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IS THERE A 'NEW NORMAL' IN VOLATILITY MARKETS...?

Probably not!

Executive summary

The spike in implied volatility this past February was more acute than what could typically be explained by normal market gyrations. The market correction along with the surge in volatility was more perceptible given, perhaps, the complacency that has taken hold amidst a prolonged period of historically low volatility. This got many observers very excited, in part owing to the volley of Exchange Traded Products that were specifically designed and sold to profit from a low and lowering volatility environment. These instruments subsequently faltered in dramatic fashion after the surge in volatility. Many felt compelled to opine, proposing theories such as 'volatility regime shifts' and a 'new normal' in volatility markets. We look at whether any of these ideas hold credence.

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Introduction

After a sizzling start to 2018, global markets got roiled as the S&P 500 and most other equity indices suffered deep declines. The S&P 500 fell 3.9% in February, its worst monthly performance in more than two years. Market commentators were particularly tickled by the record 115.6% one day increase in the CBOE VIX – the market's de facto volatility indicator – on February 5.

Wide consensus suggests the genesis for the correction was, in all likelihood, the better than expected wage growth in the January Employment Situation Report (ESR) – more commonly known as the US nonfarm payrolls. Overshooting economists' expectations of a 2.6% increase, the 2.9% increase was seen as a harbinger of faster-than-expected inflation growth in the future, with the US Federal Reserve (Fed) perhaps likely to accelerate their monetary tightening schedule. The suggestion, as most observers have claimed, that the modest uptick in 'average hourly earnings' acted as the spark that set off the market sell-off is, in and of itself, dubious. For those who profess bottom-up fundamental analysis, a series that is notoriously seasonal and unstable should not have such a significant and profound impact on prices. This debate, however, will be left for a subsequent paper.

Traders also laid blame, owing especially to the speed of the correction, at the feet of electronic trading and obscure volatility funds. The relentless prattle on the upsurge of volatility and the rise-and-ruin of a myriad of newfangled Exchange Traded Products (ETPs) that were short the VIX was, to some extent, justified. These ETPs allowed investors to wager on the US stock market continuing to languish at the low volatility levels it has been languishing for the past two years by taking inverse bets, that is to say, shorting the two front months of the VIX future contracts (i.e. the two nearest maturing). The creation of these ETPs enabled investors of all stripes to trade volatility, itself now evolved into a unique, stand-alone asset class. Lured by eye-watering returns owing to the historically low volatility environment, the popularity of these VIX-related ETPs exploded from about 2010, with, now being easily accessible, retail investors piling in. The ETPs became evermore popular as investors kept betting on persistently tranquil markets.

After volatility spiked, however, many of these ETPs collapsed. The most widely cited of these doomed products was the 'XIV', or the somewhat cumbersomely titled 'VelocityShares Daily Inverse VIX Short-Term Exchange-Traded Note (ETN)'. The XIV nosedived from $99 on February 5, to $7.4 at close on February 6 – erasing 93% of its value. Credit Suisse, the issuer of the note, invoked an 'event acceleration', a provision enabling the issuer to board up the fund when the instrument loses more than 80% of its value from one day to the next. The XIV was duly liquidated on February 21.

The argument as to how these ETPs may have exacerbated market volatility lies in the nature of their construction: whereas futures contracts settle once, on a predetermined day, the XIV and other similar ETPs rebalanced the proportion of holdings in the first and second month future contracts on a daily basis. Since these ETPs hold short futures contracts, they had to buy more of these contracts to cover their short position when the VIX spiked, pushing up the price of these contracts, and, in turn moving a normally upward-sloping (positive) curve, into a downward sloping (negative) curve – see Figure 1. We intend to review in this note the claim that, amongst others, arcane levered volatility instruments caused the market to separate from past historical configurations. We also intend to look into a further claim that the market has been forced into a new paradigm, a 'new normal', unhinging well-known and accepted 'stylised facts' of implied and realised volatility.

