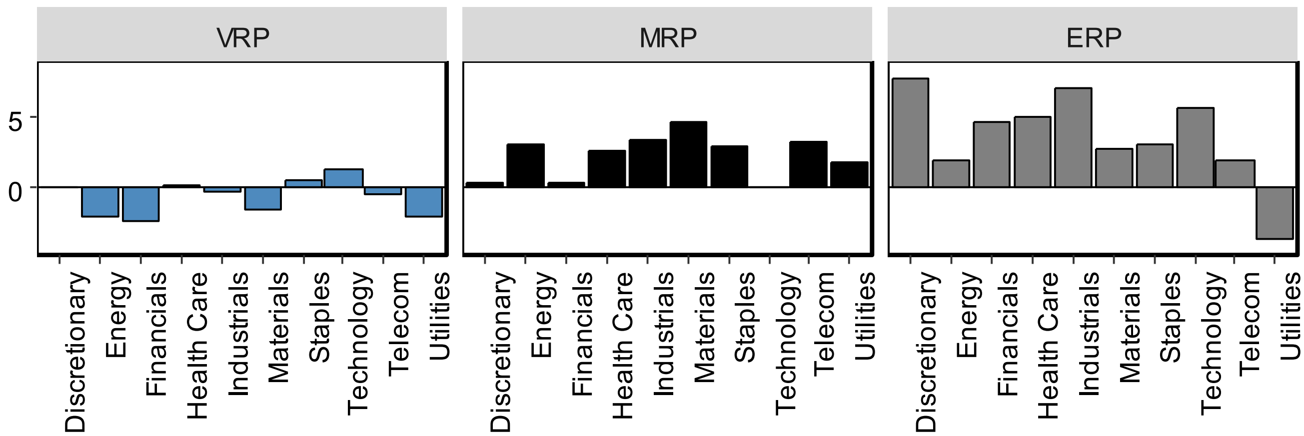
Figure 2: Correlation matrix of the three return components of a call overwriting position



J.P. Morgan Equity Derivatives Strategy

Figure 3: Average risk premium returns by sector

Annualized return (%)



Source: J.P. Morgan Equity Derivatives Strategy

While ERP is undoubtedly the biggest factor in the performance of a call overwriting strategy, it will not be the focus for the rest of our report. The reason is that this area is actively and extensively studied by the investor community. More importantly, with a strong conviction on the direction of equity returns, it would make more sense for an investor to go long the stock outright, as opposed to overwriting calls.

A more meaningful exercise for option investors is to focus on picking call overwriting candidates that are expected to deliver relative outperformance compared to long delta positions. This essentially amounts to modeling the VRP and MRP, since they produce the added value on top of the ERP.

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Model and estimation procedures

As discussed in the previous section, our definition of an attractive call overwriting candidate is one with an attractive combination of VRP and MRP. To be precise, we compute the P&L of overwriting 1M ATM call options on the SX5E members, and subtract the 50% of the underlying stock P&L from it. Since 50% is roughly the delta of an ATM option, this isolates the VRP and MRP of the call overwriting return:

$$
\begin{aligned}
Option\ Value\ Added &= Call\ OW\ return - 50\% \cdot Underlying\ equity\ return \\
&= VRP + MRP \\
&= f(Fundamental\ factors, volatility\ factors, sectors)
\end{aligned}
$$

As the last line of the equation suggests, we model the Option Value Added (OVA) as a function of a number of technical and fundamental factors, including:

Table 1: Explanatory variables in our model

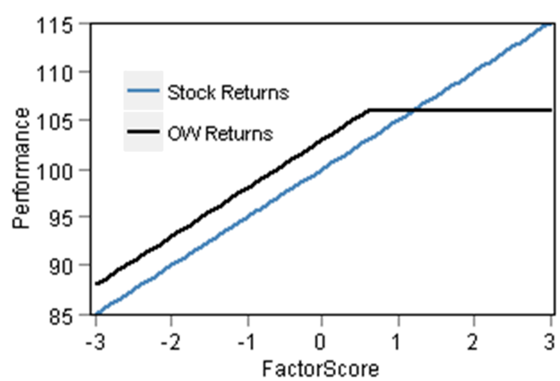
Fundamental Factors	Value, Quality, Growth, Momentum, and Historical Volatility
Volatility Factors	1M RV ranking[4] and 1M 95-105% implied skew
Sectors	10 GICS sectors

Source: J.P. Morgan Equity Derivatives Strategy

To make the measures comparable, we cross-sectionally normalize the variables into z-scores which have a mean of 0 and standard deviation of 1, and additionally, winsorize the resulting z-scores to a range of +3 to -3. The Sectors are indicator variables, with 1 indicating a stock belonging to that sector, and 0 otherwise.

Having identified the two sides of the equation, the next question is the choice of function $f(\cdot)$ that would relate them. A linear regression does not apply to the situation very well. The issue comes from the non-linearity in the payoff function of the option strategy. Imagine in an ideal situation, we have a factor which predicts perfectly the returns of the underlying stocks, as shown in Figure 4. This means that the factor will not have a linear relationship with the OVA (the difference between OW Returns and 0.5x Stock Returns in Figure 4). As a result, a linear regression would not perform well in modelling the OVA.

Figure 4: The non-linearity of call OW returns makes linear analysis inappropriate



Source: J.P. Morgan Equity Derivatives Strategy

[4] The New Relative Value Single Stock Volatility Model, 19 May 2016

Instead, we model the probability of OVA > 0 using two different statistical learning techniques: 1) **logistic regression (LR)**, and 2) **K-nearest neighbor (KNN)**. The two approaches are vastly different but both account for the aforementioned nonlinearity. More technical discussions of the two methods can be found in our previous report[5] as well as in the Appendices.

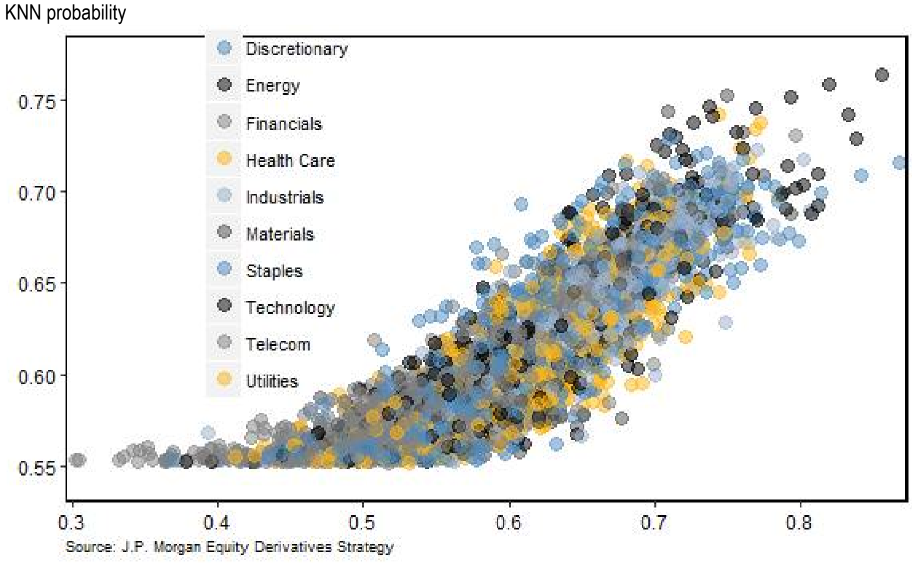
Data

We take the members in the SX5E over the last 10 years, and divide them into two groups. The data contains 5,844 monthly observations (some with missing data points) of 57 unique tickers. The training set contains 2,211 complete observations in the four-year period (between 1 year ago and 5 years ago), whereas the test set contains 3,238 complete observations outside of the training set. We conduct all the model calibration on the training set. The performance on the test set is presented in the Results section.

Results

Both logistic regression and KNN produces a probability associated with each test set observation. Taking a closer look at the probability predictions by the two methods, we find that they are highly but far from perfectly correlated (Figure 5), which indicates to us that they capture additional information. Moreover, sectors are evenly distributed, indicating that our analysis does not produce any strong sector bias.

Figure 5: Correlation between KNN and LR predictions is 73%

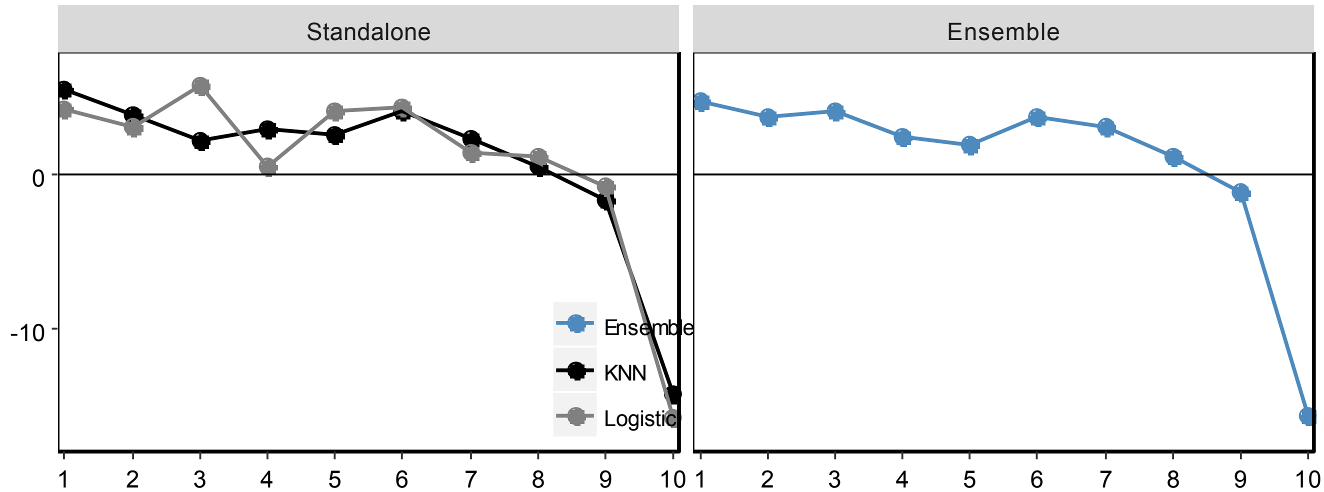


Source: J.P. Morgan Equity Derivatives Strategy

We sort these probability predictions into deciles on a monthly basis. Figure 6 shows the OVA by decile as predicted by logistic regression and KNN. Both methods show some predictive power since the performance generally declines with deciles. Neither method dominates the other, and by averaging the predictions from the two methods, we find a more monotonic relationship between our predicted and subsequent realized probability, as shown in the right panel of Figure 6. Therefore, in general, we prefer to employ the 'ensemble' method for making predictions.

