

Right Tail Hedging: Managing Risk When Markets Melt Up

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Abstract

Popular academic and practitioner lore claims that buying options, whether puts or calls, is a negative expected return investment and hence should not be undertaken by “rational, risk-neutral” investors. However, real world considerations such as the possibility of large jumps and imitative behavior of traders in both bull and bear markets can reverse this conclusion. In particular, the potential for positive economic shocks such as those observed since the 2016 US election may make call options based strategies superior to buy and hold strategies. In this article, the author extends work published in 2007 in the journal on left tail or downside tail risk hedging to “upside” hedging, whose importance has become increasingly relevant in an environment of low yields, elevated asset prices, low credit spreads, indexation and multi-decadal lows in call option prices.

Keywords: Call Options, Upside Risk, Tail Hedging

Equity markets do jump up. As a matter of fact, the historical data shows that draw-ups in markets are at least as numerous and severe as drawdowns. Even for the S&P500, the maximum drawdown since 1950 has “only” been 50%, while the “draw-ups” have been many multiples larger (we define draw-downs and draw-ups up to a time in the conventional way). Since 2015, the S&P has observed a maximum drawdown of approximately 12%, while it is still in a draw-up that has reached 50% and continuing. Despite these facts, losses are usually sharper and since they are more damaging to investor portfolios, they usually gather more public attention. Thus large losses become more salient in investor’s psyches than large gains, and this fact is reflected in the high premiums of put options on equity markets relative to call options, which is termed the implied volatility “skew” in the index options markets as illustrated in Exhibit 1.

When there is a potential for large right tails, can call options provide investment value above simply buying and holding? This question has perplexed both academics and practitioners for years. Much ink has flowed in academic journals on the naivete of investors who buy options to protect their downside risk via puts or replace outright purchase of securities with call options. The usual arguments are supported by backward looking analyses of options markets where the options are passively held over some fixed horizon, usually refer to the S&P 500, and in most cases, conclude that *on average* it does not make sense to buy any options (calls in particular). They “prove” that empirically buying and holding options is a negative expected return strategy over a given fixed horizon. But despite all these studies, which are well known to most institutional investors, the options markets continue to grow, and investors happily (and profitably) part with premium in order to obtain the value of risk transfer to parties who are willing to assume it for a price. The empirical analyses are usually backed up with the truism that “markets melt-down, but don’t melt-up”, which as discussed is not entirely consistent with data. Further, in such studies, it is also argued, that since it is possible to replicate a call option using a “delta” equivalent equity exposure in an almost continuous basis, call options are largely redundant. This paper challenges many of these conclusions.

To be clear, this paper is not about the debate of whether as a speculative strategy it makes more sense to buy or sell options, since it will take volumes to present all points of view, and this controversy lies at the heart of normative (generally utility based) theories of investing, and descriptive (generally behavioral) theories. The gist of this paper is that under certain, not

necessarily abnormal economic and market conditions, the purchase of both put and call options can be optimal for investors, and the additional convexity that only options markets can provide result in superior portfolio outcomes. Indeed today's market environment is one such environment; the spectacular performance of equity markets since the 2016 US Presidential election has demonstrated the benefit of having upside convexity in portfolios. We believe that one reason why most studies have ignored this value added from the purchase of call options is that most empirical back tests of option strategies have relied on a sample data set that has not experienced major market "melt-ups" such as the one being witnessed recently. Just as the vanilla put option on the S&P 500 could be assailed as consistently one of the most expensive securities in the markets following the surge in downside protection, a call option on the same index has possibly performed as one of its least expensive counterparts.

Readers who have read my paper in this journal and book on left tail hedging (see e.g. Bhansali 2015) may think of the present discussion as an extension of that work to upside or right tail hedging. The left tail risk paper was published in this journal a few months before the financial crisis of 2008, and this author believes that market conditions make the current environment one that is ripe for tail hedging of the other kind, to the upside. It is possible that by the time this paper goes to press, the right tail might have already passed and morphed into a left tail event. I believe, however, that in a world of tightly coupled markets, instance news-feeds and the presence of technologically advanced trading "bots", both left and right tails will become a permanent fixture of investment markets. Thus I hope that this paper and the discussion will have a long shelf life that will outlive the most recently observed set of manias, panics and crashes, as the next one is likely not too far behind. The value from both active left and right tail hedging of portfolio risks is being realized by astute investors, just as the value from actively managing bond portfolios was realized a few decades ago and has now become standard fare in the investment industry.

