Overreaction in Implied Volatility Jumps

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Abstract

We examine jumps in implied volatility of equity options. Based on single stock options in the US market from 1996 to 2023, we find that on average such jumps represent an overreaction of the market. This conclusion is based on two observations: First, the realized volatility risk premium (implied minus realized volatility) rises to a significantly abnormal level after a volatility jump. This methodology uses Black-Scholes implied volatilities. However, second, also (model-free) delta-hedged option returns rise to abnormally high levels after volatility jumps.

JEL Classification

G13 *General Financial Markets: Contingent Pricing, Futures Pricing,*

Keywords

Option pricing, jump risk, volatility jump, volatility short position, overreaction, volatility risk premium, delta-hedged returns

1 Introduction

Observed option prices reflect market participants' expectation of future stock price volatility. In this paper we analyze jumps in (at-the-money) implied volatility time series of US stocks. Usually, sharp increases in implied volatility happen according to news events that increase uncertainty about the respective firm's development. Market participants react to increased uncertainty by demanding higher prices for options. We argue that, on average, the market *overreacts*.

From equity index options, a negative variance risk premium, defined as the difference between variance expectation under the physical and the risk-neutral measure, is well documented (Jackwerth and Rubinstein, 1996; Buraschi and Jackwerth, 2001; Coval and Shumway, 2001). Thus, the implied volatility is, on average, higher than the subsequently realized volatility. For single stock options, evidence for a variance premium was weaker (e.g., Carr and Wu, 2009), however, recent studies provide stronger support (Hollstein and Wese Simen, 2020). In this paper, we take a closer look at the variance risk premium after the occurrence of a volatility jump. A volatility jump reflects a sudden shock in information uncertainty about the underlying stock price. We hypothesize that the market overreacts to such an information shock. Under this hypothesis, the (negative) variance premium, i.e., the difference between implied and realized variance, rises to an abnormal level after a volatility jump.

For equity index options, a model-free implied variance can be derived based on a series of option prices with different strikes (Britten-Jones and Neuberger, 2000). For the majority of single stocks, this is however not possible because of the scarcity of liquid option prices. For a first insight, we therefore rely on at-the-money Black and Scholes (1973) implied volatilities, considering the "volatility risk premium" as the difference between realized and model-implied volatility.

We test the overreaction hypothesis empirically based on US equity options from 1996 to 2023 with data taken from the OptionMetrics IvyDB database. Unconditional on jumps, we observe a monotonic increase of the volatility risk premium in the implied volatility level. For example, for an implied volatility of 50%, the average subsequent realized volatility (over a 30-days horizon) is 44%, meaning a volatility risk premium of 6% for that level. For an implied volatility of 100%, this premium rises to a level of 20%.

After a volatility jump, we indeed observe significantly higher premiums. We identify jumps in the implied at-the-money volatility time series from OptionMetrics, adopting the metric proposed by Lee and Mykland (2008) for stock price jump detection. We calculate abnormal volatility risk premiums, defined as realized premiums after a jump minus expected premiums given the implied volatility level and the calendar time. When volatility jumps to a level of 50%, for example, the average subsequent realized volatility is only 39%, meaning a volatility risk premium of 11% and, given the expectation of 6% unconditional on a jump, an abnormal premium of 5%. We also find that this abnormal realized volatility risk premium increases with the implied volatility level (up to a level of 100%).

While these results rely on the Black and Scholes (1973) model, as a second, model-robust approach, we analyze delta-hedged option returns (Bakshi and Kapadia, 2003). Given a negative variance or volatility risk premium, a strategy of writing an option and hedging the position against underlying movements should result in positive average returns. In our sample, the unconditional relation of delta-hedged returns to the implied volatility level is not as pronounced, however, we also observe an increasing pattern. Unconditional on a jump event, the average delta-hedged return on shorting a 30-days at-the-money call or put is about 3% (with respect to the option price). This figure rises after a volatility jump to about 10% for calls or 6% for puts, respectively. Thus, we can confirm abnormally high delta-hedged returns after jump events, controlling for the implied volatility level (after the jump) and calendar time.

Our research builds on the literature on the volatility risk premium. The existing literature mainly focuses on index options, in particular S&P 500 options as the most liquid market segment. Option liquidity is necessary for a robust computation of model-free volatility and synthetic variance swaps. Todorov (2010) analyzed the volatility risk premium around jumps in the index level and found a significantly higher premium for such events.

While the existence of an index volatility risk premium is widely accepted, Carr and Wu (2009) and Driessen et al. (2009) did not find a significant variance risk premium for single stock options. Later Hollstein and Wese Simen (2020) showed that the insignificance for single stocks occurred due to measurement errors influencing the calculation of synthetic variance swap rates. Adjusting for these errors yields a volatility risk premium also for single stocks.

Stock price models with volatility jumps are so far underrepresented in common literature so that empirical results about volatility jumps are quite rare. Jacod and Todorov (2010) introduced a test about the relation between price jumps and volatility jumps. They found evidence that most S&P 500 price jumps are mostly associated with jumps in volatility. Todorov and Tauchen (2011) introduced a test whether the volatility process contains jumps within a time period for high frequency data.