[5] Big Data and AI Strategies: Machine Learning and Alternative Data Approach to Investing, M. Kolanovic and R. Krishnamachari, May 2017

Figure 6: Logistic regression, KNN, and ensemble rankings show good predictive power in out-of-sample testing
Annualized OVA (%)



Source: J.P. Morgan Equity Derivatives Strategy

Ranking Decile (1 = attractive to sell, 10 = unattractive)

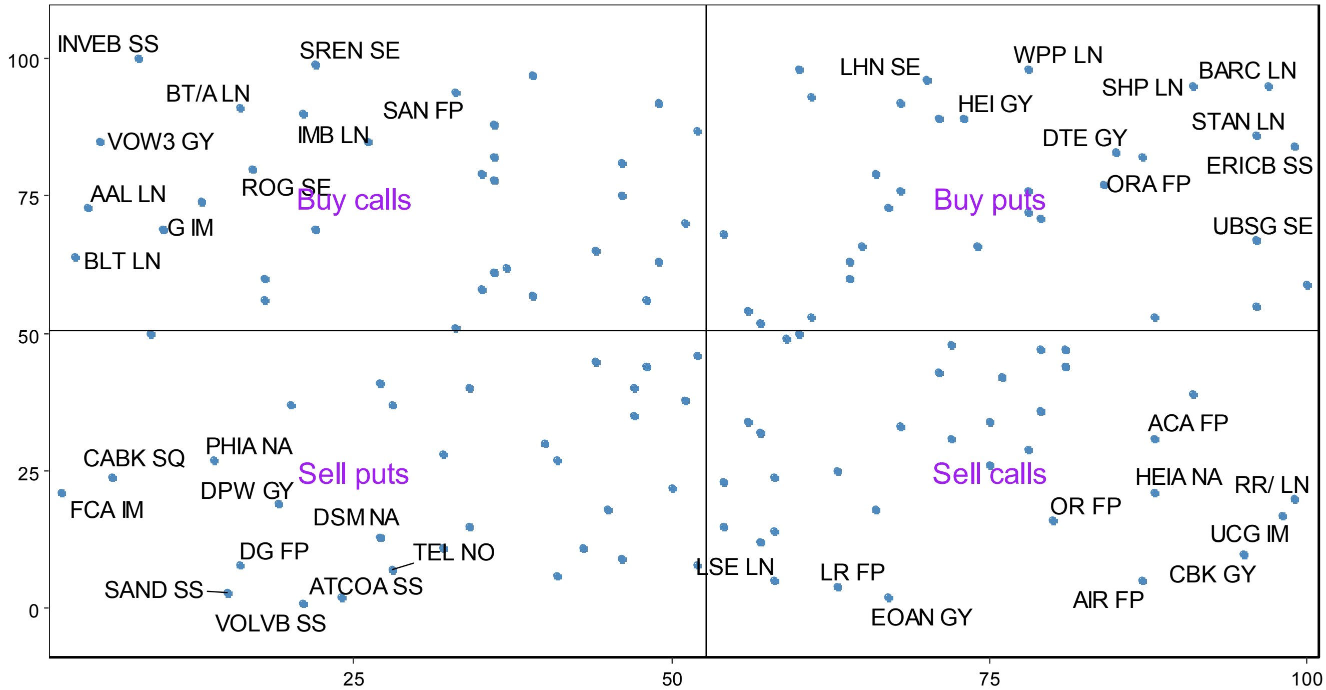
Generalization to other option strategies

Although the previous analysis is done on buy write strategies, we note that the results of our analysis are independent of the stock price directionality, since the delta component is excluded from the modelling. Investors can overlay fundamental views to decide on specific option strategies. For instance, in Figure 7 we combine the Quantitative Equity Strategy Q-Score[6] with our model ranking. Names in the four quadrants respectively correspond to attractive put/call buying/sell candidates.

[6] Introducing a Quantitative Multi-Factor Model for European Stock Selection, K. Chaudhry, A. Hanif, and V. Shaikh, 20 Jan 2016

Figure 7: Option strategy screen produced by combining our OVA model and Quant Strategy Q-score

OVA ranking (1 = attractive to sell, 100 = unattractive)



Source: J.P. Morgan Equity Derivatives Strategy

Q-Score Ranking (1 = attractive to own, 100 = unattractive)

Appendix 1: Factor Definitions

Table 2: Definition of factors used in our model

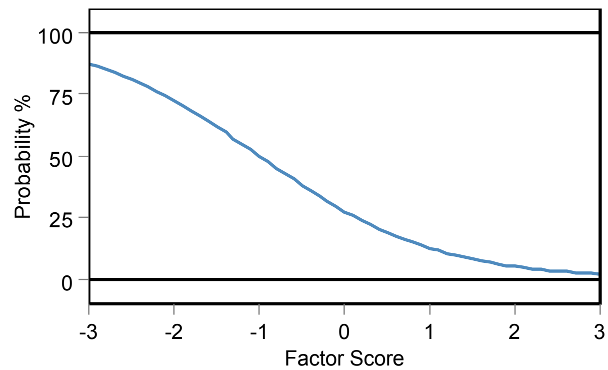
Type	Factor	Definition
Growth	Earnings Momentum 3M	This factor ranks stocks by their 3 month Forward Earnings Momentum. For each stock, we calculate the change in FY1 earnings over the last 3 months and the change in FY2 earnings over the last 3 months. We calculate the 3 month revision number by taking the average of the change in FY1 and FY2.
Growth	Net revisions to Mean FY2 EPS	Stocks are ranked by their earnings revisions over the prior 4 weeks. The Net revisions ratio is calculated as the number of consensus EPS upgrades less number of consensus EPS downgrades divided by total changes. The next forecast year (FY1) and following forecast year (FY2) ratios are calculated independently and averaged. The long portfolio contains the stocks that have the highest Net revisions ratio (i.e. the upgraded stocks) and the short portfolio contains the stocks with the lowest revisions ratio (i.e. the downgraded stocks). Net revisions are often regarded as a blunter version of Earnings Momentum.
Growth	1M Change in Consensus Recs	Recommendation over the last month. Those with the biggest improvement are in the long portfolio (regardless of whether they have moved from Strong Sell to Sell or Buy to Strong Buy, etc) and those with the biggest decline are allocated are in the short portfolio.
Momentum	12M Price Momentum	The 12 Mth Price Momentum factor is calculated by ranking stocks by their total return over the previous 12 months.
Momentum	1M Price Momentum	The 1 Mth Price Momentum factor is calculated by ranking stocks by their total return over the previous month. It is often employed 'in reverse' on account of the reversion that is observable in many markets and sectors. (Last month's winners become this month's losers and vice versa.)
Quality	Earnings Certainty	EPS is adjusted for the risk associated. Coefficient of variation is used as a proxy for earnings risk.
Quality	Historical ROE	A popular Quality proxy; stocks are ranked by their 12 month trailing Return On Equity. The long portfolio contains the stocks with the highest ROEs and the short portfolio contains stocks with lowest (or negative) ROEs.
Value	1Y Earnings Yield	Popular proxy for the Value style. Stocks are ranked by their 12-month forward Earnings Yield. The long portfolio contains the cheapest stocks and the short portfolio contains the most expensive stocks (as well as loss makers).
Value	EPS Growth	Companies are ranked by their average annualised EPS Growth over this year and the next year. The long portfolio contains the companies with the highest average growth and short portfolio contains those with the lowest average growth.
Value	1Y Earnings Yield vs. Country Sector	Earnings Yield adjusted according to the sector
Volatility	3M realised	3M historical volatility of price returns

Source: J.P. Morgan Quantitative and Derivatives Strategy

Appendix 2: Logistic regression

The logistic regression models the probability as a function of the explanatory variables. In our case, we model the performance of OVA for a given stock in any given month as a binary variable (1 for outperformance, 0 otherwise). For the factor shown in Figure 4, Figure 8 shows the relationship between the factor score and the probability.

Figure 8: Logistic regression avoids the non-linearity of OVA by modelling Prob(OVA>0)



Source: J.P. Morgan Equity Derivatives Strategy

Logistic regression takes the following functional form:

$$y = \alpha + \beta_1 \times \ factor_1 + \beta_2 \times factor_2 + \cdots$$

$$Prob(OVA > 0) = \frac{e^y}{1 + e^y}$$

To ensure the robustness of the analysis, we employ bootstrap aggregation (bagging). Specifically, we randomly sample (with replacement) 25% of the training set, and construct logistic regression models. The models obtained from these subsets are then used to make predictions on our test set. By repeating this procedure 10,000 times, we obtain 10,000 sets of predictions on our test set, which we average to create an 'ensemble' prediction that is more robust.

The values of β averaged across sectors and across 10,000 bootstrapped fittings are shown in Figure 9.

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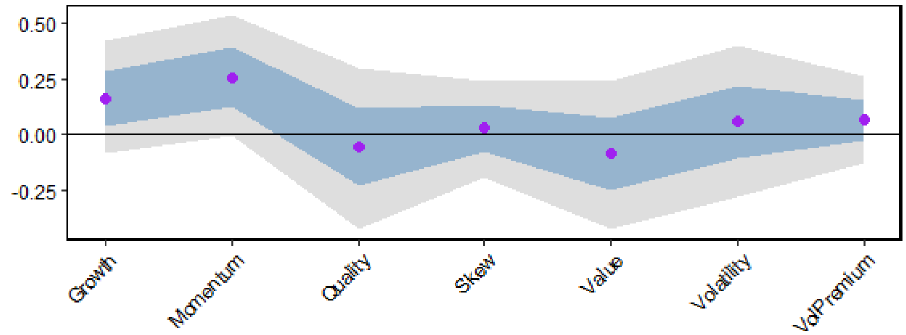
Figure 9: Average regression coefficient across sectors (blue band = 67%, grey band = 95% of all observations)



Source: J.P. Morgan Equity Derivatives Strategy

How do these coefficients translate into economic terms? A rule of thumb of the logistic regression is that the change in probability per unit change in an explanatory variable is a quarter of the coefficient magnitude[7]. As Table 3 shows, the most significant variable seems to be Momentum, where every unit increase in Z-score raises the probability of OVA > 0 by 6.4%. **High growth, historical volatility, implied volatility premium, and low quality and value also contribute to the attractiveness of option selling.**

Table 3: How beta of each factor approximately translates into probability for (per unit change in Z-score)

Name	Beta	Approximate Change in Probability
Growth	0.16	4.0%
Momentum	0.26	6.4%
Quality	-0.06	-1.5%
Skew	0.03	0.8%
Value	-0.09	-2.3%
Volatility	0.06	1.5%
Vol Premium	0.06	1.6%

Source: J.P. Morgan Equity Derivatives Strategy

The final outcome of our model is a probability per stock per month, which indicates how likely the OVA is positive. The higher the probability, the more attractive the stock is for option selling.