Motivating Need For Upside Tail Risk Hedging

Unhedged upside risk in equity markets is a reality today as economic, politics, bond yields, interest rates and equity markets are all in new regimes rarely experienced since real-time options data has been collected. Due to the significant amount of excess liquidity in the financial markets, the prevalence of indexed and passive strategies, and coordinated global

macroeconomic growth, asset prices have rallied significantly from their financial crisis lows. For instance, the S&P500 has increased over 400% during this period. Along with the performance of equity markets, the liquidity drove bond market yields, asset return volatilities and credit spreads to almost all-time lows.

When an investor thinks of buying an option he is making a conscious tradeoff between limited loss and the possibility of time decay on the one hand, and unlimited gain as well as benefit from rising perceptions of risk on the other hand. In other words, purchase of an option instead of the underlying is an implicit bet on volatility mispricing, which tends to get larger when there are jumps, uncertainty and the possibility of new regimes. To set the stage, an example from our experience from last year will be helpful.

On September 1, 2017, with the S&P 500 trading at 2471, the price of a 5% out of the money call, with strike 2594 with one year left to expiry was 2.67%. This option had a theoretical Black-Scholes delta of 0.33, and the implied volatility for that strike at that time was 12.14%. Compare this to an outright exposure to the underlying at the same time. In order to equalize the linear exposures approximately three times the options would need to be bought. On January 2, 2018, the price of the same option, after accounting for time decay, was 6.45% with a reference S&P 500 index value of 2691 and an implied volatility of 14%. Even as the market rallied, the implied volatility of the fixed strike put increased due to the put-call skew, since by put-call parity, in the money calls inherit the volatility of the out of the money puts of the same strike. The index thus returned 8.91% over the four month period. The option lost four months of time value, but despite the time decay, on an equal delta basis delivered 10.88% marked to market return, handily beating the linear equivalent on a risk adjusted basis.

Clearly, the reason the call option in this cherry-picked example outperformed the underlying index was because the ex-ante probability distribution as implied by the options markets was incorrect in pricing the probability of such a large move in the underlying. And when large market moves happen, the inherent non-linearity of an option magnifies returns.

One of the key thrusts of this paper is that when major economic and market forces are at work and there is a possibility of large, non-linear jumps, using the implied probability distribution from traded options prices can be erroneous. Our view is that major policy changes, such as the

US tax reform, has the potential of creating such non-linearity. There are also some other reasons on why upside hedging might be more relevant today than any time in recent memory:

- *Influence of the trend towards passive products:* The move from active to passive investment management makes it likely that significant amount of investment capital will continue to flow into low cost ETFs and mutual funds that will be more price and valuation insensitive.
- *Low cost of capital:* Capital is cheap in a low (and negative yield environment in Europe) and seeking return it will flow into risk assets where the prospect of a possible loss looms less risky than a certain loss. In such an environment, it makes sense for corporations to issue debt to buy back equity.
- *Extremely Low Call Option Volatility:* As discussed briefly below and in much detail in another paper (Bhansali and Harris 2018), the need for yield in a yield-starved environment has resulted in a proliferation of short volatility strategies. Many of these volatility selling strategies are symmetric in their exposure to calls and puts. As discussed later, a lower implied volatility of call options requires a larger notional sale of call options, making the call option volatility depressed.
- *Elevated Volatility Skew:* The cost of equity replacement using call options is at a multi-year lows (see Exhibit 1). There are two reasons for this. First, the level of implied volatilities is at all-time lows, and second the skew (difference in volatility spread between put options and call options) is still elevated (see exhibit 1), which makes call options relatively cheaper than puts on a volatility normalized basis. One driver of the elevated skew are costless collar strategies, where investors sell call options to finance the purchase of out of the money put options. As upside risk becomes more visible, it is likely that investors will increasingly look to finance the purchase of upside calls from the sales of put options.