Our hypothesis suggest that volatility jumps are accompanied by some kind of market overreaction. The research in the field of market overreaction of traders has been heavily influenced by the milestone paper of de Bondt and Thaler (1985). They have shown in their empirical study that recent winner companies at the stock market tend to under perform over the next several month to years and vice versa. This matches with the suggestion of Kahneman and Tversky (1979) that individuals tend to overweight recent information. In the short-term setting with daily returns, similar results of abnormal returns pointing towards an overreaction have been found by Atkins and Dyl (1990) and Cox and Peterson (1994), both with the additional result that abnormal returns have not been exploitable due to transaction costs.

The remainder of the paper is structured as follows: Section 2 summarizes Literature methods and results regarding the volatility risk premium and delta hedged returns of single stock options. In Section 3, we introduce the database used for the empirical analysis. Further, we provide an overview over the included single stocks and deduce the statistic that we use to determine implied volatility jumps. In Section 4 we analyze the volatility risk premium for single stocks and test for an abnormal volatility risk premium after volatility jumps. In Section 5, we look at delta-hedged returns and confirm the previous finding with a model-free analysis. The results are summarized in the conclusion in Section 6.

2 Related Literature

In order to distinguish between an observed overreaction, explainable price behaviour and already known anomalies, it is important for us to be familiar with previous research findings on delta hedged returns of single stock options. Some of the explanatory factors for delta hedged returns that have already been discovered interact with our explanatory variable, the occurrence of an implied volatility jump. Therefore, our research on delta-hedged returns following implied volatility jumps will also include regressions to determine whether our observed effect significantly exceeds the effect explained by previously discovered factors in a future version.
In the table 1 we summarize some previous key results about single stock delta hedged returns and additionally the methodology applied to observe these results. Thus we can use a similar delta hedged return calculation for our empirical analysis.

[Insert Table 1 about here.]

The effect of several different known anomalies on delta hedged returns has been tested recently by Hollstein and Wese Simen (2025). They found significant impact on delta hedged returns of single stock options by for example the idiosyncratic volatility, IV slope and the volatility of volatility. These parameters are all likely to interact with implied volatility jumps.

3 Data and Descriptive Statistics

3.1 Option and Stock Price Data

The main data set is the Option Metrics Ivy-DB US 6.0 options database that includes end-of-day option prices for US equity options from 1996 to August 2023. We exclude option prices that violate no-arbitrage bounds and options prices where no implied volatility could be computed by Option Metrics. Stock prices, short-term interest rates, option deltas, and implied volatility are also derived from the Option Metrics database. We exclude all options with an underlying that is not a single stock.

The realized volatility used to calculate volatility risk premiums is deduced from the log total returns of Option Metrics stock prices that include dividends and new shares.

For the implied volatility we use Option Metrics' standardized option, taking the mean of the call and put options' implied volatility where the maturity is in 30 days and the absolute delta is 0.50.

We apply an additional filter for every underlying to only include implied volatility data from days where there has been observed at least one option satisfying:

- bid price > 0.5 \$ and
- open interest > 0 and
- 30 days $\leq$ maturity $\leq$ 60 days.

Descriptive statistics of the so calculated implied and realized volatility are given in Table 2. The data exhibit a first impression of the volatility risk premium: Based on the median, the implied volatility is about 7 percentage points higher than the realized volatility.

[Insert Table 2 about here.]

3.2 Volatility Jump Detection

For identifying volatility jumps, we consider the implied volatility time series of standard options (30 days expiry, delta 0.5) provided by OptionMetrics. We adopt the test statistic developed by Lee and Mykland (2008) to detect jumps in stock prices:

$$\Pi(i,t) = \frac{V(i,t) - V(i,t-1)}{\hat{\sigma}(i,t)} \tag{1}$$

with

$$\hat{\sigma}^2(i,t) = \frac{1}{K-2} \sum_{s=t-K+2}^{t-1} |V(i,s) - V(i,s-1)| \cdot |V(i,s-1) - V(i,s-2)|. \tag{2}$$

In our setting, V is the implied volatility level. For K, the number of observations before the observation day that should be included in the statistic, Lee and Mykland (2008) propose 16 days. This test statistic intuitively includes relates the change in the volatility level to a measure of normal variation during recent trading days.

Table 3 provides details on the distribution of this test statistic. Lee and Mykland (2008) propose a threshold of 4.6 for a jump. However, compared to stock price series, volatility time series themselves are more volatile. We therefore rely on a threshold of 6.9, meaning 50% higher than Lee and Mykland (2008). With this threshold, a volatility jump occurs in 0.69% of all stock-day observations.

[Insert Table 3 about here.]

Figure 1 displays the number of stocks in the sample over time (black line). Further, the gray bars show the number of jump events per day (different scale), based on the threshold 6.9 for the Lee and Mykland (2008) statistic. On most days there are only a very few underlyings with a jump, whereas some market-wide, systematic events like the financial crises and the corona pandemic show up with a large number of individual jumps.

[Insert Figure 1 about here.]

4 Volatility Risk Premium

4.1 Calculation

The standard approach to estimate the volatility risk premium is to calculate synthetic variance swap rates and realized returns of synthetic variance swaps. This procedure has the advantage of being model-free. The disadvantage is the rather large amount of strike prices with reliable price data that is needed to consistently calculate synthetic variance swaps. Therefore, an application of this method to single stocks is not possible, except for the largest components of the S&P 500 (Carr and Wu, 2009; Hollstein and Wese Simen, 2020).