[7] Data Analysis Using Regression and Multilevel/Hierarchical Models, A. Gelmand and J. Hill, 2006

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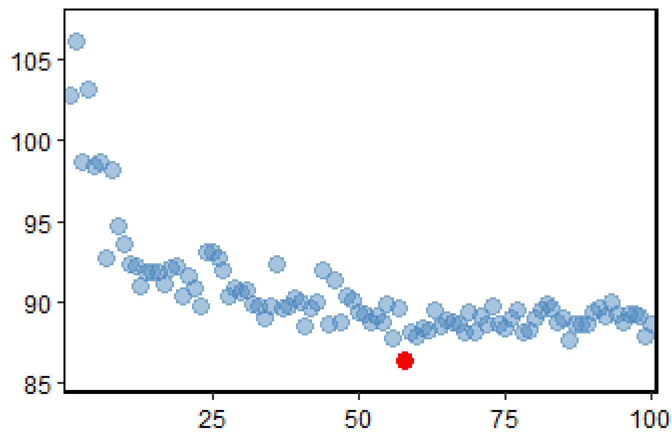
Appendix 3: K-nearest neighbor (KNN)

Unlike logistic regression, KNN makes no assumption on the relationship between the outcomes and the explanatory variables. Instead it identifies a number (K) of observations that most closely resemble a particular data point based on the 7 factors (plus sector) given, and predict the outcome of that data point by a majority vote.

$$Prob(OVA > 0) = \frac{1}{k} \sum_{x_i \in N_k} Prob(OVA > 0)$$

Figure 10: We find optimal K to be 58

Test error



Source: J.P. Morgan Equity Derivatives Strategy

Choice of K

Carrying out KNN is a two-step process since there is no predefined value for K. We find the optimal K via 10-fold cross validation within the training set for values of K ranging between 1 and 100. The K that produces the least classification error turns out to be 58 (Figure 10). In other words, for every data point in the test set, we would examine 58 of its 'nearest neighbors' (excluding its own tickers) in the training set. The proportion of the 58 observations that have OVA > 0 becomes our probability prediction. We then carry out the same bagging procedure (10,000 times), and use the results to predict out of sample observations.

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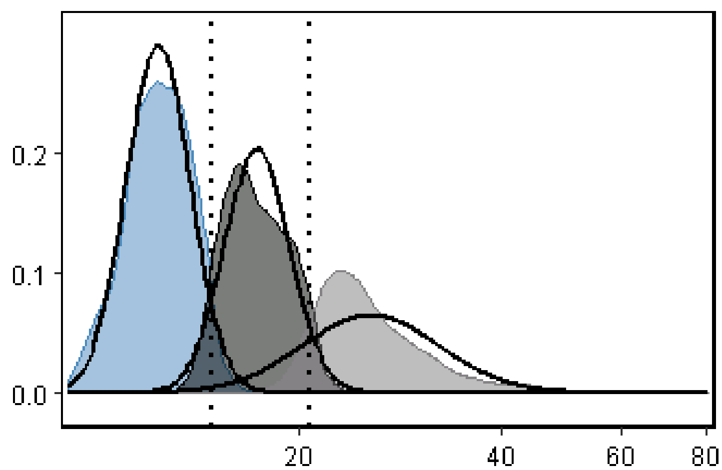
Modeling Regime Switches and Mean Reversion in VIX

- Terms such as high and low volatility regimes are frequently used by investors to describe the market environment.
- Although the two state classification is intuitively appealing, we believe a three regime approach is more appropriate.
- In this report we try to identify the three VIX regimes and understand the behavior of VIX under different regimes.
- Lastly we look at what are the implications for volatility trading strategies.

Figure 11: The log(VIX) distribution can be decomposed into a mixture of three normals
Distribution density



Source: J.P. Morgan Equity Derivatives Strategy

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Introduction

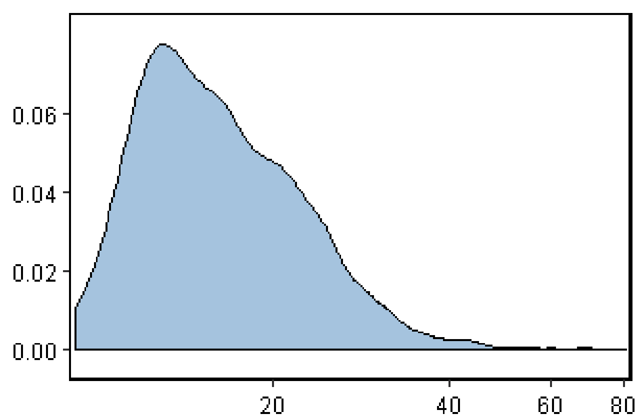
Terms such as high and low volatility regimes are frequently used by investors to describe the market environment. Although the two state classification is intuitively appealing, we believe a three regime approach is more appropriate. In this report we try to identify the three VIX regimes and understand the behavior of VIX under different regimes. Lastly we look at what are the implications for volatility trading strategies.

Identifying the Regimes

We start by looking for a distribution that best describes the VIX. We know that VIX is not normally distributed, since it cannot take on values below zero. Transforming VIX values by natural log (Figure 12), the distribution still looks very far from normal. In our view, what we see here is the mixture of a number of distributions. From past experience, we believe VIX can be classified into three regimes (high, medium, and low)[8]. Therefore, we will decompose the distribution into three separate distributions, each with its own mean and variance.

Figure 12: Distribution of natural log of VIX over between Jan 1990 and Feb 2018

Distribution density

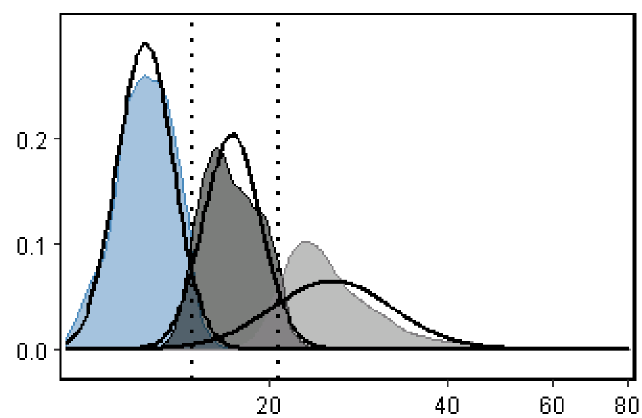


Source: J.P. Morgan Equity Derivatives Strategy

VIX (natural log scale)

Figure 13: Decomposing the log(VIX) distribution into a mixture of three normals

Distribution density



Source: J.P. Morgan Equity Derivatives Strategy

VIX (natural log scale)

To do so, we employ a three state Hidden Markov Model (HMM)[9]. It is important to note what the HMM does and does not tell us. Our model utilizes only the VIX time series data and is therefore purely technical. Moreover, we assume the drivers of regime change are based on exogenous fundamental data. Therefore, the model tells us what regime we are likely to be in, but does not predict whether a regime change will happen. For instance, in our model, the amount of time VIX has spent in one regime does not predict the next day's regime change probability.

The results can be seen in Figure 13. The distribution has been decomposed into three, which now resemble normal distribution much more closely. Naturally, the model is simple and unable to perfectly fit the distribution. The fit on the high

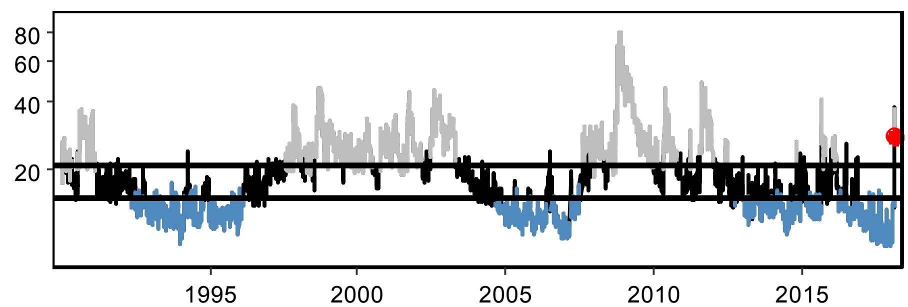
[8] For instance, we found the three regime approach to be effective when applied to VSTOXX: European Equity Derivatives Outlook, 10 Oct 2017
[9] For detailed implementation see Time Series Analysis (1994) by James D. Hamilton, Princeton University Press

volatility state seems poorer than the other two states. However the model is a good starting point for us, and will be refined in the later section.

From the analysis, what do we learn about each regime? The average values of the regimes are 12.5/17.6/27.0, respectively. Historically, VIX spends roughly one third of the time in each regime. The average time for regime transition varies greatly, however. VIX could spend as little as a few days or as much as a year in a particular regime. As Figure 13 shows, the vol of vol is the highest in the high regime, and lower in the low and mid regimes.

Figure 13 shows that the three regimes have substantial degrees of overlap. We estimate the boundary values to be approximately 15 and 21. We can also observe that 15 and 21 appear to serve as a good technical support/resistance level in the context of the long term VIX time series (Figure 14).

Figure 14: VIX values of 15 and 21 appears to be the boundaries for the volatility regimes
VIX index (natural log scale)



Source: J.P. Morgan Equity Derivatives Strategy

Modeling mean reversion behavior within each regime

We can gain further understanding of the behavior of the VIX by fitting a model with richer dynamics, based on two observations about the VIX behavior: it tends to be mean reverting and the rate of mean reversion depends on whether the VIX is above or below its regime mean.

We fit three asymmetric Vasicek models, one for each regime (for more details of the model please see the Appendix), and find the following (Table 4): In all three regimes, it takes longer for VIX to revert to the mean from below than from above. In the low and mid regime, the rate of mean reversion is much faster than in the high regime. The slow rate of mean reversion in the high regime we estimated may not be as reliable, since the actual mean reversion behavior may be oftentimes overwhelmed by the high vol of vol accompanying the regime.