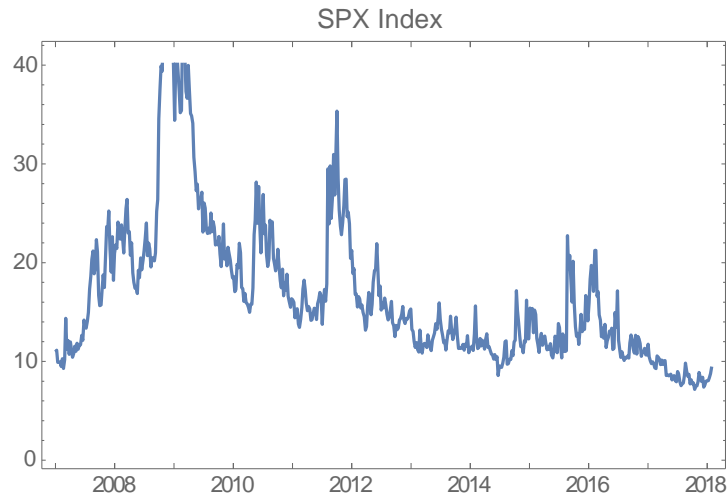


Exhibit 1: Implied Volatility of 5% out of the money call options on the S&P 500 index. Source: Bloomberg, LongTail Alpha.

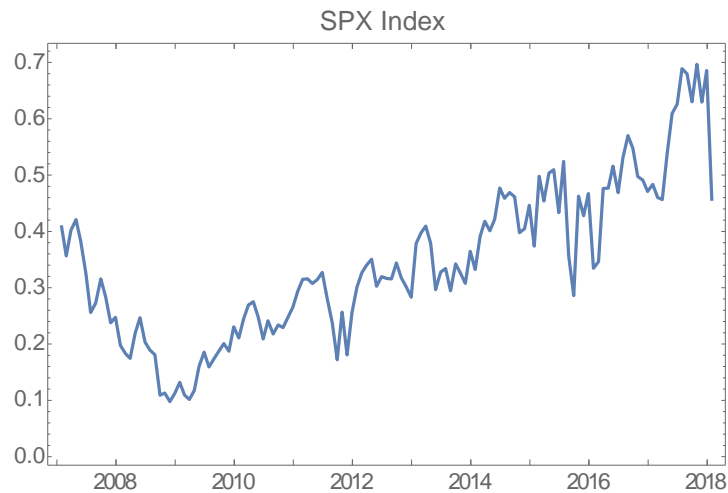


Exhibit 2: Normalized volatility skew for S&P 500 3 month index options. The difference of implied volatility for the 5% out of the money put and 5% out of the money call divided by the at-the-money volatility is displayed. Rising skew means that equidistant call options are priced at a lower volatility than the same distance put options. Source: Bloomberg, LongTail Alpha.

- *Cross-market demand for convexity:* Credit products, such as high yield, cannot keep up with large rallies in the equity markets. Since many credit investors track popular benchmarks, as credit lags equity they will likely look to enhance total return by using

upside convexity strategies. Similarly, “alpha” strategies such as long-short equity hedge funds are unable to keep up with the rally in equity markets, and the only way to recapture the “beta” is via synthetic long positions.

Let us illustrate the last point further. Consider an investor who is invested in high yield credit. Credit risk as measured by credit spreads is negatively correlated to the equity of the issuing firm and positively correlated to the asset volatility of the firm. In other words, one can locally (but not globally) replicate a long position in the corporate bonds of a company by buying an appropriate amount of equity in the company. To replicate larger moves in the corporate bonds requires the purchase of options. As the value of the underlying assets rises, credit spreads compress as the implicit put option in the bond price is now worth less. If the uncertainty or volatility in the company’s financial prospects decreases, the value of the put also falls, compressing spreads. This suggests that in addition to the indirect exposure to the equity price, an investor holding credit also has exposure to the volatility of the underlying equity which reflects the uncertainty in the asset prices of the company. When spreads are neither too large nor too small, and the volatility of the underlying assets is not too high, credit can thus locally be replicated using only the underlying equity. But when either asset prices fall (which is accompanied by rising volatility) by larger magnitudes, or vice versa, the replication of credit requires that the investor supplement the equity with explicit options. Clearly, to participate in the upside, call options overlaid on credit are required.