Thus, we have to rely on a valuation model. OptionMetrics provides implied Black and Scholes (1973) volatilities for a range of standard options, defined by their expiry date and option delta. We proxy the risk-neutral expected volatility over 30 days with OptionMetrics' implied volatility for at-the-money options, given by an absolute delta of 0.50, and averaging between call and put volatility. The realized volatility is calculated as the annualized standard deviation of the logarithmic returns of the corresponding stock until the option expiry date in 30 calendar days. The realized volatility risk premium for stock i at time t results as the difference

$$VRP(i,t) = IV(i,t) - RV(i,t). \tag{3}$$

This approach for computing the volatility risk premium has the advantage of requiring not as many data as the calculation of variance swap rates, since only at-the-money options are required. The major disadvantage is the dependency on the Black and Scholes (1973) model. We address this issue in Section 5 by analyzing delta-hedged returns instead.

Figure 2 shows the average realized volatility risk premium as a function of the implied volatility level. Each data point represents an average of two percent of the overall data, grouped by implied volatility.

[Insert Figure 2 about here.]

We observe a clear relationship between the implied volatility level and the volatility risk premium. This relation is monotonically increasing and convex. For implied volatility levels up to 100%, a simple regression shows that the relation is well described by the quadratic function

$$VRP(i,t) = 0.187\, IV(i,t)^2 + \epsilon(i,t). \tag{4}$$

Assuming a standard u-shaped volatility smile, the applied at-the-money volatility should be close to the minimum of the implied volatility function. Thus, the Black and Scholes (1973) volatility we use should underestimate the actual implied volatility resulting from variance swap rates. The actual volatility risk premium would therefore be even larger than the values shown in Figure 2.

4.2 Volatility Risk Premium and Volatility Jumps

We now analyze whether a jump in implied volatility is an overreaction in the sense that the realized volatility risk premium after the jump is larger than expected. To this end, we calculate an expected volatility risk premium based on the results of the previous subsection as a function of the implied volatility level.

Moreover, the expected risk premium may vary over time. We therefore do not use the estimated function (4) as an expected value, but rather follow an non-parametric approach. The expected value is estimated as an average over all realized risk premiums within 60 days before the observed events for implied volatility levels that deviate no more than two percentage points from the implied volatility level at the event:

$$E[VRP(i,t)|IV(i,t),t] \hat{=} \frac{1}{N_{i,t}} \sum_{\substack{(j,s):\, t-60 \le s < t \,\wedge \\ |IV(j,s)-IV(i,t)| \le 0.02}} IV(j,s) - RV(j,s), \tag{5}$$

where $N_{i,t}$ is the number of pairs (j,s) that fulfill the condition under the sum operator.

The *abnormal volatility risk premium* is then the difference between the actual (realized) risk premium and this expectation:

$$AVRP(i,t) := VRP(i,t) - E[VRP(i,t)|IV(i,t),t]. \tag{6}$$

We hypothesize that the abnormal volatility risk premium *on volatility jump days* is positive on average.

Figure 3 shows the observed abnormal volatility risk premium after an implied volatility jump as a function of the implied volatility level (after a jump). The jump is defined by the Lee and Mykland (2008) statistic with a threshold of 6.9. Similar to Figure 2, each data point represents an average of five percent of the overall data, grouped by implied volatility.

[Insert Figure 3 about here.]

For all implied volatility levels, we observe a significant positive abnormal volatility risk premium. Up to implied volatility levels of 100%, the relation is monotonic and almost linear with a steep ascent. At a level of 50%, the abnormal risk premium amounts to 6% and thus almost doubles the unconditional risk premium.

We thus find strong support for the overreaction hypothesis: When implied volatility jumps, this jump is “too high” on average. This means that the subsequently realized volatility is abnormally smaller, compared to average realized volatility for the same implied volatility level without a previous jump.

5 Delta-hedged Returns

5.1 Methodology

The observed abnormal volatility risk premium heavily depends on the Black and Scholes (1973) model. In this section, we therefore directly look at option prices instead of model-dependent values. A positive abnormal volatility risk premium should result in abnormal returns from shorting options after volatility jumps.

Shorting options is equivalent to “selling volatility”. However, options are not only subject to volatility risk, but also to price risk. A common methodology to eliminate price risk from an option strategy is based on delta-hedging, as pioneered by (Bakshi and Kapadia, 2003). Such a strategy hedges price risk of options with a position in the underlying, which is adjusted on a regular basis.

To test for overreaction *in option prices* in correspondence with a volatility jump, we calculated delta-hedged returns for call and put options written on the event day and held until expiry. We focus on the most liquid options for each stock, which are short-term near-the-money options. Thus, we choose the respective out-of-the-money call and put with strike price closest to the underlying spot price and expiry closest to 30 calendar days from the event day. The delta-hedge is adjusted on a daily basis. The return is calculated with respect to the option price at the event day. For comparison, it is linearly rescaled to 30 calendar days.

For a call option written at time t with strike price X expiry date T, the delta-hedged return is given by

$$dhr(i,t) = -\frac{(S_{i,T} - X)_{+} - call_{i,t} \cdot e^{r_t(T-t)} - \sum_{s=t+1}^{T} \Delta_{i,s-1} \cdot (S_{i,s} - S_{i,s-1}) \cdot e^{r_{s-1}}}{call_{i,t} \cdot \frac{T-t}{30}} \quad (7)$$

where $call_{i,t}$ is the mid price of the selected call for underlying i at the event day t, $\Delta_{i,s}$ is the delta of this call at time s and $S_{i,s}$ is the closing price of the underlying i at day s. r_s is the short-term daily continuous interest rate at time s.