Table 4: VIX mean reversion behavior based on our model estimates

	Regime	Low	Mid	High
	Long Term Average VIX	12.5	17.6	27.0
Mean reversion time (business days)	if VIX > Average	7	7	24
	if VIX < Average	17	11	27

Source: J.P. Morgan Equity Derivatives Strategy

Finally, our model also allows us to have a better understanding of the VIX tail behavior. We find that a student t-distribution with a degree of freedom of 4.2 much

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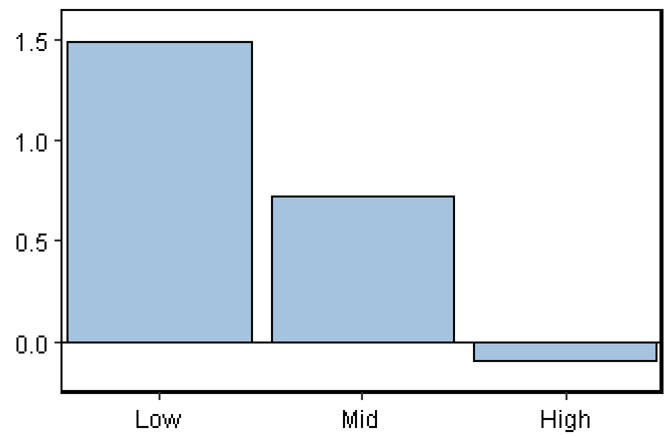
better at capturing the tail moves. For instance, the move of the VIX from 17 to 37 on Feb 5, 2018 is a 10 standard deviation move (standard deviation based on VVIX previous close). Assuming a normal distribution, the probability of such a move is 1.2 x 10^{-23}., or once in every 3×10^{20} years. Under our distribution assumption, such a move is observed once every 17.5 years. Although this estimate may still be too conservative, it is a much more realistic estimate than the normal distribution.

Implications for volatility strategies

The identification of volatility regimes also has important implications for the performance of volatility strategies. As Figure 15 demonstrates, Short VIX strategies tend to perform well in low and mid volatility regimes, and poorly in high vol regimes. Therefore, we would deem low and mid volatility regimes to be normalized environments for monetizing volatility premium.

Figure 15: Sharpe ratio of short 1M volatility futures strategy



Source: J.P. Morgan Equity Derivatives Strategy

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Appendix: Asymmetric Vasicek Model

We specify an asymmetric Vasicek model as follows:

$$dv_t = \alpha \cdot (\mu - v_t) + \beta \cdot (\mu - v_t)^{-} + \sigma dW_t$$

In the equation above, v_t is the log(VIX) value at time t.$dv_t$is the daily % change in the VIX at time t. α, β are parameters which indicate the rate of mean reversion, and σ is the vol of vol parameter. $(\cdot)^{-}$ indicates that the term takes on value 0 if the value inside the bracket is greater than 0. Lastly, we assume dW_t to be a process with a student-t distribution, of which the degree of freedom will be estimated from the data.

Note that the Vasicek model is made 'asymmetric' by the β parameter. This is due to our observation that the mean reversion tendency is different depending on whether the VIX is above or below its long term mean. This set up allows β to capture the additional rate of mean reversion when VIX is above its long term average.

Finally, the significance of using the student t distribution is to capture the tail behavior of the (log of) VIX. If dv_t is close to being normally distributed, we would expect a high value. A small degree of freedom indicates fat tails.

The estimates over the sample of VIX values between Jan 1990 and Feb 2018 are shown below. We provide more interpretation of the parameters in the main text.

Table 5: Parameter estimates

Regimes	Low	Mid	High
alpha	0.058	0.091	0.036
beta	0.078	0.047	0.006
sigma	0.039	0.047	0.051
t-distribution Degree of freedom	4.2		

Source: J.P. Morgan Equity Derivatives Strategy

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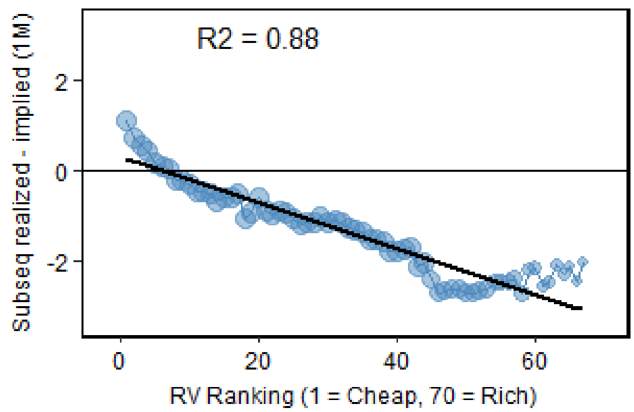
US ETF Relative Value Volatility Model

- The Relative Value Volatility model (RV model) is a quantitative framework for determining the rich/cheapness of option implied volatility.
- Our model uses a combination of realized volatility and stock returns to produce a rich/cheap volatility ranking – the Relative Value (RV) ranking
- In this report **we review our model methodology, demonstrate its effectiveness in trading the volatility of US listed ETFs, and introduce our US ETF RV screen**, available on J.P. Morgan Markets.

Figure 16: RV ranking is strongly correlated with subsequent implied - realized volatility spread
Subsequent realized – implied volatility (1M tenor)



Source: J.P. Morgan Equity Derivatives Strategy

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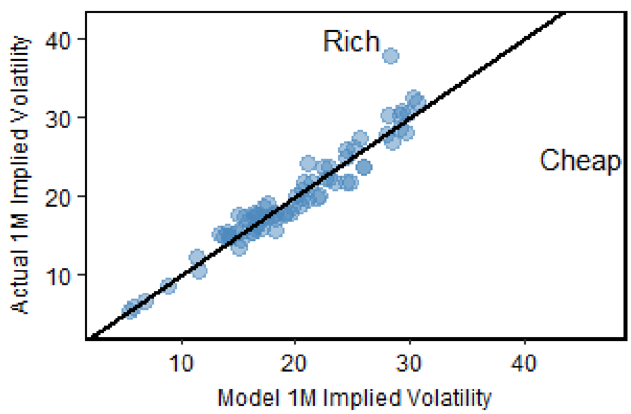
Introduction

The Relative Value Volatility model (RV model) is a quantitative framework for determining the rich/cheapness of option implied volatility. The model aims to find relative value between underliers rather than predicting the future volatility of an underlier in isolation. We first introduced the original RV model in October 2007[10], and subsequently updated the model in April 2012[11] and May 2016[12] for European single stocks.

In this report, we modify the model to adapt to the US market and apply to US listed ETFs. To summarize, we aim to find the fair relationship between the implied volatility of ETFs at a given point in time. The output is seen in Figure 17, where we can compare our model implied volatility with market implied volatility, and identify the names as having rich or cheap implied vol.

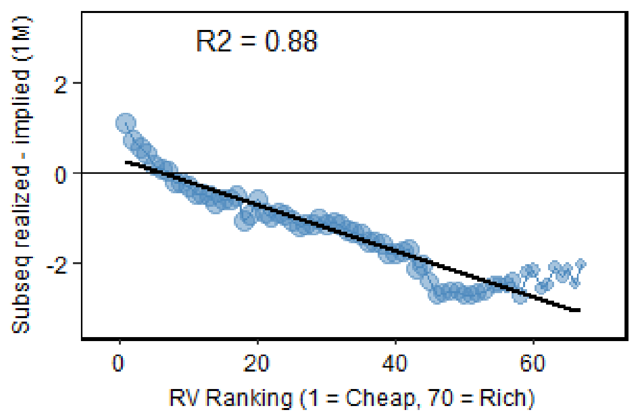
We tested the effectiveness of the new model over the last ten years on 80 US ETFs[13]. As Figure 18 below demonstrates, the RV ranking is successful in identifying rich and cheap volatility stocks.

Figure 17: Implied volatility is compared against RV model volatility on a given date



Source: J.P. Morgan Equity Derivatives Strategy

Figure 18: RV ranking is strongly correlated with subsequent implied realized volatility spread



Source: J.P. Morgan Equity Derivatives Strategy

The rest of the report is divided into three sections: we first review in detail the methodology of our model, then illustrate its uses and the back test results. Finally, we introduce the ETF RV screen, which is updated regularly on J.P. Morgan Markets.

[10] See the original RV model report, Oct-2007
[11] See Enhanced RV model report, Apr-2012
[12] See New RV model report, May-2016
[13] Please see the Appendix for a complete list of ETFs used in our analysis

Methodology

The main idea behind our RV model is to compare the current implied volatility with model volatility across names at one point in time. In order to estimate the model volatility, we propose the following regression:

$$iv = \alpha_j + \beta_{1j} ewma + \beta_{2j} r^- + \epsilon \qquad [1]$$

$$\begin{bmatrix} \alpha \\ \beta_1 \\ \beta_2 \end{bmatrix} \sim N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$$

Where iv is the (natural) log of the ATMF implied volatility squared, $ewma$ is the log of the exponentially weighted moving average volatility squared, and r^- is the last 3M stock return if negative, and 0 otherwise. The regression coefficients are subscripted by $j = 1 \ldots 4$ denoting the four groups of ETFs: Broad Market, Country, FICC, and Sector. Here we allow the regression coefficients to vary across groups by employing a **hierarchical regression**. To do so, we model the coefficients as random variables with a multivariate normal distribution and a non-spherical covariance matrix, i.e. $N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$. The main advantage of using the hierarchical regression, instead of OLS regression, is that it allows group specific dynamics to be modeled simultaneously. The resulting regression coefficients are optimally blended averages between no pooling (four separate group level OLS regressions) and complete pooling (one OLS regression across all groups)[14].

We discuss the choice of our model specification below:

Why cross sectional and not time series analysis?
Although it may sound counterintuitive, the answer is that cross-sectional models are generally better at capturing long term relationships than time series models. For instance, from a cross-sectional sample on a given day, the implied volatility can range between 20 and 100 (e.g. in 2008), thereby giving us opportunities to observe the relationship between implied and realized volatility over a broad range of risk profiles. On the other hand, time series analysis on an individual underlyer may only reveal such information with a very long observation window.

Exponentially weighted moving average volatility (EWMA)
Realized volatility is typically defined as the standard deviation of returns over an observation period. The standard deviation gives equal importance to the returns on every day of the time period. In equity volatility, however, we observe a very high degree of persistence. In other words, days of high volatility tend to be followed by more days of high volatility, and days of low volatility tend to be followed by more days of low volatility. Therefore, recent observations should be given more weight.

On the other hand, we also observe that the implied volatility market has a long memory. When a stock experiences a sharp move on one day, its implied volatility will usually stay elevated for a long period of time relative to its realized vol, even after the sharp move has dropped out of the observation period.