Why would a credit investor need to keep up with the equity markets? To answer this, we have to think of modern financial markets as a competitive ecosystem where each participant is seeking outperformance over their benchmark and also against other types of investors in the market. A credit investor can thus perform better relative to his own peer group by owning a

small amount of additional convexity that contingent on a large event can result in outperformance. Such “out-of-index” bets are fairly common in the asset management industry, and have become easier to implement due to the availability of liquid derivatives and ETFs. For instance, an equity investor can purchase an ETF, which trades on a stocks exchange, to obtain exposure to interest rates, bonds, and even alternatives, such as the volatility and inverse volatility ETFs that have recently become popular. By adding closely related sources of convexity that are not available from within credit, the credit investor is thus exploiting the mispricing of the fundamental risk factors across the credit and equity markets, which we know in the limit are closely related.

Derivatives such as call options are risky due to inherent leverage. To illustrate why the additional, finite loss (limited to premium) leverage risk is acceptable can be explained within an evolutionary model of markets (see McDermott 2008). We assume that each credit market participant can choose between a safe choice and a risky choice. For survival in the competitive game of the markets, each participant has to meet or exceed a minimum absolute and relative return threshold. This according to this model, requires investors to choose the risky proposition under four conditions: (1) when the difference between the required threshold return and the safe return rises, (2) when the difference between the risky return and safe returns rises, (3) when the variance in the risky asset falls, and (4) when the prospective variance of the environment rises. When option volatilities are low, call options can provide an ability to achieve all four objectives in one package, with a finite risk of loss limited to the premium spent, ensuring survival in conditions where survival is important.

Another perspective on this effect arises from the dynamics of imitation between traders which is also well documented in speculative markets (see Sornette 2003). Under this model, prices

exhibit characteristic “log-periodic” behavior as exhibited for the S&P500 (see our fit in Exhibit 3):

$$\ln[SS(tt)] = AA - mmt^{\alpha} [1 + CCCCC[\omega\omega \ln(tt)]]$$

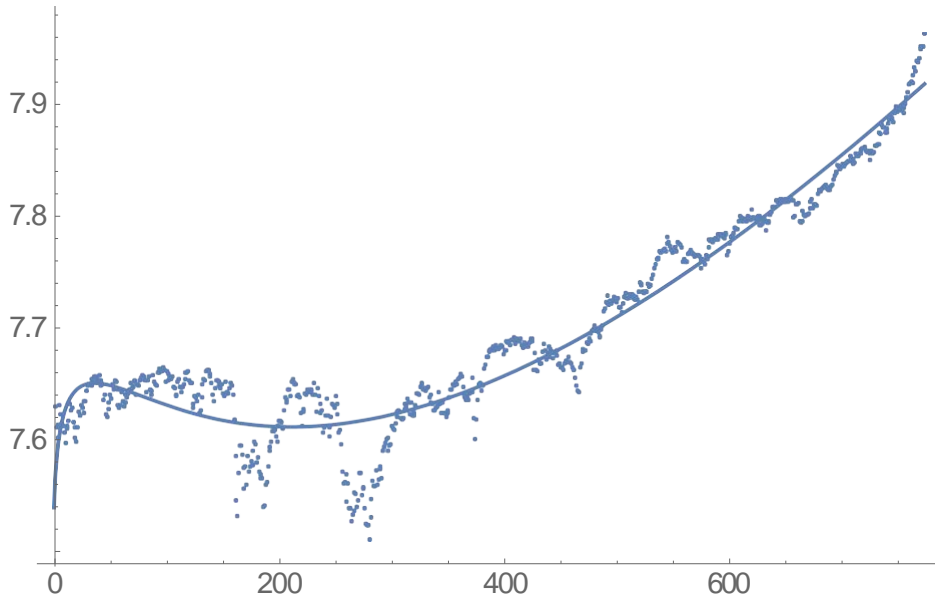


Exhibit 3: A fit of the log of the S&P 500 from January 1, 2015 to January 15, 2018 using the log-periodic model of Sornette(2001). The power-law dependence on time is illustrated. Source: LongTail Alpha.