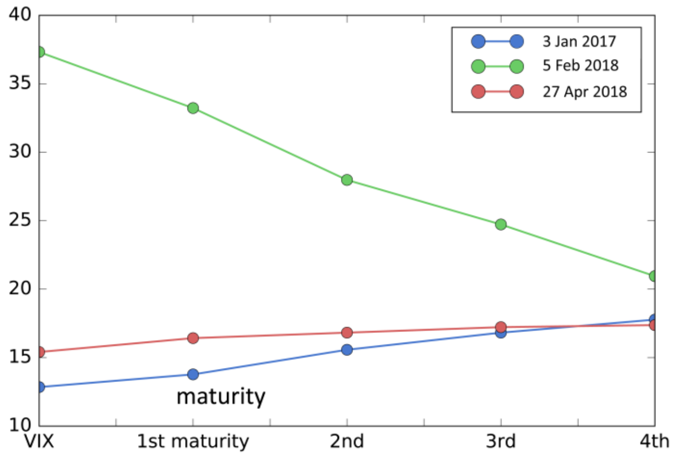


Figure 1 - During 'normal' market conditions, the term structure is upward-sloping: the VIX spot is lower than the first maturity, which in turn is lower than the next maturity and so forth. When the market undergoes periods of severe stress, the curve typically 'inverts', as happened in February and as is shown by the green line.

What is the VIX? The P&L of an option portfolio explained.

The VIX is the most commonly quoted implied volatility index and is constructed by the CBOE by:

"Aggregating the weighted prices of S&P 500 Index (SPX^{SM}) puts and calls over a wide range of strike prices. Specifically,

the prices used to calculate VIX Index values are midpoints of real-time SPX option bid/ask price quotations."[1]

The VIX itself is therefore purely a measure of implied volatility and is not a physical instrument that can be held. Its constant maturity nature actually removes the premium from the P&L and the long term performance of the VIX is flat.

The physical profit and loss (P&L) from selling delta hedged options can generally be considered as arising from two terms: the P&L from the changes in the implied volatility which is noisy and flat, plus a component proportional to implied-realised volatility:

$$P\&L_{short} \sim -A\Delta\sigma_I + B(\sigma_I - \sigma_R) \sim \text{random walk} + \text{drift}$$

Equation 1

The negative sign in front of the first term accounts for the fact that the insurer (option seller)[2] loses when the event being insured against actually occurs, that being a surge in realised volatility, which, habitually occurs when equity markets fall quickly. The second term gives the premium demanded – if more people are willing to buy than sell, then the option seller stands to make more money. This expansion of the P&L is exact for a variance swap[3] which can be replicated with a basket of options. The extra complication of considering the P&L of a variance swap should not distract us from the general model of option portfolio P&Ls being a combination of noise and a risk premium (RP). This is illustrated in Figure 2 where we show the P&L for a variance swap and the P&L of the VIX.

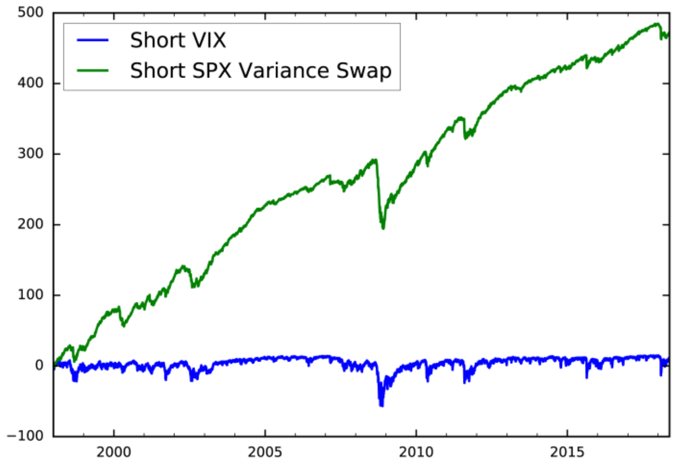


Figure 2 - Short SPX variance swaps is the cumulated P&L of being short one unit of 'vega'. Short VIX illustrates a cumulated P&L of being short VIX (i.e. assuming VIX is an investable security). The VIX P&L shows no drift, proving that first term of Eq. 1 has no drift in this case and that the source of drift is the second term, the volatility risk premium.