Based on the two observations above, we can improve the measurement of realized volatility by using a measure that gives more importance to the very recent returns,

[14] See A Guide to Econometrics, P. Kenney, 2003 MIT Press and Data Analysis Using Regression and Multilevel/Hierarchical Models, A. Gelman and J. Hill, 2007, Cambridge University Press

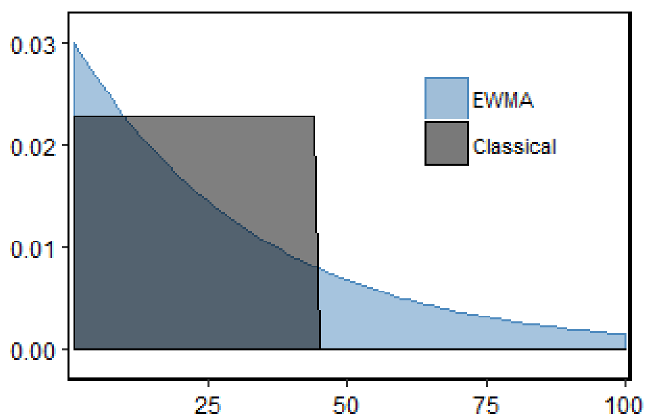
without chopping off its observation window after a set period of time. The Exponentially Weighted Moving Average (EWMA) volatility serves this dual purpose. There are two equivalent definitions of the EWMA volatility:

$$EWMA_t^2 = \lambda \cdot EWMA_{t-1}^2 + (1-\lambda)r_t^2 \quad [2]$$

$$EWMA_t^2 = (1-\lambda)r_t^2 + \lambda(1-\lambda)r_{t-1}^2 + \lambda^2(1-\lambda)r_{t-2}^2 + \cdots \quad [3]$$

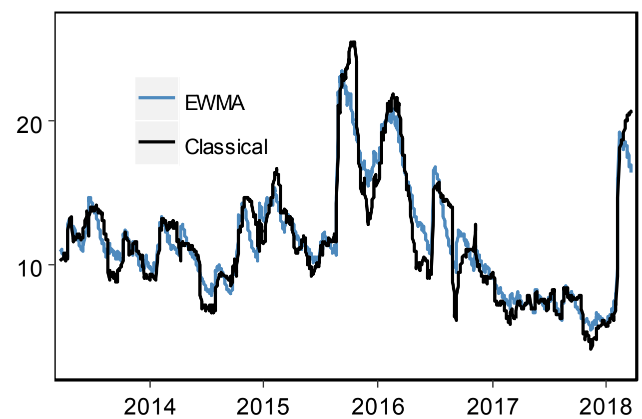
In [2], we can see that the EWMA variance (volatility squared) on day t is the weighted average of the previous day EWMA variance and the squared return on day t (r_t^2). We can choose the parameter λ between 0 and 1 to assign the weight to the most recent return. In [3] the weights given to the observations are explicitly shown. The weights decay every day by a factor of λ, but never go to 0, thereby preserving more distant observations. In the RV model we choose λ to be 0.97, which we find to correspond approximately to the classically defined two-month realized volatility.

Figure 19: The EWMA weighting scheme gives more importance to recent observations and retains more distant data points
Weights of returns used in computation



Source: J.P. Morgan Equity Derivatives Strategy

Figure 20: The large moves in EWMA volatility fall out of the sample more gradually than traditional realized volatility for SPY US Equity
Volatility (%)



Source: J.P. Morgan Equity Derivatives Strategy

In Figure 19 and Figure 20, we demonstrate the features of the EWMA volatility compared to the traditional definition of realized volatility. For the rest of the report, we use the EWMA definition to compute realized volatility.

Winsorization:

A drawback of the EWMA volatility measure is that excessively large moves are given a very high weight in the days immediately following the move. Therefore, we apply winsorization, which shrinks the excessively large (as well as small) moves towards the median. As Figure 21 demonstrates, we cap the observed values to no more than the 97.5 percentile, and no lower than 2.5 percentile. This produces a more reasonable realized volatility seen in Figure 22 for SPY US Equity.

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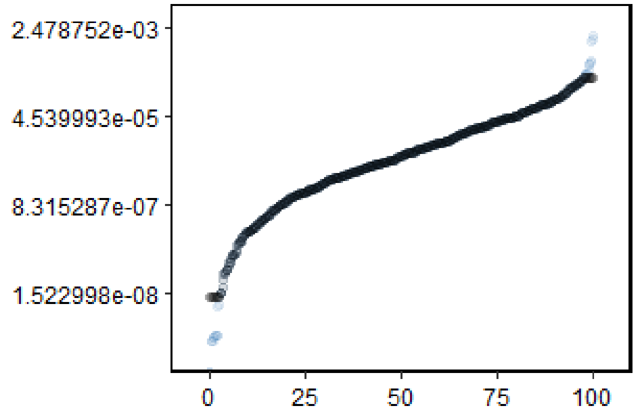
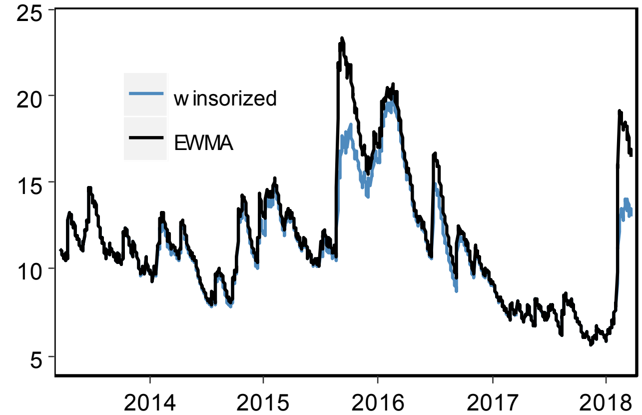
Figure 21: Daily variance observations before/after winsorization
Daily variance (log scale)



Source: J.P. Morgan Equity Derivatives Strategy

Figure 22: Winsorization allows a more reasonable estimate of realized volatility after large moves
Volatility (%)



Source: J.P. Morgan Equity Derivatives Strategy

Accounting for the leveraged effects

We generally observe that a decrease in equity price tends to increase the subsequent realized volatility by more than a price increase of the same magnitude. This is known as the 'leverage' effect. We aim to capture this by including the past 3M negative return term to the regression. That is, the r^{-} term denotes the past 3M total return of the ETF if it is negative. If the return is positive, the value is 0.

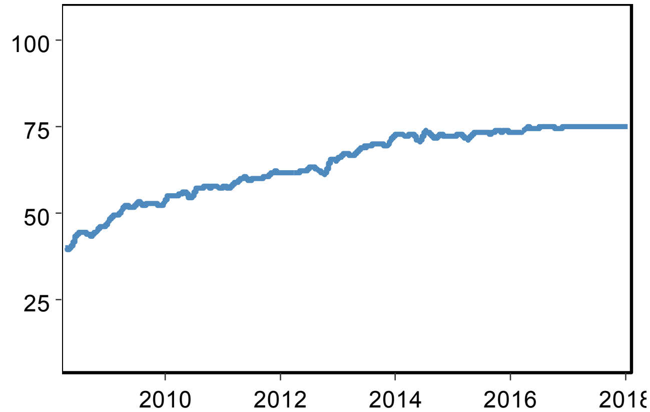
Back Tests

In this section, we demonstrate that the RV score does a good job of distinguishing between rich and cheap volatility, over the period of the last 10 years (Feb 2008 – Feb 2018).

Data

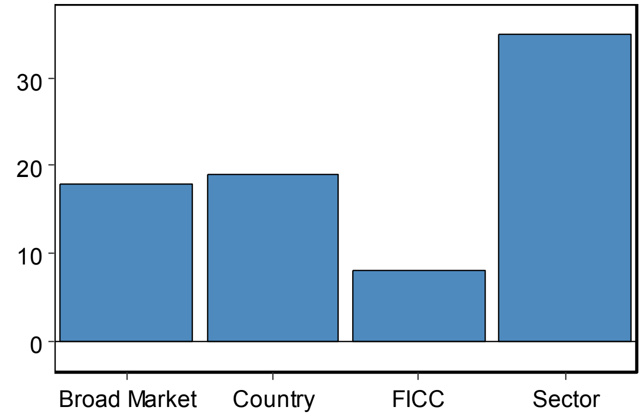
We take the historical data as described in the previous section of US ETFs over the said period (last 10 years). Figure 23 shows the number of US ETFs available. Not all members have all available data at all times, but the data availability generally improves over time. Figure 24 shows the distribution of US ETFs in our sample.

Figure 23: Number of US ETFs available during our back test period
# of members with available data



Source: J.P. Morgan Equity Derivatives Strategy

Figure 24: Distribution of the US ETFs
# of members



Source: J.P. Morgan Equity Derivatives Strategy

Methodology

- Every day we rank the US ETFs according to the RV score and initiate short volatility positions on the 5 richest stocks, and long volatility positions on the 5 cheapest stocks.
- The positions are held until the 1-month expiry. In total we have 2,473 trade days in the back test period.
- The profit and loss of each position is computed only at expiry, as the average difference between ATMF volatility and subsequent realized vol. We assume a bid-ask spread of 1.0 vol points on each name. Although the results are not directly tradeable we compute the risk and return statistics to give an idea of the performance of a pure volatility strategy based on our RV model.
- By the convention of volatility swaps, we cap maximum gains/losses at 2.5 times the implied vol entry levels.

Performance

The results of the back test are shown below. In Figure 25, we show the average long volatility P&L of our strategy, sorted by the ranking deciles. The P&L uniformly decreases as the ranking increases (going from cheap to rich). Figure 26 shows the time series of the long/short P&L of our strategy. As the figure shows, the average held to maturity P&L is 3.8 vega in our long/short strategy. In Table 6, we show more detailed statistics of the performance, and find that on average, our long vol names outperforms the blanket long vol strategy, and our short vol names outperforms the blanket short vol strategy. Overall, the long/short strategy produces an information ratio of 2.2 annualized over the back test period.