For puts, the approach is analogous. To avoid corresponding biases, we exclude observations that would include dividends or splits before option expiry.

As with the realized volatility risk premium, we are interest in *abnormal* delta-hedged returns after a volatility jump. To this end, we will relate these returns to their "normal" expected value. As a preparation, we therefore calculate delta-hedged returns for all stock-day observations. We only include option observations that show a positive trading volume on the observation date with close prices that do not violate no arbitrage bounds. Options with a bid price below 0.50 $ are excluded. Table 4 shows descriptive statistics for calls and puts.

[Insert Table 4 about here.]

On average, delta-hedged returns are positive for the writer of the option, in line with a positive difference between implied and realized volatility. For both calls and puts, the average is about 3%, however, with a large standard deviation.

As with the volatility risk premium, we take a look at the dependency of delta-hedged returns on the implied volatility level of the specific option. Figure 4 shows this relation. Each data point represents an average of five percent of the overall data, grouped by implied volatility.

[Insert Figure 5 about here.]

We do observe an increase in the delta-hedged return with rising implied volatility level. However, this increase is not as pronounced as for the volatility risk premium in Figure 2.

5.2 Delta-hedged Returns after Volatility Jumps

According to the overreaction hypothesis, we would expect abnormally high delta-hedged returns from selling volatility after a volatility jump. Analogously to the volatility risk premium, we define an *abnormal delta-hedged return* as

$$Adhr(i,t) = dhr(i,t) - E[dhr(i,t)|IV(i,t), t]. \tag{8}$$

The expected value is again a local estimate:

$$E[dhr(i,t)|IV(i,t), t] \hat{=} \frac{1}{N_{i,t}} \sum_{\substack{(j,s):\ t-60 \leq s < t\ \wedge \\ |IV(j,s) - IV(i,t)| \leq 0.02}} dhr(j,s). \tag{9}$$

Hence, we take the average of all delta-hedged returns observed up to 60 days prior to the event day with a difference in implied volatility of up to 2%.

Again, we identify volatility jumps according to the Lee and Mykland (2008) statistic $\Pi(i,t)$ with a threshold of 6.9. Figure 5 shows abnormal delta-hedged returns with respect to the implied volatility level on jump days.

[Insert Figure 5 about here.]

For calls, the abnormal return is positive for all implied volatility buckets. The pattern is increasing in the implied volatility, with a concave shape. The average abnormal return amounts to 5%, which is huge given the average unconditional delta-hedged return of 3.24% according to Table 4. For puts, the abnormal return is less pronounced both in absolute values and in the functional form. However, it is also significantly positive over all observations.

Summing up, the model-free results from delta-hedged returns confirm the overreaction hypothesis: After volatility jumps, option traders can earn abnormally high return from selling volatility, i.e., shorting options.

xxx hier käme dann die Lit zu delta-hedged returns ins Spiel: Man müsste eine Regression in der Art

$$dhr = \alpha + \beta_0 * 1_{JUMP} + beta_1 * 1_{JUMP} * IV + \gamma_0 * IV + \gamma^T * Controls + \epsilon$$

oder ähnlich fahren, wobei Controls aus den in der Literatur identifizierten Faktoren besteht:

6 Conclusion

We find evidence for an overreaction in volatility jumps for single stocks. When implied volatility jumps, the size of the jump is too high on average, related to the subsequently realized volatility. More precisely, the gap between implied and physically expected volatility is larger than without a jump, controlling for the implied volatility level and calendar time.

These insights are based on Black and Scholes (1973) implied volatilities to deduce volatility risk premiums in option prices. While this methodology depends on the valuation model and is therefore prone to biases, we find clear patterns in the volatility risk premium that shows a convex increase in the implied volatility level. Our results therefore also contribute to the controversy about the existence of a volatility risk premium for single stocks.

Leaving the model-dependent framework, we confirm the results based on delta-hedged option returns. A jump in implied volatility induces jumps in option prices. We find evidence that the size of these jumps is also too high on average. More precisely, option traders can earn higher return from selling volatility (i.e., shorting options) after a volatility jump than in normal situations, controlling for the implied volatility level and calendar time.

These findings leave several questions for future research. A natural extension would be to distinguish between idiosyncratic, stock-specific jumps and market-wide events. Another point is the interpretation of the results as an "overreaction". Predominantly, option prices are made by market makers. Maybe the observed overreaction goes in line with a widening of the bid-ask spread. Analyzing the spread behavior after a jump and relating it to the increase in option prices would thus be another promising way to extend the results of this paper.