What is the VIX future?

The VIX future is a more recent innovation in capturing volatility premium. Futures on volatility indices payoff instead with a roll down in the volatility forward curve, similarly to interest rates. A position which is long a future on the VIX can be loosely thought of as 'long a portfolio of delta hedged one month options' which will be delivered at the expiry of the future. One can replicate such a portfolio by holding a portfolio of options that expire one month after the expiry of the future and shorting a portfolio of options that expire at the expiry of the future. Instead now the effective model is as follows:

$$P\&L_{short} \sim -A\Delta\sigma_I + B\ Rolldown \sim \text{random walk} + \text{drift}$$

Equation 2

Again, one loses money with such a short if the VIX increases but the drift term is positive all the while the volatility curve is upward sloping. This is illustrated in Figure 3. As tension in the market increases, the forward curve tends to change shape giving a negative P&L contribution from the 'Rolldown' term above. The premium for the VIX future is a term premium, i.e. a premium received to account for the fact that volatility is stochastic and therefore can strongly increase in the future. The premium arising from holding a rolled position in VIX futures is however much weaker than that obtained from holding hedged option portfolios. The world of Exchange Trade Products (ETPs) has grown around the idea of providing a replicated VIX future, long or short.

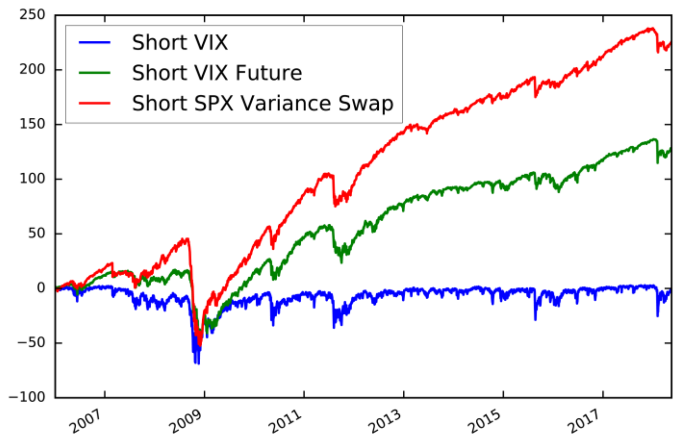


Figure 3 - A comparative illustration of volatility premia: Short VIX (zero drift) vs. Short VIX Future (positive drift due to rolldown the

[1] From the CBOE website: http://www.cboe.com/vix

[2] See the appendix for a more thorough explanation of how the VIX is calculated and how options are related to the insurance business.

[3] See the definition and interpretation of variance swap: https://en.wikipedia.org/wiki/Variance_swap

curve, i.e. VIX Futures in contango) vs. Short SPX Variance Swap (positive drift due to implied > realised). Note that these 3 P&Ls are obtained by investing $1 (one unit of Vega) in each strategy.

Are we witnessing a new normal in either implied or realised volatility?

Sophisticated and unsophisticated investors alike have been attracted to the short volatility trade. Access to these markets has been eased by the prevalence of ETPs that provide exposure to a short volatility play with the providers hedging their exposure through the VIX futures market. It is sensible to question whether this has changed the way implied volatility trades and behaves, and, to what extent it also feeds through to realised volatility. We look at this from three different angles to judge whether markets have changed or whether in fact the existence of a new normal simply satisfies a human desire to rationalise market dynamics with explanations based on statistically insignificant patterns.