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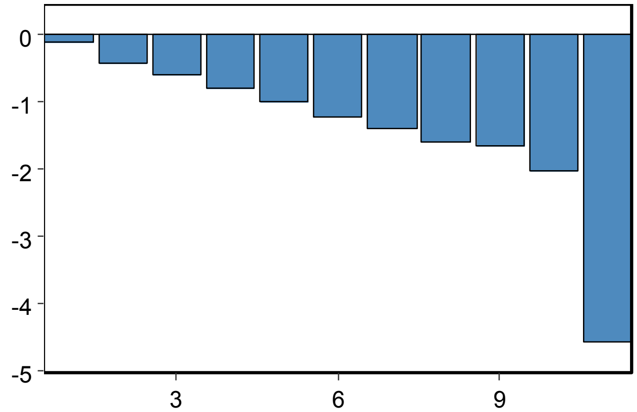
Figure 25: Average P&L of long volatility strategy by decile rank

P&L (vegas)

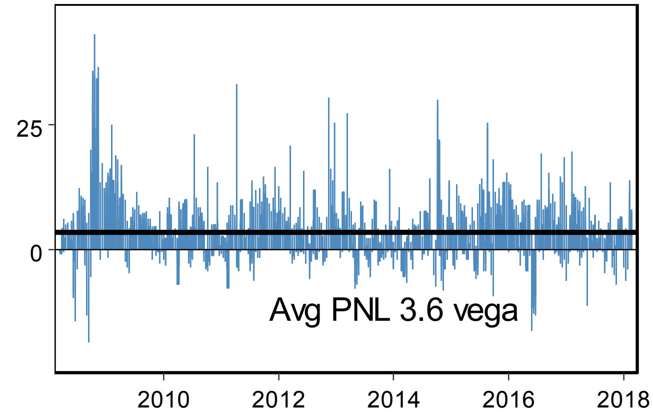


Source: J.P. Morgan Equity Derivatives Strategy

Volatility ranking decile (1 = cheap, 10 = rich)

Figure 26: History of the long/short volatility strategy P&L

P&L (vega)



Source: J.P. Morgan Equity Derivatives Strategy

Table 6: RV model performance on 1-month implied volatility (P&L in vega, back test period: 10 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	0.1	-1.8	3.6	0.8	3.7
Median	-1.3	-3.0	4.4	2.0	3.2
Max	60.8	48.4	36.6	27.6	40.6
Min	-20.5	-28.6	-50.7	-49.4	-15.5
Standard Deviation	7.3	7.5	8.2	7.5	5.3
Information Ratio	0.1	-0.8	1.5	0.4	2.4

Source: J.P. Morgan Equity Derivatives Strategy

Besides benchmarking against the simple long/short strategies, we can also benchmark against comparable strategies. Firstly, Figure 27 shows only a moderate volatility bias, which suggests that the RV strategy does not simply equate low vol with cheapness and high vol with richness. In Table7, we compare our RV strategy with a simple Implied - Realized volatility strategy, where names are ranked based on their 1M implied - 1M realized vol spread, an implied - EWMA volatility strategy, where we replace 1M realized vol with EWMA vol. The back test results confirm that the RV model delivers better performance than both of them.

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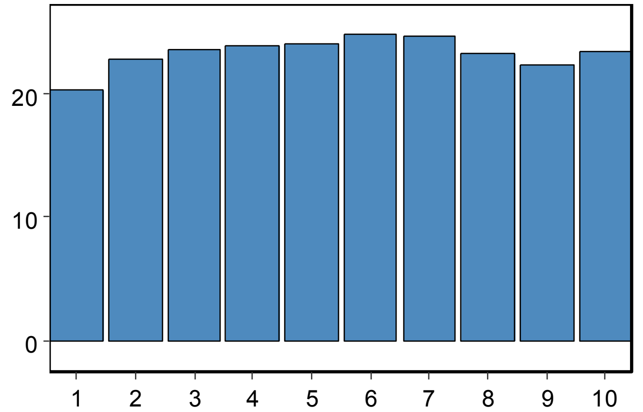
Figure 27: The volatility bias of the RV ranking is relatively low
1M ATMF volatility (%)



Source: J.P. Morgan Equity Derivatives Strategy

Table7: Benchmarking the new RV model against alternative models (P&L in vega)

	RV	Imp - EWMA	Imp - Real
Average	3.7	3.4	1.4
Median	3.2	3.3	1.1
Max	40.6	33.2	29.0
Min	-15.5	-32.7	-26.2
Standard Deviation	5.3	7.6	6.7
Information Ratio	2.4	1.5	0.7

Source: J.P. Morgan Equity Derivatives Strategy

Longer dated expiries

We can equally apply the same methodology to 2M and 3M expiries. The results are shown in Table 8 and Table 9. The outperformance of the RV strategy is consistent with 1M expiry. However, we do find some performance slippage as the expiries are extended, and therefore suggest using the RV ranking for relatively short dated options.

Table 8: RV model performance on 2-month implied volatility (P&L in vega, back test period: 10 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	-0.1	-1.8	2.9	0.8	2.7
Median	-1.7	-3.3	4.0	2.3	2.3
Max	49.9	46.8	27.0	21.9	33.8
Min	-19.1	-22.9	-40.2	-47.8	-16.2
Standard Deviation	7.0	7.9	7.7	7.9	4.6
Information Ratio	0.0	-0.6	0.9	0.3	1.5

Source: J.P. Morgan Equity Derivatives Strategy

Table 9: RV model performance on 3-month implied volatility (P&L in vega, back test period: 10 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	-0.3	-1.9	2.6	0.9	2.4
Median	-2.0	-3.9	4.2	2.9	2.3
Max	41.6	41.8	28.8	20.5	30.1
Min	-15.7	-21.5	-45.4	-42.8	-22.9
Standard Deviation	7.4	8.4	8.4	8.4	4.5
Information Ratio	-0.1	-0.5	0.6	0.2	1.0

Source: J.P. Morgan Equity Derivatives Strategy

Shorter back test period

We back tested the strategy for last five years instead of ten years .The results are shown in Table 10, Table 11 and Table 12. The outperformance of the RV strategy is consistent with 10 year history, demonstrating that the strategy performance is not skewed by the 2008 – 2011 high volatility period.

Table 10: RV model performance on 1-month implied volatility (P&L in vega, back test period: 5 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	-0.5	-1.7	3.5	0.7	3.0
Median	-1.1	-2.5	3.9	1.5	2.8
Max	19.4	13.9	26.7	10.3	29.8
Min	-10.4	-11.3	-23.9	-14.9	-15.5
Standard Deviation	4.0	4.0	5.9	4.0	4.7
Information Ratio	-0.5	-1.5	2.0	0.6	2.2

Source: J.P. Morgan Equity Derivatives Strategy

Table 11: RV model performance on 2-month implied volatility (P&L in vega, back test period: 5 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	-0.8	-1.8	2.5	0.8	1.7
Median	-1.3	-2.7	3.1	1.7	1.6
Max	21.9	9.6	27.0	10.9	21.4
Min	-11.7	-11.9	-14.4	-10.6	-12.0
Standard Deviation	3.6	3.7	5.0	3.7	4.0
Information Ratio	-0.5	-1.2	1.3	0.5	1.1

Source: J.P. Morgan Equity Derivatives Strategy

Table 12: RV model performance on 3-month implied volatility (P&L in vega, back test period: 5 years)

	Long Cheap 5	Long All ETFs	Short Rich 5	Short All ETFs	RV Long Short
Average	-1.2	-2.0	2.5	1.0	1.2
Median	-1.8	-2.9	3.1	1.9	1.3
Max	18.3	8.2	23.8	10.0	17.6
Min	-10.3	-11.0	-17.1	-9.2	-13.9
Standard Deviation	3.4	3.6	4.9	3.6	3.8
Information Ratio	-0.7	-1.1	1.0	0.6	0.6

Source: J.P. Morgan Equity Derivatives Strategy

Dispersion

A natural application of the RV framework is SPX sector dispersions. Therefore, when implementing the dispersion trade, one can go long selectively the volatility of sector ETFs that are ranked cheaper than SPY.

How has our RV strategy performed historically? The correlation weighted dispersion P&L are shown in Figure 28. Here we compare a full dispersion strategy where all SPDR sector ETFs are used against the dispersion strategy using only our RV model. The RV model based strategy produces a higher Information Ratio as well as a smaller worst drawdown (Table 13). We find consistent performance improvement across maturities.

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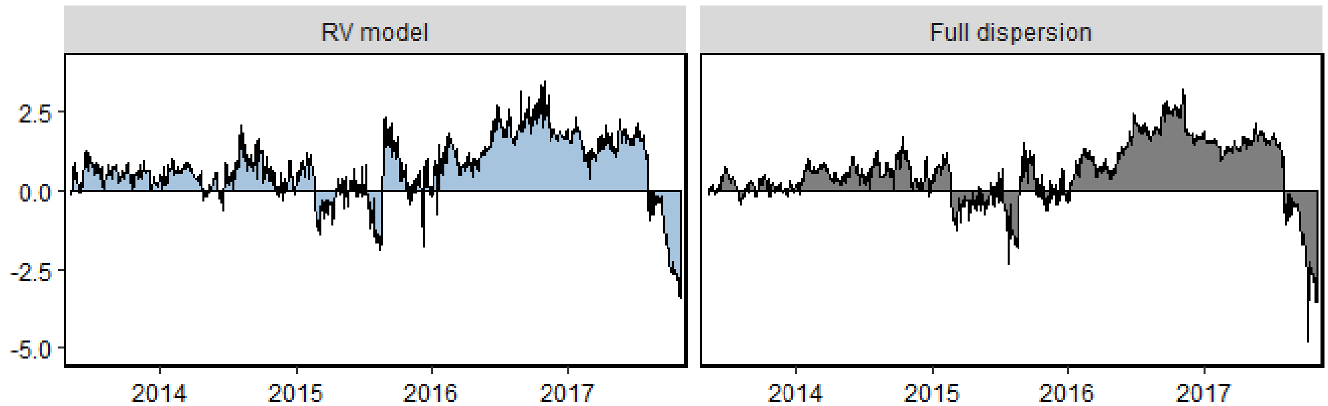
Figure 28: Comparison of 6M correlation dispersion P&L between full SPX sector dispersion and RV model based dispersion

P&L (Vega)



Source: J.P. Morgan Equity Derivatives Strategy

Table 13: Performance of SPX sector full dispersion vs. RV model

	Average	Median	Max	Min	Standard Dev	Information Ratio
Full dispersion	0.57	0.55	3.22	-4.78	1.01	0.80
RV model	0.70	0.66	3.50	-3.39	1.01	0.98

Source: J.P. Morgan Equity Derivatives Strategy

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RV Screen on Morgan Markets

The RV Screen is available on J.P. Morgan Markets and a sample of the report can be accessed from the link below:

JPMorgan ETF Relative Value Volatility Screen

The screen contains US listed ETFs with sufficient option liquidity and rare classified into 4 categories. We show the overall top 10 richest and cheapest names. In addition, we divide the names into their respective category, as shown in Figure 29.