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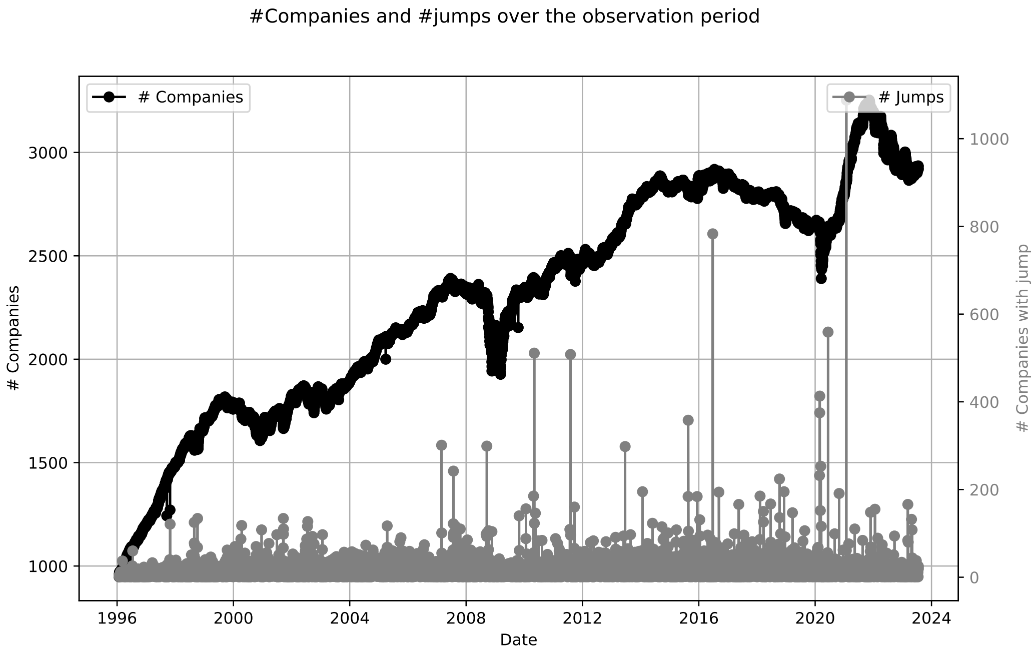


Figure 1. *Number of companies in the dataset (black line) and number of jumps with* $\Pi(i,t) > 6.9$ *per day (gray bars).*

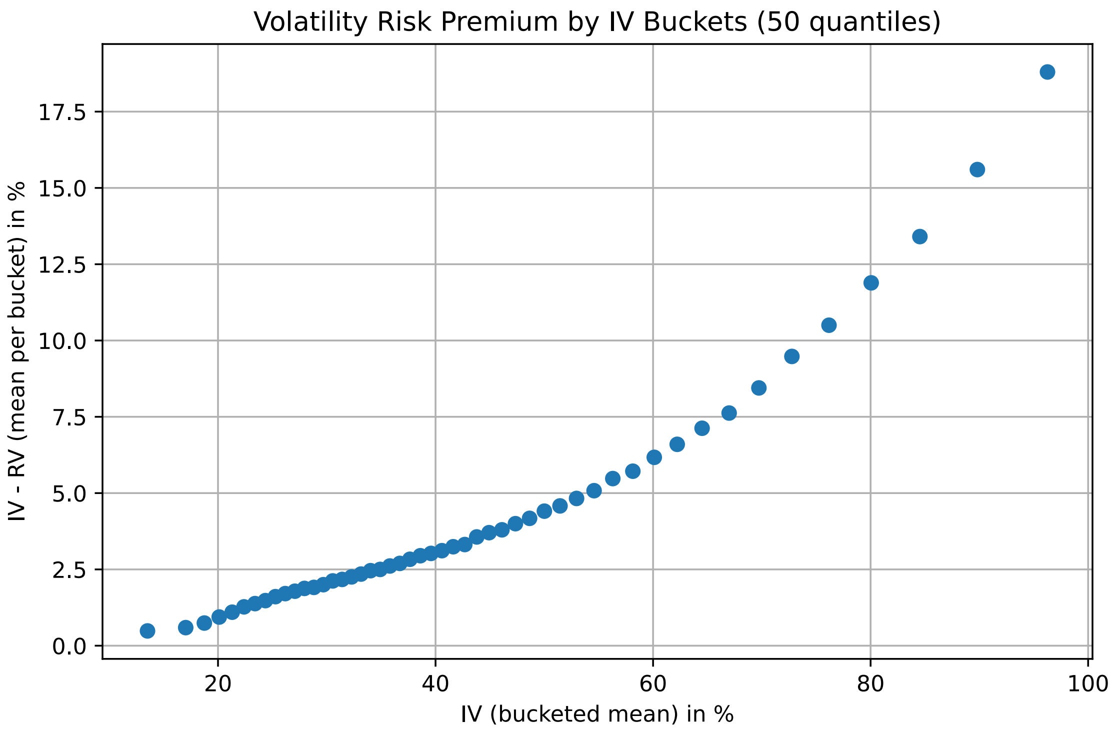


Figure 2. *Volatility risk premium grouped by implied volatility buckets. The premium is the mean difference between implied at-the-money volatility and realized stock volatility for 30 days.*