1. Has the Risk Premium changed?

The existence of a RP, defined as the excess demanded in implied volatility relative to realised volatility, may have changed with the persistent low volatility regime of the past few years and with an excess of short volatility providers entering the market. In Panel 1 we plot the RP of volatility for S&P 500 options, along with a selection of well-known global indices. We calculate the realised (forward) volatility by taking the log returns of the S&P 500, as shown in Equation 3:

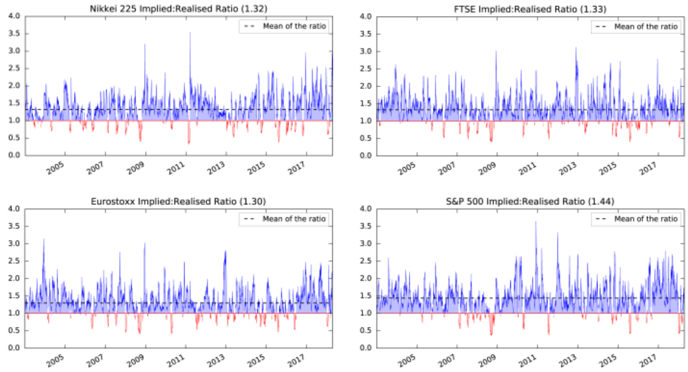
$$Realised\ Forward\ Volatility\ (t) = \left[\sum_{i=1}^{30} r^2\,(t+i)\,.\frac{365}{30}\right]^{\frac{1}{2}}.100$$

Equation 3

Where:

$$r(t) = \log\big(Index(t)\big) - \log\big(Index(t-1)\big)$$

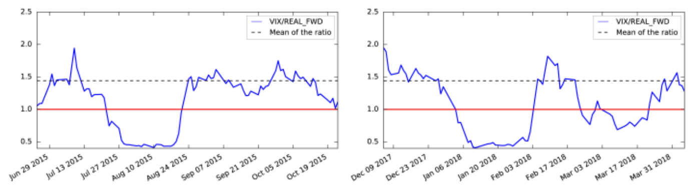
The relationship between the two measures has been exceptionally stable, and, has been characterised by implied volatility habitually exceeding realised volatility, in the case of the S&P 500, 87% of the time. This relationship holds across a diverse range of equity indices.



Panel 1 - The Implied to Realised volatility ratio of the S&P 500 and three other major global equity indices. The realised volatility is calculated as described in Equation 3, with the start date of all indices set as 2003 (The mean of each index is indicated in brackets). All of these indices display a similar, and consistent volatility risk premium, where the ratio turns sharply, and abruptly negative in times of severe financial market stress.

One observes that, despite the low volatility regime of the past few years, a persistent premium continues to be present. This demand for insurance does not seem to have changed and, even if the supply of insurance has increased, continues to pay a premium to the insurance seller.

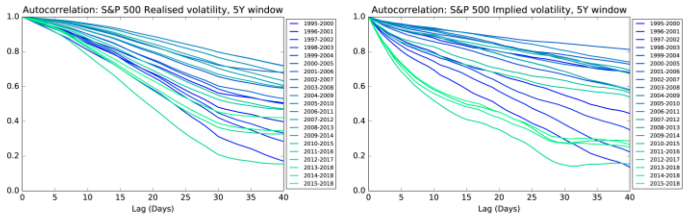
Comparing the February volatility spike with the most recent similar high market stress events, i.e. the August 2015 China crash, we see, as illustrated in Panel 2, a remarkably similar pattern of the S&P 500 implied to realised volatility ratio sinking below one, only to return to above one after the ‘event’ or correction to pre-spike levels.



Panel 2 - The implied to realised volatility ratio of the S&P 500 plus/minus two months from the peak of the VIX during the 2015 ‘China crash’ (left) and plus/minus two months from the peak of the VIX during the February 2018 correction (right). One can see the evolution of the volatility risk premium (VRP) where these plots suggestively show how implied volatility (VIX) tends to exceed realised volatility of the same underlying asset during market drawdowns. This phenomenon also holds universally across option markets on other equity indices and asset classes. The VRP tends to turn negative during periods of severe market turmoil, before reverting to the long-term mean.