This formula illustrates amplification and non-linear acceleration in the price as a function of time as more and more participants begin to agree on the fundamentals. Markets then make new highs in succession, with the time intervals between new highs decreasing rapidly (before reaching a critical point that results in a “crash”). For the present purpose, the key parameter is α which determines the rate of growth of SS with time. Taking derivatives with respect to time,

$$\frac{dS}{dt} \sim \frac{e^{t^{\alpha\alpha}}}{t^{\alpha\alpha-1}}$$

Fitting the model to the logarithm of the S&P500 since 2015 as shown in exhibit 3 shows that $\alpha = 0.72$, i.e. the index level grows as $S \sim e^{t^{\alpha\alpha}} \sim e^{t^{0.72}}$. Compare this to a Black-Scholes world, where due to the assumption of the ability to create a continuous hedge using the underlying, the rate of change of the market is a linear function of time proportional to the difference between the interest rate and the dividend rate. For a market in a “melt-up” phase then the pricing of call options will then be attractive if linear drift is replaced by the power-law drift.

One final motivation for upside tail hedging emerges from the role that options markets play in enforcing investment discipline and time consistency for risk management purposes. The well-known “disposition effect” has been studied extensively (Shefrin 1985) in the literature and documents that unless there is a mechanism to enforce time-consistency in investment decisions, an investor who initially plans to let his profits run in the event of a large, low probability gain, is very likely to change his mind mid-way to the gain being realized (Barberis 2012). On the other hand, even though the investor plans to “stop-out” of the trade when faced with losses, it is observed that once confronted with small losses, investors tend to change their mind and stay with the losing position in contradiction to their initial plan. Thus, even in the case of a 50/50 bet, it is possible to ex-ante create a strategy where the stop-loss rule enables the investor to create a positively skewed investment plan. But while initially the investor plans to stay invested while profitable, and exit as soon as he has a loss, due to the combination of time-inconsistency and absence of a commitment device he ends up violating this initial plan and exits too early when winning and stays too long while losing. Entering a long position through call options does not completely eliminate the tendency to take profits too early, but by building in a finite loss

right at the inception of the trade, which is limited to the maximum premium paid, provides one mechanism by which large losses cannot accumulate. This is similar to the motivation discussed in Bhansali 2008 for pre-committing using left tail hedges when faced with the problem of keeping losses contained. Call options thus provide a pre-commitment device to overcome the disposition effect, but more importantly contain the maximum loss when bull markets inevitably reverse.

Do Call Options Cost Too Much?

However valuable upside optionality might be from the perspective of a real-world investor, what can we say about the pricing and value in call options? In this section we take a fresh look at the pricing of call options using a simple and well-known model that allows for “up jumps” in the price process. Note that in the presence of large jumps, it is not possible to create a perfect local hedge, i.e. many of the assumptions of Black-Scholes are violated ab-initio, so option prices should be expected to be higher than they would be in the absence of jumps.

Assume that returns of the equity market follow a jump diffusion, i.e.

$$\frac{dS}{S} = \mu dt + \sigma dW + J dN$$

The expected log return after a time Δt is $(\mu + J\lambda)\Delta t$, where λ is the density of jumps in a unit time interval (e.g. number of jumps per year). For simplicity we assume that the jumps are of a constant size J . In the limit that the time interval goes to zero, the variance of the jump-diffusion for one large jump is then $\sigma_{\text{eff}}^2 = \sigma^2 + J^2\lambda$, i.e. jumps increase the volatility of the underlying process. In the jump diffusion framework (Merton 1976), the price of a call option is the weighted sum of call options with zero to many jumps, with the weighting equal to the Poisson

probability of observing that many jumps. In other words, the price of the call option CC_{JJJ} is the expected payoff weighted by the number of jumps:

$$CC_{JJJ} = e^{-r_{rrr}} \sum_{nn=0}^{\infty} \frac{(\lambda \lambda \lambda)^{nn}}{nn!} e^{-\lambda \lambda rr} EE[\max[S S^{nn} - KK, 0]]$$

The jump formula for a call option can then be written in terms of Black-Scholes options prices CC_{BBBB} as

$$CC_{JJJ} = e^{-\lambda \lambda tt} \sum_{nn=0}^{\infty} \frac{(\lambda \lambda tt)^{nn}}{nn!} CC_{BBBB}(SS, KK, tt, \sigma \sigma, \mathbb{m}_n)$$

