Gamma Scalping Trading Strategy

The University of Chicago
MS in Financial Mathematics
FINM 33150 - Quantitative Trading Strategies (Winter 2024)

Team: Nicholas Lee (ID: 12408152), Joey Recchia (ID: 12151786), Raafay Uqaily (ID: 12225382), Jesse Yan (ID: 12406982)

Executive Summary

- We explore a potential edge in leveraging a model-free approach to calculating implied volatility from [Jiang & Tian]
- We use this model-free implied volatility calculation in a gamma scalping trading strategy on SPY[1]
  - Initiate positions by buying or shorting both at-the-money[2] calls[3] and puts[4] with ~30 days to expiration as a straddle
  - Position decisions are guided by our calculated model-free implied volatility versus the implied volatility derived from the Black-Scholes (B-S) model[5]
  - Positions are typically closed after a week before expiration to reduce risk
  - Stock positions are rebalanced daily to maintain risk-neutrality, enabling us to scalp profits throughout the strategy's execution

Jiang, George J., and Yisong S. Tian. "The model-free implied volatility and its information content." Review of Financial Studies, vol. 18, no. 4, 2005, pp. 1305–1342, https://doi.org/10.1093/rfs/hhi027.

Implied Volatility

- Implied volatility is a forecast of a likely movement in a security's price
- The model-free implied volatility computes implied volatility directly from the prices of options across different strikes and maturities, without depending on any specific model assumptions unlike B-S
- The model-free implied volatility often disagrees with the B-S model values and is generally closer to the realized volatility

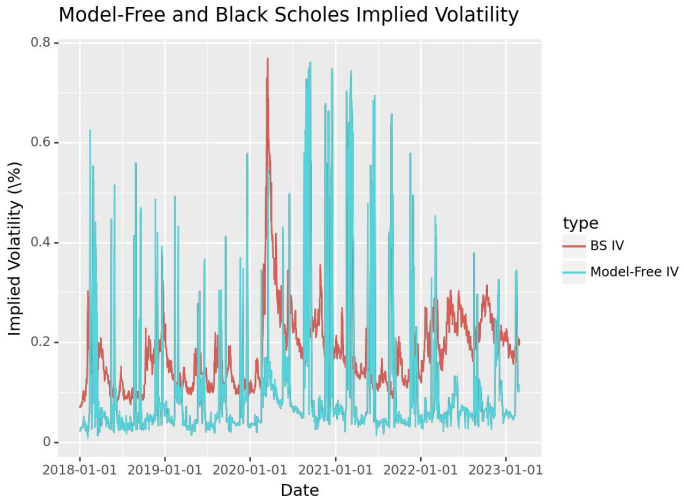


Figure 1. Time-series plot of the model-free and at-the-money B-S implied volatilities.

Gamma Scalping

- Gamma measures the rate of change in an option's delta for a one-point change in the price of the underlying asset
- Gamma scalping profits from short-term price movements in an asset by rebalancing positions to have a net-zero delta[7] position (ie. neutral to movement in asset price) while only having exposure to gamma
- Advantages include limited risk exposure to options' time decay and high potential for returns

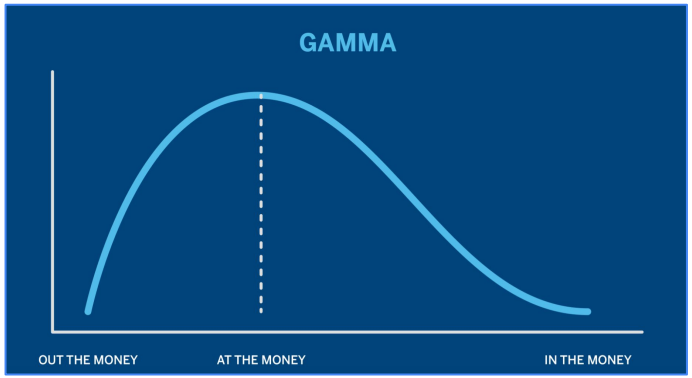


Figure 2. Sensitivity of gamma, noting that it is highest at-the-money.