2. Has volatility clustering changed?

The clustering of volatility allows firms such as CFM to control P&L risk and exists in both realised and implied volatilities. This clustering simply means that if today's volatility is high/low then tomorrow's volatility will also likely be high/low. One can translate this into what is called an autocorrelation function – correlating the volatility of today with yesterday, today with the day before yesterday, today with the day before that etc.[4] An example of this autocorrelation function can be seen in Panel 3. A comment that our clients often make is that volatility does not seem to persist like it used to and that volatility spikes are much more short-lived than before. This is something that will be noticeable in measuring the correlation of volatility with itself in the form of the said autocorrelation function.

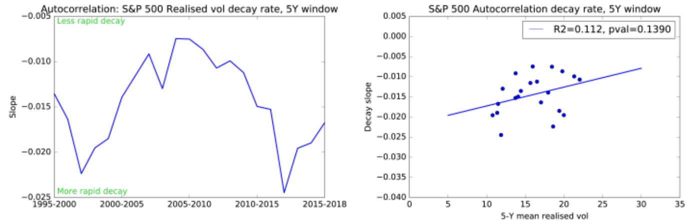


Panel 3 - The autocorrelation function of both the realised (left) and implied (right) volatility of the S&P 500 captured in overlapping, rolling 5-year windows from 1995 to the present. The plot shows how the current autocorrelation function of implied and realised volatility does not feature a unique decay pattern, since a similar pattern was observed in the early to mid-90's.

We measure the autocorrelation function of both the realised and implied volatility with a lag up to 40 days over a rolling 5-year window. We further measure the steepness of the autocorrelation function for each of the 5-year windows. If the slope of the function is steep then volatility persists for shorter periods while a flatter function reveals longer term correlation (or clustering). As one can see in Panel 4, the slope of the autocorrelation seems to loosely correlate with the level of realised volatility, while the qualitative behaviour of implied volatility displays similar features.

We focus our attention on the short end of the autocorrelation of both implied and realised volatility, meaning we ignore observations that are separated by long periods of time. It is this part of the spectrum that is of interest and the level of noise in the measurement of correlation is reduced compared to points separated by large periods of time.

It seems that autocorrelation in low volatility periods is shorter-lived, making volatility spikes followed by a quick relaxation more likely. High volatility periods, meanwhile exhibit long lived persistent volatility. This feature is fitted in the data, in Panel 4, where we plot the slope of the autocorrelation as a function of the level of the volatility itself to reveal a weak dependence (right-hand plot).



Panel 4 - The slope of the decay of the autocorrelation function of the realised volatility of the S&P 500 from 1995 to present (left). The flatter (less negative) the slope of the autocorrelation curve (as shown in Panel 3), the slower the autocorrelation (or clustering) of volatility decays. One observes a loose relationship between the autocorrelation and the level of volatility in the right-hand plot. This implies that in high volatility environments volatility spikes persist while in low volatility environments, as has been the case in recent times, volatility spikes are shorter lived.

3. Has the VIX forward curve changed?

The various VIX future maturities allow us to study whether the forward curve has changed in its behaviour compared to a longer history. The forward curve, or term structure, illustrates the market's expectation of future volatility: an upward sloping term structure (in commodity markets the forward curve is said to be in '*contango*') indicates an expectation of *increased* volatility in the future, whereas a downward sloping term structure (in commodity markets the forward curve is said to be in '*backwardation*') indicates the opposite. The term structure is typically upward sloping, but is known to flip between upward and downward sloping as a function of volatility, while a RP is received through the upward sloping curve compensating short volatility positions for the possibility of an increase in volatility. In Figure 4 we show the slope as fitted through the first few expiries at the front of the curve as a function of time and in comparison to the level of the VIX. One clearly sees a strong correlation between the two quantities with little change in behaviour with more recent data.

When we calculate the term structure of the VIX, we observe that the forward curve is typically upward sloping, i.e. the ratio between the first and second expiring futures is greater than one, but, tend to turn negative in spells of market distress. The historical mean of the VIX term structure (that is to the say, the ratio of the front: second future contracts is ~ 1.05, i.e. an upward sloping term structure on average). This pattern repeated itself in

[4] Autocorrelation function can be expressed as $(\tau) = \frac{E[(X_t-\mu)(X_{t+\tau}-\mu)]}{\sigma^2}$, where τ is the lag (40 days in our calculation); μ the mean; and σ the standard deviation.