Here $r_{rrn} = rr - \lambda \lambda (e^{JJ} - 1) \frac{nnJJ}{tt}$ is the compensated drift to account for risk-neutrality.¹

As an example, let us assume that the volatility of the traditional diffusion process is 12%, which is close to the realized volatility over the last few years in the S&P 500. Now faced with a

¹ In the more general case, which is not relevant for the current discussion, the jump size itself can be random. If the jump distribution is normally distributed with a jump volatility $\sigma \sigma_{JJ}$ then the formula for the call option becomes

$$CC_{JJJ} = e^{-\lambda \lambda tt} \sum_{nn=0}^{\infty} \frac{(\lambda \lambda tt)^{nn}}{nn!} CC_{BBBB}(SS, KK, tt, \sigma \sigma_{JJJ}, \mathbb{m}_n)$$

where $\sigma \sigma_{JJJ} = \sigma \sigma^2 + n \frac{\sigma \sigma^2 JJ}{tt}$ is the volatility adjusted for jumps and is strictly higher than the diffusion volatility.

significant change in fiscal policy, e.g. due to tax laws, protectionism, or any number of macroeconomic surprises, let us assume that the stock market has a 100 percent probability of one jump of 10%. Using just the diffusion based Black-Scholes formula, the price of a one-year option, 5% out of the money is computed to be approximately 2.9%. With the 10% jump, the price of this same option is computed to be 4.23%, or approximately 50% higher. As another example, for a one-month horizon, the 5% out of the money call option according to a jump model would cost almost four times as much if the jumps were appropriately priced! None of this is new knowledge, since it is well known that the “smile” in the option volatility surface is very steep for shorter dated options. However the focus of the investment industry has been on down, rather than up, jumps.

If “up-jumps” are not priced in the market price of options, market participants may thus erroneously believe that they can hedge their upside exposure by trading continuously. While the assumptions of the ability to dynamically hedge were found to be seriously flawed in the market crash of 1987, the dearth of equity market melt-ups still provides many participants the comfort that they can hedge their upside risk by continuous trading, which has resulted in the asymmetric index option skew of Exhibit 2. Anecdotally, in the last few years we have observed “up-jumps” in international markets such as the Shanghai (2015), and Japan (late 2017). The put-call pricing asymmetry is reflected in the relative pricing of options, and hence in the implied volatilities corresponding to different strikes. For example, the CSFB “Fear Barometer” measures investor sentiment for a 3-month horizon by pricing a “zero-cost” collar (selling an upside call to purchase a downside put). The fear barometer represents the strike of an out of the money put that can be bought by selling a 10% out of the money call. If the value of the fear barometer falls, this implies that the strike of the put that can be purchased is closer to at the

money, i.e. that the market “feels” less fearful. In other words, the volatility skew can be interpreted as the extra premium a seller of the option requires in order to mitigate the risk that he might not be able to hedge his risk by trading in the underlying.

To address how up jumps impact the volatility skew, let us assume that the risk free rate is zero and there is only one large jump of size J . Then, with current index price of SS and a small probability pp of up jump and probability $1 - pp$ of small down move DD , risk-neutrality requires

$$SS = pp(SS + JJ) + (1 - pp)(SS - DD)$$

i.e.

$$DD = \frac{pp}{1 - pp} JJ \sim ppJJ$$

If we assume that $pp \ll \sigma\sigma\sqrt{tt} \ll JJ/SS$, i.e. the jump probability is much smaller than the diffusion volatility and the percentage size of the up jump, then we can show that close to at the money the price of a call option with strike KK under jump diffusion with only one jump is given by

$$C_{JJJ} \approx C_{C_{BBB}}(SS, \sigma\sigma) + ppJJ \left(\frac{1}{2} - \frac{1}{\sigma\sigma\sqrt{2\pi tt}} \ln \frac{SS}{KK} \right)$$

Note that the risk to an option market maker emanates from the mistake in estimating the “gamma” of an option between the jump based model and the Black-Scholes model. This is derived by taking the second derivative of the option prices with respect to the underlying and equals

$$\frac{\partial^2 C_{JJJ}}{\partial SS^2} - \frac{\partial^2 C_{C_{BBB}}}{\partial SS^2} = \frac{JJpp}{\sqrt{(2\pi tt)SS^2\sigma\sigma}}$$

Thus, when volatility is low, the gamma or the rate of change of delta of the option priced under jumps will be much larger than the option priced under Black-Scholes. If the product of the jump magnitude and probability increases, the gamma increases rapidly.