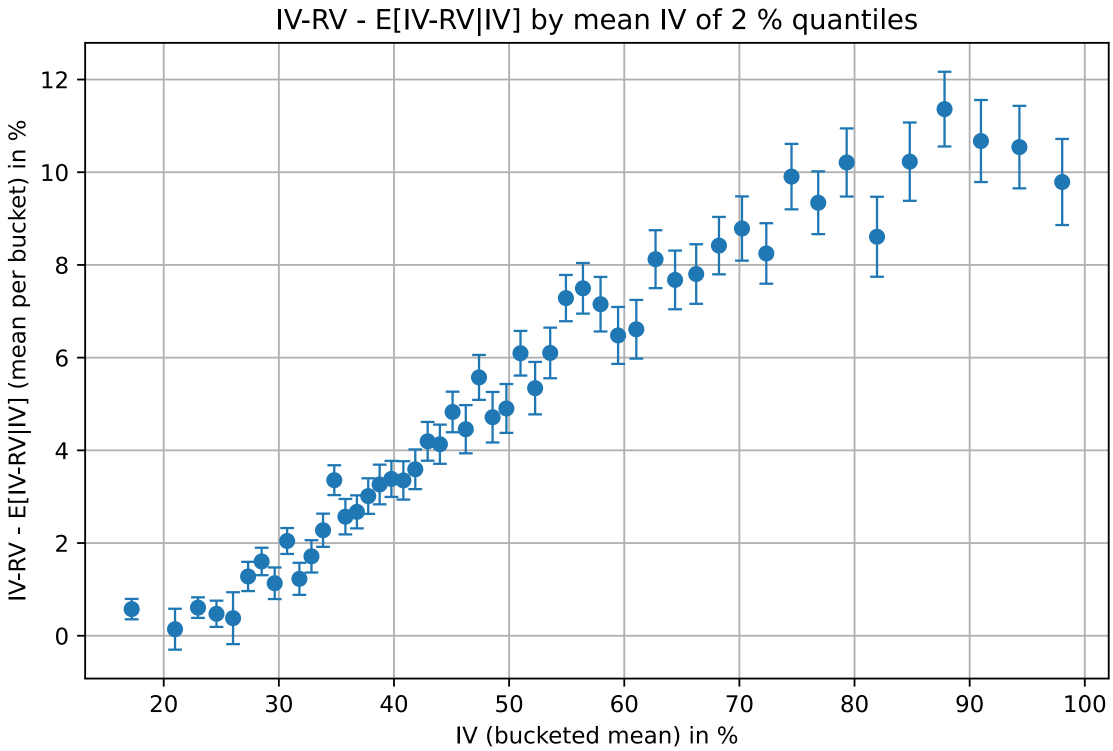


Figure 3. *Abnormal volatility risk premium grouped by implied volatility buckets, after volatility jumps. Jumps are identified by the Lee and Mykland (2008) statistic* $\Pi(i,t)$ *with threshold 6.9. The vertical bars represent standard errors for each bucket.*