February, akin to other well-known and extreme market sell-offs. A comparison with the most recent correction of similar magnitude – 'China's Black Monday' in August 2015 – exhibits stark similarities. In both cases the term structure transformed from contango to backwardation in the week preceding the market sell-off. However, when the markets calmed in subsequent weeks, the term structure returned to close to its long term average.

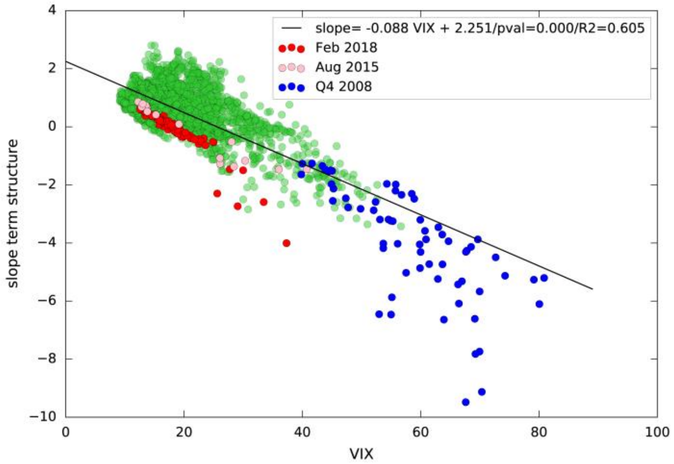


Figure 4 - A scatterplot illustrating the relationship between the slope of the term structure, whether it is positive or negative (positive sloping with maturities in the future having higher values than the spot) and the level of the VIX. The term structure exhibits, most of the time, a positive slope (as indicated by values > 0 on the y-axis) but turns negative when the level of the VIX increases. The points in blue (Q4, 2008) constitute the overwhelming majority of outliers, with the points in pink (August, 2015) and red (February, 2018) displaying similar levels (and behaviour) that are well within the perimeters of the cloud of observations.

Conclusion

Volatility markets provide an environment for investors to speculate and hedge using options and futures. These markets have become some of the most liquid in the world and are a good source of the RP in selling financial insurance. Shorting volatility is however a risky business! Even sophisticated institutional clients should be wary, but, controlled in the appropriate manner diversifying across such sources of RP seems an essential portfolio addition for institutional investors such as pension funds. Retail money, on the other hand, is less suited to such markets. The arrival of products allowing investors with modest intentions and expertise to invest (speculate) in vehicles that are in essence leveraged equity market bets, where they can lose up to 100% of the notional, will attract those looking for a fast buck and will probably end in tears.

It is difficult to deny, however, that the existence and growing popularity of these implied volatility ETPs may potentially have an effect on implied volatility and indeed the direction of equity markets (which could then affect realised volatility). It seems superficially that the persistent nature of volatility has remained relatively unchanged and indeed, anecdotally, the ability of constant volatility products to achieve and control risk would suggest that volatility remains autocorrelated. The frequency of short-lived volatility spikes seems to be related to the level of volatility and a persistent feature of markets. The RP in short volatility has remained unchanged and, despite a recent stretch of low volatility, it seems investors still seek out insurance and push implied volatility higher than realised. The forward volatility curve as implied by VIX futures also seems relatively unchanged when comparing recent data to a longer history.

Appendix

What is an option and how is it related to insurance?

Implied volatility is calculated using the price of call and put options on an underlying equity index at an average expiration of 30 days, which serves as an estimate of how volatile the underlying (the S&P 500 in the case of the VIX) will be (how much the price may vary), based on the prices of the options on the underlying between the current date and the option's expiry date.