Figure 29: Table of Contents

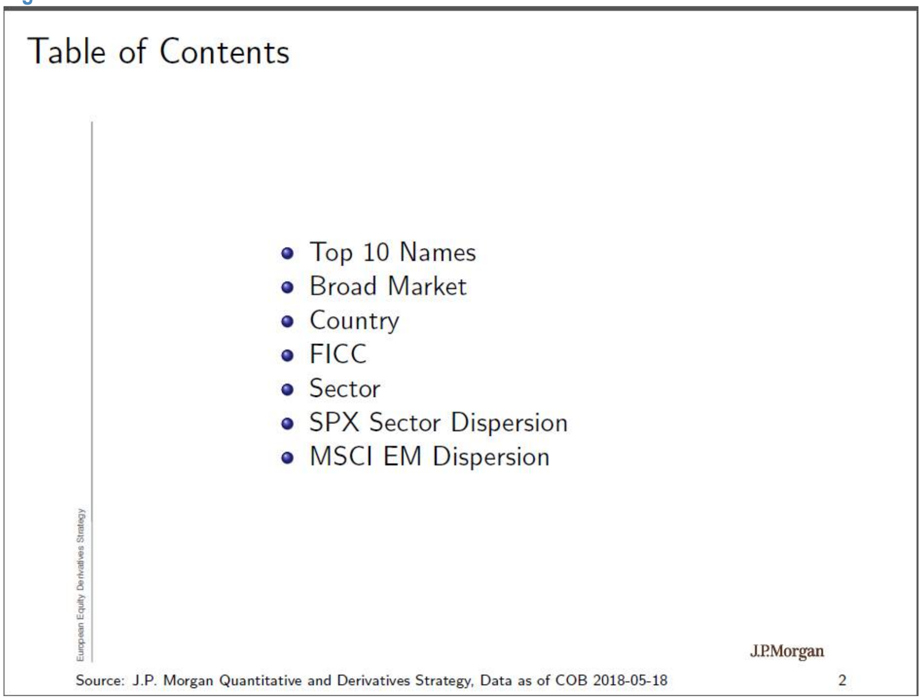

Figure 30 shows the ranking for ETFs with the overall richest and cheapest 3M implied volatility, based on our model. A ranking closer to the top indicates a more attractive long/short vol candidate.

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Figure 30: Top 10 Cheapest/Richest vol names

Top 10 Cheapest/Richest Vol Names

Top 10 Cheapest

	Name	Description	3M Implied	RV Predicted	EWMA Realised	3M Returns	RV Rank
IEF	ISHARES 7-10 YEAR TREASURY B	FICC	4.5	5.3	3.9	-0.5	1
TLT	ISHARES 20+ YEAR TREASURY BO	FICC	9.8	11.2	9.3	-0.1	2
GLD	SPDR GOLD SHARES	FICC	9.8	11.2	9.8	-4.8	3
XLK	TECHNOLOGY SELECT SECT SPDR	Sector	16.2	18.4	18.8	2.6	4
EWJ	ISHARES MSCI JAPAN	Country	11.5	13.0	12.0	0.6	5
XLV	HEALTH CARE SELECT SECTOR	Sector	14.1	15.8	15.8	-1.6	6
EZA	ISHARES MSCI SOUTH AFRICA ET	Country	26.6	29.7	30.2	-17.4	7
IWF	ISHARES RUSSELL 1000 GROWTH	Broad Market	12.6	14.0	15.2	1.1	8
EWT	ISHARES MSCI TAIWAN	Country	15.7	17.2	17.1	-2.8	9
ACWI	ISHARES MSCI ACWI	Broad Market	11.0	12.0	12.3	-0.9	10

Top 10 Richest

	Name	Description	3M Implied	RV Predicted	EWMA Realised	3M Returns	RV Rank
JNK	SPDR BBG BARC HIGH YIELD BND	FICC	7.2	5.3	3.8	0.0	77
EWI	ISHARES MSCI ITALY	Country	19.3	15.9	15.4	-2.2	76
EMB	ISHARES JP MORGAN USD EMERGI	FICC	8.3	6.9	5.5	-2.8	75
GDXJ	VANECK VECTORS JUNIOR GOLD M	Sector	23.8	20.9	21.5	-2.1	74
EWZ	ISHARES MSCI BRAZIL	Country	31.4	27.6	27.3	-17.2	73
USO	UNITED STATES OIL FUND LP	FICC	25.1	22.6	21.2	15.7	72
GDX	VANECK VECTORS GOLD MINERS E	Sector	21.0	18.9	19.3	-3.5	71
FEZ	SPDR EURO STOXX 50	Broad Market	12.4	11.2	11.4	0.4	70
VGK	VANGUARD FTSE EUROPE	Broad Market	12.1	10.9	11.1	0.1	69
AMLP	ALERIAN MLP	Sector	21.3	19.3	19.8	-1.2	68

European Equity Derivatives Strategy

J.P.Morgan

Source: J.P. Morgan Quantitative and Derivatives Strategy, Data as of COB 2018-05-18 3

Under each category section, the rankings are shown for each name and the corresponding category. A ranking closer to the top indicates a more attractive long vol candidate. For instance, Figure 31 shows the ranking for the Broad Market ETFs on a chosen date. VGK has the cheapest implied volatility, whereas DIA the richest.

Figure 31: Ranking by category

Broad Market

Ordered from Cheap to Rich

	Name	3M Implied	RV Predicted	EWMA Realised	3M Returns	RV Rank
IWF	ISHARES RUSSELL 1000 GROWTH	12.6	14.0	15.2	1.1	8
ACWI	ISHARES MSCI ACWI	11.0	12.0	12.3	-0.9	10
IWD	ISHARES RUSSELL 1000 VALUE E	11.2	12.2	12.4	-1.1	11
SPY	SPDR S&P 500 TRUST	12.0	12.9	13.5	-0.2	16
EEM	ISHARES MSCI EMERGING MARKET	18.2	19.0	18.9	-7.6	21
EFA	ISHARES MSCI EAFE	9.6	10.0	9.9	0.3	22
IVV	ISHARES CORE S&P 500	12.6	13.0	13.8	-0.2	26
QQQ	POWERSHARES QQQ TRUST SERIES	16.3	16.9	19.2	1.2	28
DIA	SPDR DJIA TRUST	13.4	13.6	14.2	-1.4	34
VWO	VANGUARD FTSE EMERGING MARKE	17.2	17.4	17.0	-7.4	36
VTI	VANGUARD TOTAL STOCK MKT	12.5	12.6	13.3	0.5	39
IWO	ISHARES RUSSELL 2000 GROWTH	14.3	14.1	15.3	6.4	47
IWM	ISHARES RUSSELL 2000	13.7	13.4	14.4	6.0	49
HEDJ	WISDOMTREE EUROPE HEDGED EQU	11.0	10.7	10.7	6.7	56
MDY	SPDR S&P MIDCAP 400 TRST	12.8	12.4	12.9	2.8	58
IWN	ISHARES RUSSELL 2000 VALUE E	13.7	12.8	13.5	5.5	64
VGK	VANGUARD FTSE EUROPE	12.1	10.9	11.1	0.1	69
FEZ	SPDR EURO STOXX 50	12.4	11.2	11.4	0.4	70

European Equity Derivatives Strategy

J.P.Morgan

Source: J.P. Morgan Quantitative and Derivatives Strategy, Data as of COB 2018-05-18 4

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Readers can find the SPX Sector Dispersion Screen (Figure 32), where the implied volatility of SPY and its sector ETFs are ranked from cheapest to richest.

Figure 32: SPX Sector Dispersion Screen

SPX Sector Dispersion

	Name	Description	3M Implied	RV Predicted	EWMA Realised	3M Returns	RV Rank
XLK	TECHNOLOGY SELECT SECT SPDR	Sector	17.5	20.1	20.8	-1.0	1
XLV	HEALTH CARE SELECT SECTOR	Sector	15.4	16.4	16.5	-8.1	14
XLF	FINANCIAL SELECT SECTOR SPDR	Sector	17.0	18.1	18.3	-9.2	15
XLP	CONSUMER STAPLES SPDR	Sector	13.9	14.7	14.5	-14.2	16
XLB	MATERIALS SELECT SECTOR SPDR	Sector	17.1	18.0	18.3	-6.8	17
SPY	SPDR S&P 500 TRUST	Broad Market	13.9	14.5	15.0	-5.3	19
XLY	CONSUMER DISCRETIONARY SELT	Sector	16.0	16.5	16.8	-2.2	25
XLI	INDUSTRIAL SELECT SECT SPDR	Sector	16.6	16.6	16.7	-9.3	39
XLE	ENERGY SELECT SECTOR SPDR	Sector	18.6	18.5	18.9	-1.7	42
XLU	UTILITIES SELECT SECTOR SPDR	Sector	13.7	12.8	12.8	3.3	62

Source: J.P. Morgan Equity Derivatives Strategy

For instance, based on our screen, we would go long market cap weighted volatility on XLK, XLV, XLF, XLP and XLB against the short SPY volatility leg, and avoid XLY, XLI, XLE and XLU.

Similarly, investors can find the EEM custom dispersion screen in our RV report, where the implied volatility EEM and its country constituents are similarly ranked from cheap to rich (Figure 33).