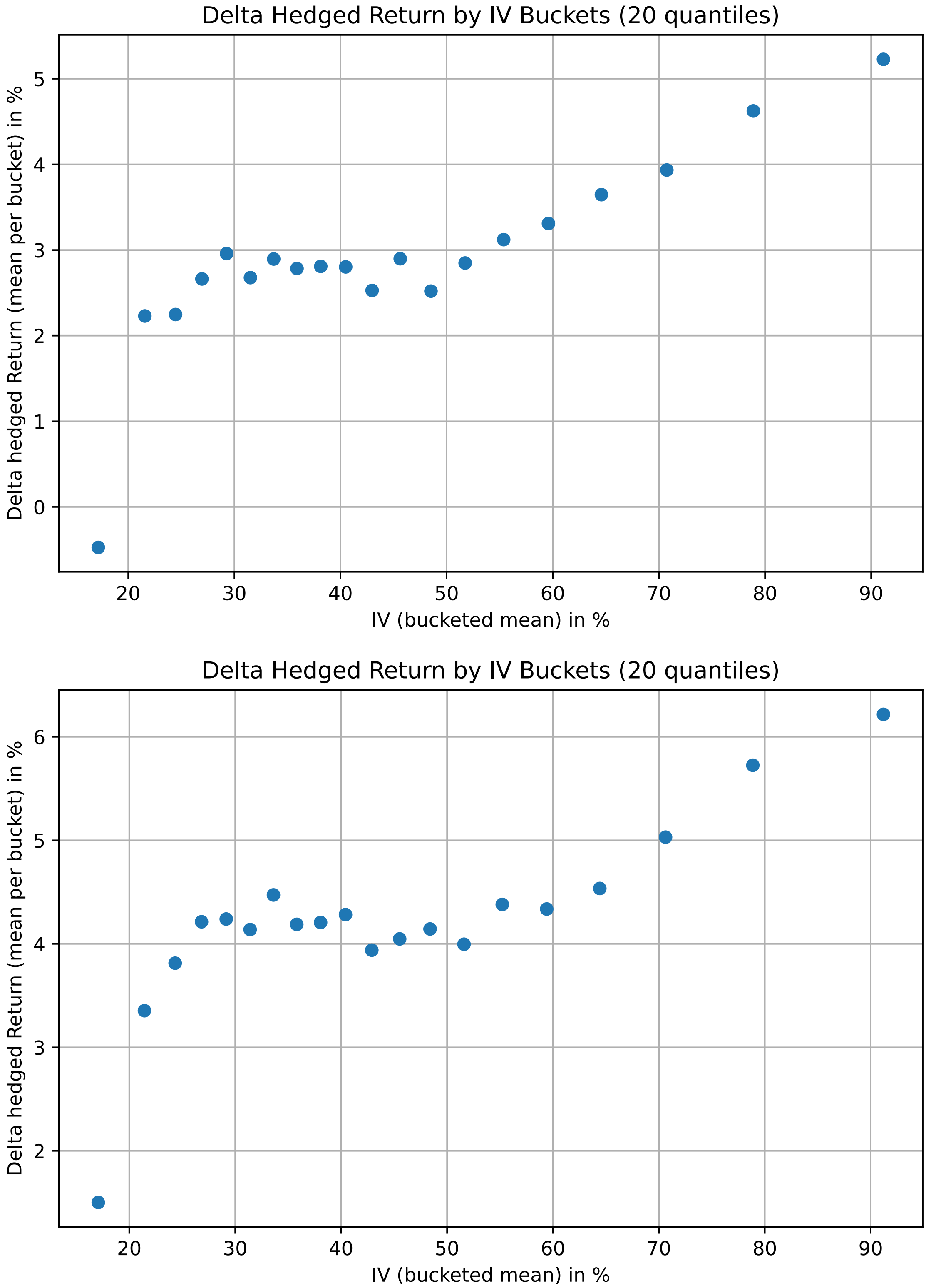
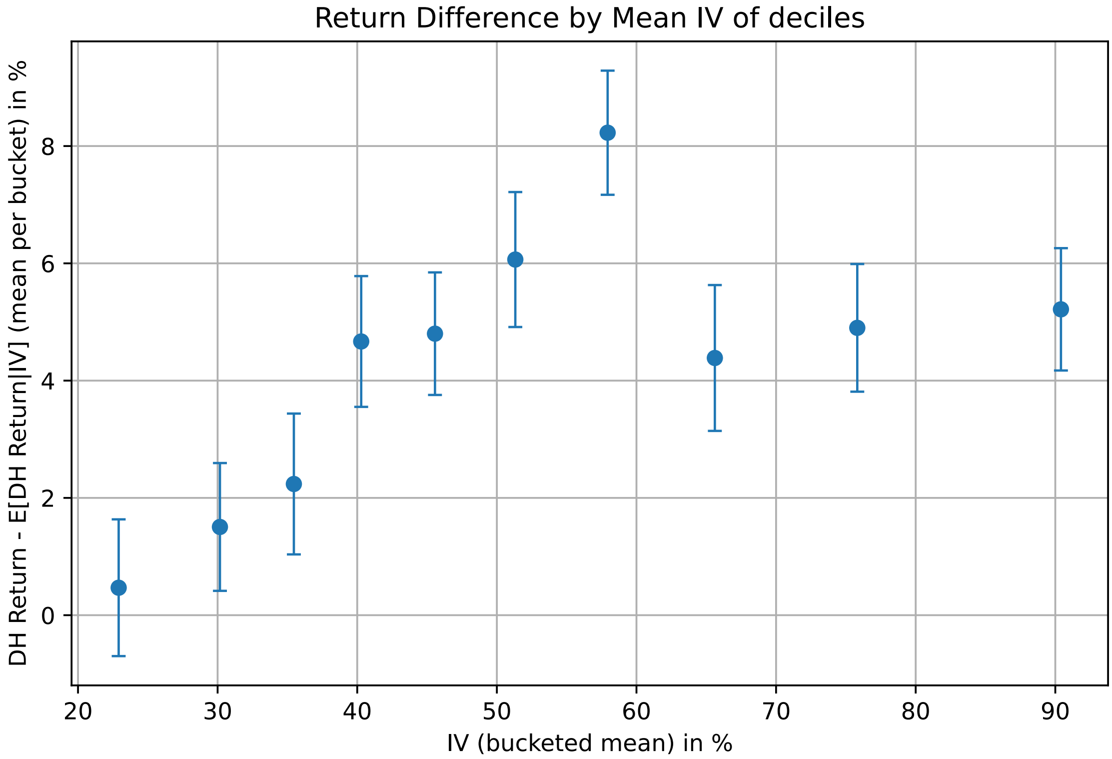


Figure 4. *Mean delta-hedged call returns (top) and put returns (bottom) on single US stocks in the observation period 1996–2023, grouped by implied volatility buckets.*