A call/put option is a financial derivative instrument that gives the buyer the option to buy/sell an underlying instrument at a given strike price on a given date. Options now represent some of the most liquid derivatives in the world, in particular on such ubiquitous underlying indices such as the S&P 500. Options are difficult to price – how does one put a fair value on something that might pay off in the future, or, maybe expire worthless? Fischer Black, Myron Scholes and Robert Merton solved the problem by considering the underlying price as a random walk with Gaussian returns to give the Black-Scholes-Merton (BSM) option pricing equation.[5] Though this equation offers an analytical solution to the problem it comes with many

[5] The formula was introduced in their 1973 paper entitled 'The Pricing of Options and Corporate Liabilities'. Their work was ultimately awarded the Nobel Memorial Prize in Economic Sciences in 1997 for shaping 'a new method to determine the value of derivatives'.

assumptions and does not necessarily provide us with an intuitive description of what happens when one buys or sells an option.

At the heart of the BSM framework is the notion of *implied volatility*. The BSM option price is dependent on the volatility of the underlying, a higher volatility increasing the probability of the option expiring in the money and therefore demanding more premium. The logic of the BSM price is commonly reversed to obtain a volatility implied by the price of the option as seen in the market. This implied volatility is commonly seen as the market estimate of risk and its level quoted in the financial press at times of stress.

In a BSM world, options are priced such that the average payoff for both seller and buyer is zero – a price which is considered *fair*. Options can finish in or out of the money for any given case, but the average over all scenarios is a zero payoff. This fair price is, in reality, not the price at which options trade. This is due to the insurance nature of the option payoff.

Options can be, and are used to hedge and are therefore similar in nature to buying an insurance contract: consider a portfolio manager who wants to hedge downside exposure for an equity portfolio prior to the Fed's Federal Open Market Committee (FOMC)[6] meeting – he can purchase put options that will pay off if the market falls or will expire out of the money if nothing happens, in which case the option premium is lost.

Implied volatility is as such characterised by a tendency to rise before scheduled and potentially significant market moving announcements (such as FOMC meetings, elections, referendums, etc.) only to drop sharply after the 'event' because of an immediate removal of uncertainty (and lower demand for options) as soon as the announcement has occurred or following the release of results. The UK's Brexit vote serves as a useful, and recent example to illustrate the point. Leading up to the referendum on June 23, 2016, the key implied volatility indices all rose above their respective 20-day moving averages reaching, in the case of the FTSE 100 volatility index (VFTSE), its highest level of the year on June 16 (32.49 points), only to fall below the historical average by July 1.

The insurance business is one with which we are all familiar. Society obliges us in many cases to take out insurance against certain events such as car accidents and house fires, but also appeals to the very risk averse nature of the human psyche. It comes as no surprise to hear that the insurance seller is in it for the money, and the insurance premium paid by the buyer is not the fair price as previously defined. In fact, as has been shown by articles written by CFM[7], the premium charged over and above the fair price is proportional to the risk assumed by the seller which is captured in the level of negative skewness of the insurance sellers' returns. In the insurance world these premia are calculated once at the inception of a contract and vary little over time. In the financial world, however, options are priced based on supply and demand dynamics. In such a world the premium demanded for owning an option with its inherent potential insurance like payoff depends on how many people want to buy options and how many are willing to sell them. Again, due to the risk averse nature of investors, there tends to be more demand than supply which is then reflected in a divergence between the volatility implied by the option market and that actually realised by the underlying. This difference – implied volatility versus realised volatility – is then considered a *Risk Premium* (RP). In the absence of this difference, options are priced fairly and neither the option buyer nor seller, averaged over a large range of outcomes, makes money. This difference can be considered as the profit for an option seller who can in turn be considered the insurance seller.

Disclaimers

[6] The FOMC is the primary monetary policy setting body of the US Federal Reserve. They meet periodically to decide on the level of the fed funds rate – the effective interest rate of the United States.

[7] See our paper 'Risk premium investing – A tale of two tails' available on the CFM website. For a deep-dive into the topic, please refer to our academic paper entitled 'Risk premia: Asymmetric tail risks and excess returns' also available on the CFM website.

CFM has pioneered and applied an academic and scientific approach to financial markets, creating award winning strategies and a market leading investment management firm.

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