Figure 33: MSCI EM dispersion screen

MSCI EM Dispersion

	Name	Description	3M Implied	RV Predicted	EWMA Realised	3M Returns	RV Rank
EWY	ISHARES MSCI SOUTH KOREA	Country	20.8	21.8	22.5	-3.7	18
EZA	ISHARES MSCI SOUTH AFRICA ET	Country	26.0	27.0	27.5	-8.3	22
EWT	ISHARES MSCI TAIWAN	Country	17.3	17.7	16.9	-6.6	32
FXI	ISHARES CHINA LARGE-CAP	Country	20.8	21.3	20.0	-10.9	33
RSX	VANECK VECTORS RUSSIA	Country	23.0	23.2	22.3	-10.7	36
EEM	ISHARES MSCI EMERGING MARKET	Broad Market	18.3	17.9	18.6	-8.1	48
TUR	ISHARES MSCI TURKEY	Country	34.7	33.7	29.3	-24.9	53
EPI	WISDOMTREE INDIA EARNINGS	Country	16.8	15.5	14.1	-7.6	66
EWZ	ISHARES MSCI BRAZIL	Country	28.8	26.2	24.8	-13.7	67
EWW	ISHARES MSCI MEXICO	Country	25.0	22.5	21.5	-10.3	70

Source: J.P. Morgan Equity Derivatives Strategy

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US ETF universe included in the analysis

Table 14: List of ETFs included the analysis

Ticker	Name	Description	Option Daily Volume ($MM)	Ticker	Name	Description	Option Daily Volume ($MM)
SPY	SPDR S&P 500 TRUST	Broad Market	105,352	DXJ	WISDOMTREE JAPAN HEDGED EQ	Country	26
QQQ	POWERSHARES QQQ TRUST SERIES	Broad Market	16,285	GDXJ	VANECK VECTORS JUNIOR GOLD M	Sector	25
IWM	ISHARES RUSSELL 2000	Broad Market	7,377	FEZ	SPDR EURO STOXX 50	Broad Market	22
EEM	ISHARES MSCI EMERGING MARKET	Broad Market	1,765	XHB	SPDR S&P HOMEBUILDERS	Sector	20
DIA	SPDR DJIA TRUST	Broad Market	1,642	AMJ	JPMORGAN ALERIAN MLP INDEX	Sector	17
GLD	SPDR GOLD SHARES	FICC	1,270	SOXX	ISHARES PHLX SEMICONDUCTOR E	Sector	13
HYG	ISHARES IBOXX USD HIGH YIELD	FICC	1,084	RSX	VANECK VECTORS RUSSIA	Country	11
TLT	ISHARES 20+ YEAR TREASURY BO	FICC	913	IYT	ISHARES TRANSPORTATION AVERA	Sector	11
EFA	ISHARES MSCI EAFE	Broad Market	805	HEDJ	WISDOMTREE EUROPE HEDGED EQU	Broad Market	11
SMH	VANECK VECTORS SEMICONDUCTOR	Sector	362	ITB	ISHARES U.S. HOME CONSTRUCTI	Sector	10
XLF	FINANCIAL SELECT SECTOR SPDR	Sector	335	KBE	SPDR S&P BANK	Sector	10
XLE	ENERGY SELECT SECTOR SPDR	Sector	319	VWO	VANGUARD FTSE EMERGING MARKE	Broad Market	9
FXI	ISHARES CHINA LARGE-CAP	Country	312	VTI	VANGUARD TOTAL STOCK MKT	Broad Market	8
EWZ	ISHARES MSCI BRAZIL	Country	282	IVV	ISHARES CORE S&P 500	Broad Market	8
XLU	UTILITIES SELECT SECTOR SPDR	Sector	246	IWF	ISHARES RUSSELL 1000 GROWTH	Broad Market	7
XOP	SPDR S&P OIL & GAS EXP & PR	Sector	245	KWEB	KRANESHARES CSI CHINA INTERN	Sector	6
XBI	SPDR S&P BIOTECH	Sector	241	VGK	VANGUARD FTSE EUROPE	Broad Market	6
KRE	SPDR S&P REGIONAL BANKING	Sector	227	IWO	ISHARES RUSSELL 2000 GROWTH	Broad Market	4
XLI	INDUSTRIAL SELECT SECT SPDR	Sector	181	EWG	ISHARES MSCI GERMANY	Country	3
XLK	TECHNOLOGY SELECT SECT SPDR	Sector	177	IWD	ISHARES RUSSELL 1000 VALUE E	Broad Market	3
IYR	ISHARES US REAL ESTATE	Sector	166	SIL	GLOBAL X SILVER MINERS	Sector	3
GDX	VANECK VECTORS GOLD MINERS E	Sector	155	ITA	ISHARES U.S. AEROSPACE & DEF	Sector	3
USO	UNITED STATES OIL FUND LP	FICC	137	EPI	WISDOMTREE INDIA EARNINGS	Country	3
XLV	HEALTH CARE SELECT SECTOR	Sector	104	MCHI	ISHARES MSCI CHINA	Country	3
LQD	ISHARES IBOXX INVESTMENT GRA	FICC	104	BOTZ	GLOBAL X ROBOTICS & ARTIFICI	Sector	3
IEF	ISHARES 7-10 YEAR TREASURY B	FICC	102	EWH	ISHARES MSCI HONG KONG	Country	3
IBB	ISHARES NASDAQ BIOTECHNOLOGY	Sector	96	ACWI	ISHARES MSCI ACWI	Broad Market	3
XRT	SPDR S&P RETAIL	Sector	91	IGV	ISHARES NORTH AMERICAN TECH-	Sector	2
XLY	CONSUMER DISCRETIONARY SELT	Sector	88	IWN	ISHARES RUSSELL 2000 VALUE E	Broad Market	2
XLP	CONSUMER STAPLES SPDR	Sector	75	EWA	ISHARES MSCI AUSTRALIA	Country	2
EWW	ISHARES MSCI MEXICO	Country	69	LIT	GLOBAL X LITHIUM & BATTERY T	Sector	2
FXE	CURRENCYSHARES EURO TRUST	FICC	62	EWI	ISHARES MSCI ITALY	Country	2
SLV	ISHARES SILVER TRUST	FICC	62	GREK	GLOBAL X MSCI GREECE	Country	2
EWJ	ISHARES MSCI JAPAN	Country	51	EWC	ISHARES MSCI CANADA	Country	1
MDY	SPDR S&P MIDCAP 400 TRST	Broad Market	47	EWU	ISHARES MSCI UNITED KINGDOM	Country	1

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XLB	MATERIALS SELECT SECTOR SPDR	Sector	46	TUR	ISHARES MSCI TURKEY	Country	1
XME	SPDR S&P METALS & MINING	Sector	37	EWT	ISHARES MSCI TAIWAN	Country	0
OIH	VANECK VECTORS OIL SERVICES	Sector	30	EWP	ISHARES MSCI SPAIN	Country	0
EWY	ISHARES MSCI SOUTH KOREA	Country	28	URA	GLOBAL X URANIUM	Sector	0
VNQ	VANGUARD REAL ESTATE	Sector	27	VIS	VANGUARD INDUSTRIALS	Sector	0

Source: J.P. Morgan Equity Derivatives Strategy

Possible Risks of Investing in ETFs

The following is an incomplete list of possible risks of investing in ETFs. Not all of the risks will apply to each investment in ETFs and the applicable risks will depend on the particular ETFs invested in and the particular facts and circumstances and investment objectives of the individual investor.

Commodities Risk. Certain ETFs invest in commodities. The commodities industries can be significantly affected by the level and volatility of commodity prices; world events including international monetary and political developments; import controls and worldwide competition; exploration and production spending; and tax and other government regulations and economic conditions.

Concentration Risk. An ETF may, at various times, concentrate in the securities of a particular industry, group of industries, or sector, and when a fund is overweighted in an industry, group of industries, or sector, it may be more sensitive to any single economic, business, political, or regulatory occurrence than a fund that is not overweighted in an industry, group of industries, or sector.

Costs of Investing in Underlying ETFs. Certain ETFs invest in other ETFs, and will bear a pro rata portion of the underlying ETFs' expenses (including operating costs and management fees).

Credit Risk. An ETF could be subject to the risk that a decline in the credit quality of a portfolio investment could cause the ETF's share price to fall. The ETF could lose money if the issuer or guarantor of a portfolio investment or the counterparty to a derivatives contract fails to make timely principal or interest payments or otherwise honor its obligations.

Early Closing Risk. An unanticipated early closing of the exchange on which an ETF's shares trade may result in a shareholder's inability to buy or sell shares of the ETF on that day.

Emerging Markets Risk. There is an increased risk of price volatility associated with an ETF's investments in emerging market countries, which may be magnified by currency fluctuations relative to the U.S. dollar.

Equity Risk. The prices of equity securities in which an ETF may invest rise and fall daily. These price movements may result from factors affecting individual companies, industries or the securities market as a whole.

Fixed Income Risk. An ETF's investments in fixed income securities are subject to the risk that the securities may be paid off earlier or later than expected. Either situation could cause the ETF to hold securities paying lower-than-market rates of interest, which could hurt the ETF's yield or share price.

Foreign Currency Risk. Currency movements may negatively impact the value of an ETF's underlying securities, even when there is no change in the value of the security in the issuer's home country.

Foreign Securities Risk. An ETF's investments in securities of foreign issuers involve certain risks including, but not limited to, risks of adverse changes in foreign economic, political, regulatory and other conditions, or changes in currency exchange rates or exchange control regulations (including limitations on currency movements and exchanges). In certain countries, legal remedies available to investors may be more limited than those available with respect to investments in the United States. In addition, the securities of some foreign companies may be less liquid and, at times, more volatile than securities of comparable U.S. companies.

High Yield Risk. Certain ETFs may invest in high yield securities and unrated securities of similar credit quality (commonly known as "junk bonds"). High yield securities generally pay higher yields (greater income) than investment in higher-quality securities; however, high yield securities and junk bonds may be subject to greater levels of interest rate, credit and liquidity risk than funds that do not invest in such securities, and are considered predominantly speculative with respect to an issuer's continuing ability to make principal and interest payments.

Income Risk. An ETF may derive dividend and interest income from certain of its investments. This income can vary widely over the short and long term. If prevailing market interest rates drop, distribution rates of an ETF's income-producing investments may decline, which then may adversely affect the ETF's value.

Interest Rate Risk. An ETF's investments in fixed income securities are subject to the risk that interest rates rise and fall over time.

Investment Risk. An investment in an ETF is not a bank deposit and is not insured or guaranteed by the Federal Deposit Insurance Corporation or any other government agency.

Jurisdiction. US-listed ETFs may not be marketed to foreign investors in certain jurisdictions, and vice versa.

Liquidity Risk. The market for certain investments may become illiquid under adverse or volatile market or economic conditions, making those investments difficult to sell. The market price of certain investments may fall dramatically if there is no liquid trading market. The lack of liquidity in an ETF can result in its value being more volatile than its underlying portfolio securities.

Loss of Money. Loss of money is a risk of investing in an ETF.

Market Risk. Due to market conditions, an ETF's investments may fluctuate significantly from day to day. This volatility may cause the value of your investment in the Fund to decrease.

Strategy Risk. ETFs use different strategies, all of which are associated with different risks. For example, an equities-based ETF may use a large-capitalization, mid-capitalization, small-capitalization or other type of strategy.

Tracking Error Risk. Although many ETFs may seek to match the returns of an index, an ETF's return may not match or achieve a high degree of correlation with the return of its applicable index.

Trading Risks. An ETF faces numerous market trading risks, including the potential lack of an active market for its shares, losses from trading in secondary markets, and disruption in the creation/redemption process of the ETF. Any of these factors may lead to the ETF's shares trading at a premium or discount to net asset value ("NAV"), which may be material. In certain markets, ETF prices have dropped precipitously and experienced greater volatility than prices of other stocks.

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Risks of Common Option Strategies

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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.

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