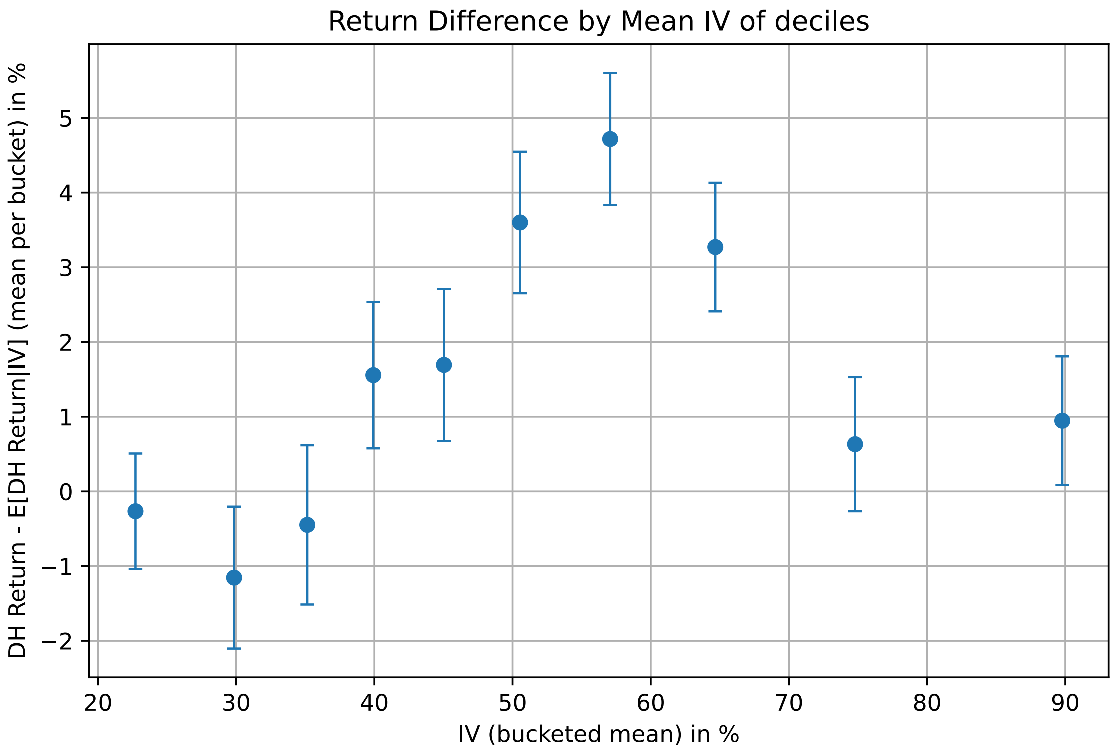


Figure 5. *Mean abnormal delta-hedged call returns (top) and put returns (bottom) on single US stocks in the observation period 1996–2023 after volatility jumps, grouped by implied volatility buckets. Jumps are identified by the Lee and Mykland (2008) statistic* $\Pi(i,t)$ *with threshold 6.9. The vertical bars represent standard errors for each bucket.*

Paper	Methodology	Key result regarding option returns
Tian and Wu (2023)	1 month ATM options holding to expiration with no, static or daily delta hedge, return normalized by stock price	One time delta hedge reduce std deviation of delta hedged returns by 70%, daily delta hedge by 90%
Bali and Murray (2013)	1 month ATM options, static delta and vega hedge, return normalized by option price	Strong negative relation between risk-neutral skewness and the skewness asset return
Vasquez (2017)	1 Week ATM Straddle Returns, 1-2 month to maturity options, return normalized by initial straddle price	Straddle portfolios with high slopes of the volatility term structure outperform straddle portfolios with low slope
Ruan (2020)	1-2 month ATM options, daily delta hedging, return normalized by stock price	The higher the Volatility-of-Volatility the lower the return
Boulatov et al. (2022)	Expiration to expiration ATM options, static delta hedge, return normalized by initial cost	Negative returns but low price stocks have significantly lower returns than high price stocks
Cao et al. (2023)	1-2-month ATM options, daily delta hedge, return normalized by initial cost	The higher the Volatility-of-Volatility the lower the expected return
Kanne et al. (2023)	Expiration to expiration ATM options, static delta hedge, return normalized by initial cost	Stock liquidity has a significant effect on option returns with sign depending on option demand
Goyal and Saretto (2025)	Expiration to expiration ATM options, daily delta hedge, return normalized by initial cost	3-factor-IPCA-model explains the majority of high delta hedged returns
Bali et al. (2025)	1-2-month ATM options, daily delta hedge, return normalized by initial cost	5-factor-Joint-IPCA can explain a large part of option returns, but other Asset classes are better integrated by the Joint-Factor-Model
Boyer and Vorkink (2014)	Option returns, no delta hedge, return normalized by option price	Options with high ex-ante Skewness have extremely negative returns
Goyal and Saretto (2009)	Expiration to expiration ATM options, static delta hedge, return normalized by initial cost	High Implied volatility minus historic volatility predicts more negative delta hedged returns
Hollstein and Wese Simen (2025)	Expiration to expiration ATM options, daily delta hedge, return normalized by initial cost	Option Return Anomalies are driven by variance risk premium and predictable changes in implied volatility

Table 1. *Relevant Literature methods and results regarding delta hedged returns of single stock options*

	IV	RV
count	18,429,587	18,429,587
mean	63.24 %	45.62 %
std	73.04 %	36.40 %
1 %	14.57 %	8.54 %
25 %	30.24 %	24.07 %
50 %	43.52 %	36.17 %
75 %	66.56 %	55.82 %
99 %	414.63 %	177.94 %

Table 2. *Descriptive statistic of the implied and realized volatility of US equity options between 1996 and 2023. Realized volatility is calculated as the annualized standard deviation of realized log total returns in the subsequent 30 calendar days.*

Panel A: Statistical Distribution							
count	mean	std	1%	25%	50%	75%	99%
18,264,401	0.10	6.72	-5.21	-0.69	0.00	0.69	5.81

Panel B: Jumps over Threshold					
threshold	4.6	6.9	10	15	20
count	302,996	125,637	57,640	26,411	15,929
percentage	1.66%	0.69%	0.32%	0.14%	0.09%

Table 3. *Descriptive statistics for the test statistic* $\Pi(i,t)$. *Panel A shows standard statistics. Panel B looks at the relevant right tail of the distribution and shows the number of observations that exceed given thresholds.*

	Calls	Puts
count	5,035,929	4,723,607
mean	3.24%	3.43%
std	144.53%	118.65%
1%	−152.60%	−153.96%
25%	−12.28%	−9.59%
50%	7.76%	8.25%
75%	26.59%	24.11%
99%	96.42%	84.36%

Table 4. *Descriptive statistic for delta-hedged option returns on single US stocks in the observation period 1996–2023.*