Backtesting Data

- We selected the SPDR S&P 500 ETF Trust (SPY) for high liquidity in both the underlying and options markets, ensuring smooth entry and exit
- We selected contracts for at-the-money call and put options with ~30 days to expiration for each trading day
- We simulated our trading strategy from Jan 2018 to Feb 2023 to ensure our dataset reflects recent market dynamics and volatility patterns

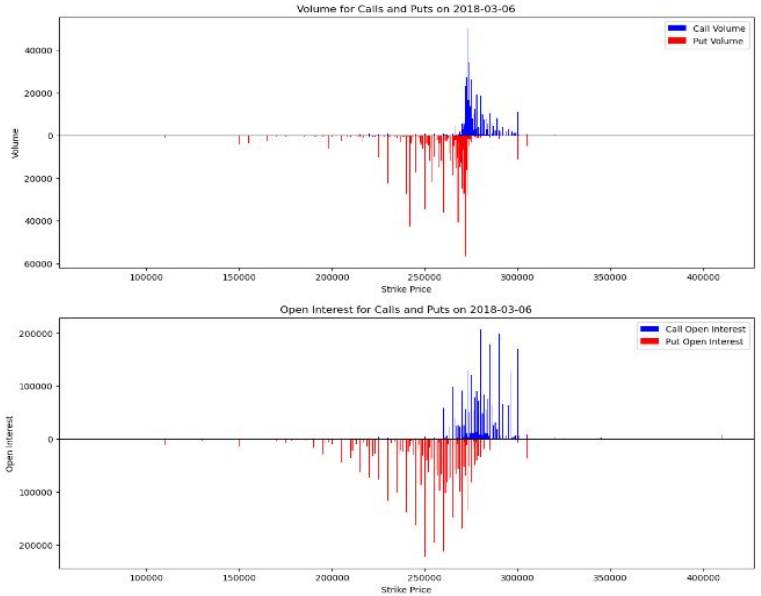


Figure 3. Sample distribution of volume and open interest for calls and puts on 03-18-2018.

Strategy Implementation

- Compare the B-S implied volatility to the model-free implied volatility to determine long or short entry position
- Analyze whether to enter a delta-hedged straddle
  - A straddle[7] reduces the required share count to initially delta-hedge and rebalance daily to maintain a zero-delta position, minimizing transaction costs
- Exit each straddle after a 3-week holding period
  - Removes the need to delta-hedge against volatile market movements in the week preceding expiration while realizing most gamma-related profits

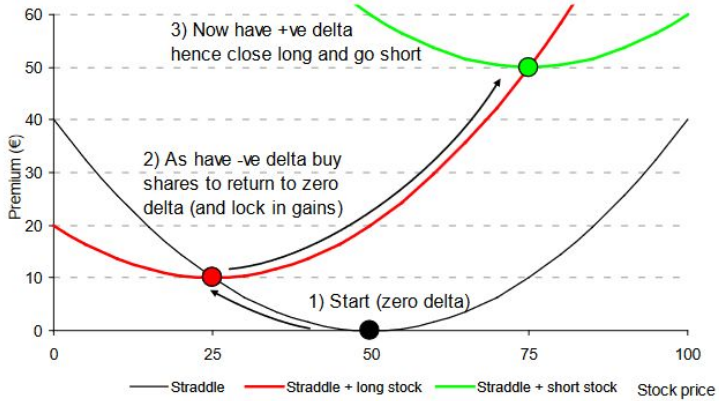


Figure 4. Visual representation of profiting from delta-hedging.

Backtesting Strategies

- Assume $1MM initial capital with $9MM available margin (10x leverage) for a total of $10MM starting capital
  - Earn interest on unused initial capital (risk-free rate)
  - Pay interest on used margin (risk-free rate plus 25 basis points)
- Test three trades on these delta-hedged straddles, which we open based on IV:
  - Strategy 1: Long-Short
  - Strategy 2: Long Only
  - Strategy 3: Short Only
- Size each trade according to the difference between our calculated model-free IV and the listed B-S IV, but no trade will exceed 10% of starting capital
- Assume 1 basis point in trading costs and pay interest to short shares
  - Risk-free rate plus 25 basis points
- Margin will be used more like a short-term borrowing facility to ensure we have enough liquidity to enter into trades, rather than purely as a source of leverage

Strategy Returns

- We regressed each strategy's returns against SPY
- As shown in the graph and the performance metrics, strategy 3 performed the best, almost mimicking SPY with significantly milder drops, whereas strategy 1 and 2 performed relatively poorly in comparison
- Strategy 3 had a sharpe ratio of 0.76, an alpha of 0.06, and an information ratio of 0.39