This equation illustrates why melt-ups in the markets may result in a feedback loop from the destabilizing influence of options based hedging. In particular, since call option volatility has been very low for an extended period of time, it is likely that the destabilizing influence of call options could be significant. If many participants are hedging their call options using Black-Scholes, and there is sharp increase in the likelihood of a large upward jump, then the need for extra hedging can propel the underlying market rapidly higher, as has been observed recently in the S&P500. Note that by put-call parity, at the money put options would suffer the same risk of hedging mismatch if the market were to suddenly jump down.

To translate the result into Black-Scholes volatility (which is market convention) we could set the jump price of the call to its Black-Scholes price with a volatility Σ , i.e.

$$C_{JJ} = C_{BS}(S, \Sigma) \approx C_{BS}(S, \sigma) + (\partial C_{BS} / \partial \sigma)(\Sigma - \sigma)$$

Solving this equation, we obtain that the adjusted volatility that needs to be plugged into Black-Scholes to recover the effect of the skew is

$$\Sigma = \sigma + \frac{pJ}{S\sqrt{t}} \left(\frac{\pi}{2} + \frac{1}{\sigma\sqrt{t}} \ln \frac{K}{S} \right)$$

Some observations from this result:

- “*Spot UP, Vol Up*”: As the probability of an up jump or the size of a jump increases, the volatility increases as a function of the product of the jump probability and the jump

magnitude. So if there is a large positive shock expected due to increased probability of the shocks, volatility will increase very rapidly if pp and JJ are positively correlated. This phenomenon is typically called “spot-up, volatility-up” in trader’s parlance, since it implies a rise in implied volatility as the markets rally, which has been considered anomalous since the 1987 crash. We see that with large positive jumps, the result is not all that surprising.

- *Impact on Term Structure of Skew:* As SS increases, or the time tt to expiry increases, the jump-adjusted volatility falls. So the jump risk is a major risk for shorter dated options, and less so as the horizon increases. As an insurance policy, shorter dated call options are thus likely to be more responsive to jump risks. Sudden unexpected positive shocks can then create rapid short term changes in the volatility smile.
- *Effect of Low Volatility Environment:* When the volatility is low, i.e $\sigma\sigma$ is small, the correction to the Black-Scholes volatility from jumps is larger as compared to when volatility is already at a high level. In other words, the potential for upside dislocation and need for upside hedges is more pronounced when starting from low volatility levels as are prevalent today. This last point is important because the combination of low volatility and high skew in index options has induced volatility selling strategies that have a large risk asymmetry to the upside. For example, since the volatility of the call options is much lower than the volatility of the put options, to make a 3 month zero cost strangle using 5% out of the money options, more than twice the number of calls than puts have to be sold. The equation for negative gamma then highlights the fact that delta hedging risk is more acute on the upside.

Conclusion

I discuss both the empirical and theoretical need for upside tail risk hedging. Under the current environment of large potential positive economic and political shocks that can impact markets, right-tail hedging is a risk management strategy whose importance is likely to increase. When markets have the potential for “up-jumps”, right –tail hedging using call options can provide investors with an approach to manage their exposure. In our previous discussion of left-tail hedging (Bhansali 2008), I discussed some macro features of tail hedging. First, left tail risk is a systematic risk, and increases as correlations increase. Since the variance of an index is the weighted average of the sum of variances and co-variances, left tail risk increases if either the variances increase or correlations increase. The reason correlations increase for large downward shocks is generally due to the impact of deleveraging. It is generally assumed that for large positive increases in equity prices correlations do not rise as much. These assumptions are likely on less solid ground today both because of major macro-economic shocks that can result in positive correlations, and due to the low levels of volatility that can be potentially destabilizing on the upside.

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IMPORTANT DISCLOSURES

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