Strategy	Ann. Return	Ann. Vol	Sharpe Ratio*	Information Ratio	Beta	Alpha	R-Squared
Strategy 1 (Long/Short)	2.16%	18.69%	6.22%	3.49%	22.19%	0.50%	0.086
Strategy 2 (Long Only)	-7.12%	13.81%	-58.80%	-42.15%	-28.55%	-2.98%	0.3867
Strategy 3 (Short Only)	11.59%	13.85%	76.42%	38.68%	54.78%	5.67%	0.3509

Table 1. Key Performance metrics for all 3 trading strategies

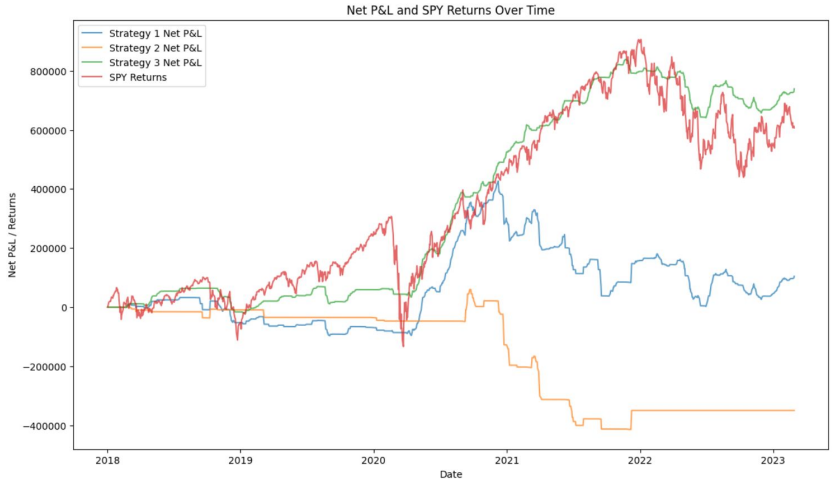


Figure 5. Graph of trading strategy returns versus the underlying (SPY)

* For simplicity, we assumed a risk-free rate of 1% when calculating excess returns

Risk and Capital

- As we are a high-risk fund with a high risk-appetite, we will set up a stop-loss once we reach a maximum drawdown of 75%, upon which we would liquidate the fund
- However, we did not have to implement this risk control in the backtest as we never had such a large maximum drawdown
    - The largest max drawdown occurred in the strategy 2, resulting in a drawdown of 48% and a position value of $597K
    - The best performing strategy had a drawdown of 14%
- The amount of cash available to trade across all three trading strategies never fell below $2.46MM (~25% of starting capital, with leverage)

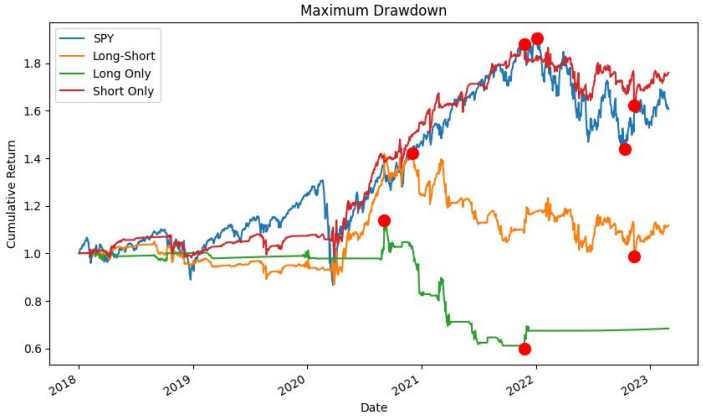
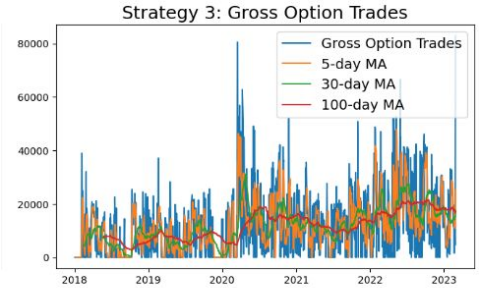


Figure 6. Graph showing maximum drawdown of each strategy versus SPY. Strategies long-short, long only, and short only are in orange, green, and red, respectively. SPY is in blue.

Analysis - Strategy 3

- Strategy 3 had insignificant correlation with the Farma-French factors (Mkt, SMB, HML)
- There was a slightly positive correlation (*r=0.23*) between gross options and stocks traded
- Both gross options and stocks traded had a significant outcome for the test for non-stationarity

Figure 7. Scatterplot showing correlation between gross options and stocks traded.



ADF Statistic: -15.12
P-Value: 0.0000

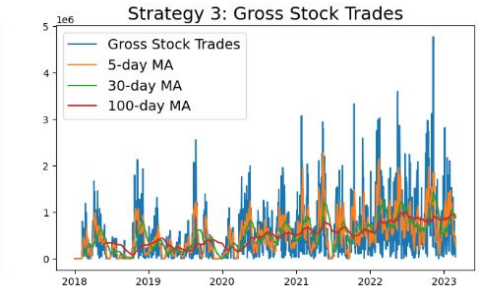


Figure 8. Moving averages of gross options and stocks traded for short-only strategy, and ADF test for non-stationarity results.

Conclusion

- Consistent with general knowledge, we found realized volatility to be lower than B-S IV.
- Model-free IV was able to identify low volatility, but struggled to identify high volatility
- Our fund will focus on short gamma based off of the backtest of these strategies
- While the short-gamma strategy has beta, this is to be expected as SPY is its underlying. With this in mind, the beta of 0.55 can be considered low, especially when given a positive alpha and a modest Sharpe ratio of 0.76, which exceeds SPY's Sharpe ratio (0.57-0.73) over the last 3-5 years [x]

[x] https://finance.yahoo.com/quote/SPY/risk/?guccounter=1

Appendix A: Options Basics

[1]***SPY***: Refers to the SPDR S&P 500 ETF Trust, which is an exchange-traded fund that seeks to provide investment results that correspond to the price and yield performance of the S&P 500 Index.

[2]***At-The-Money***: When an option contact's strike price is closest to the current market price of the underlying asset.

[3]***Calls***: Options contracts that grant the holder the right (but not the obligation) to buy an underlying asset at a specified price within a certain period of time.

[4]***Puts***: Options contracts that grant the holder the right (but not the obligation) to sell an underlying asset at a specified price within a certain period of time.

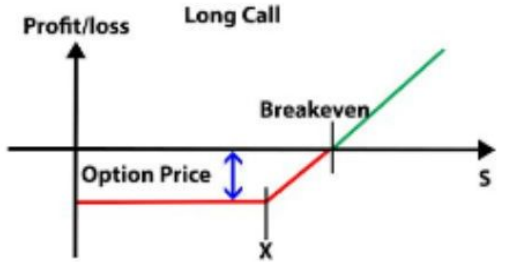


Figure 5. Payoff diagram for a call.

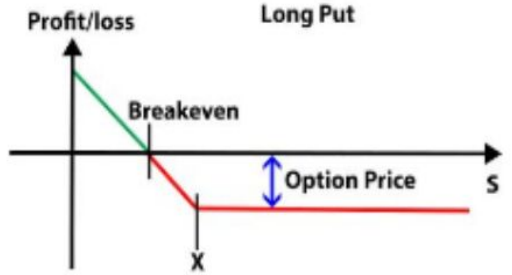


Figure 6. Payoff diagram for a put.

Appendix B: Options Basics

[5]***Black-Scholes Model***: A mathematical framework for pricing European-style put and call options based on the stock price, strike price, time until expiration, risk-free interest rate, and volatility of the stock.

[6]***Delta***: Measures the rate of change in an option's price relative to changes in the price of the underlying asset.

[7]***Straddle***: A combination of both a put and call option with the same strike price and expiry, entered on the same side (buy or short both).

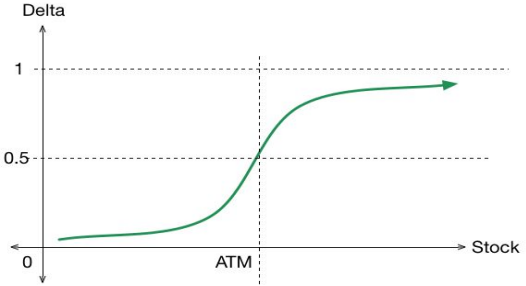


Figure 7. Call delta vs stock price.

Figure 8. Payoff for a straddle.