Derivatives Case

Cornell Trading Competition

1 Introduction

In this case you will develop a trading strategy for European-style SPX options to manage portfolio risk across varying market conditions. Your performance in this case will depend on your ability to understanding hedging and risk management. The goal is to achieve relatively consistent positive returns, rather than try a wild strategy to get the highest return possible.

1.1 Overview of Relevant Concepts

1.1.1 Options

There are two main types of options: Calls and Puts.

- A Call option gives the holder the right, but not the obligation, to purchase the underlying asset at a predetermined price (the strike price) on a particular date (the expiration date). Purchasing a call therefore represents a bullish bet on the underlying.
- A Put option gives the holder the right, but not the obligation, to sell the underlying asset at a predetermined price on a particular date. Holding a put option is therefore a bearish bet.

In the case of SPX options, the underlying asset is the S&P 500.

The price of an options depends on several factors.

- "Moneyness," or the strike price relative to the current share price
- Time to expiration
- Volatility
- Interest Rates

The impact of these factors is summarized by the options greeks:

1. Delta represents the sensitivity of the option's price to changes in the price of the underlying security.
2. Theta represents the time value decay of an option.
3. Gamma represents the rate of change of delta relative to the change in price of the underlying security.
4. Vega represents the option's sensitivity to implied volatility.
5. Rho represents the sensitivity of the option's price to interest rates.

Documentation:
SPX Options

2 Case Structure

Competitors will be given an initial capital of $100,000,000 (you can also think of the amount as $1M and just ignore the 100x multiplier on the options) and will be asked to trade using SPX options.

For SPX options, the underlying is the S&P 500 index, and they are cash-settled using the opening value of the S&P 500 index on the expiration day. Their contract multiplier is 100. This case only uses SPX options that expire on the 3rd Friday of a given month (SPXW options have weekly expirations).

Competitors can synthetically trade the S&P500 by buying a call and selling a put with the same strike and expiration date.

3 Data

Permitted training data can be accessed here along with starter code for your strategy: `https://github.com/Cornell-Quant-Fund/CTC-2024-Derivatives`. You are provided with 3 months of SPX options NBBO data along with 3 months of SPY data.

3.1 Options Data

The options data provided for this case follows the National Best Bid and Offer (NBBO) format, which includes minute-level bid and ask prices, and corresponding sizes for SPX options. Each record contains the following:

- **Timestamp**: The exact time of the bid/ask data point.
- **Bid/Ask Prices**: The best available prices at which a market participant is willing to buy or sell.
- **Bid/Ask Sizes**: The number of contracts available at the bid/ask prices.
- **Expiration Date**: The date the option expires.
- **Strike Price**: The strike price of the option contract.
- **Option Type (Call/Put)**: Specifies whether the contract is a call or a put.

3.2 Index Data

The index data provided for this case tracks daily performance for the SPY index, which serves as a proxy for the S&P 500. Each record contains the following:

- **Open**: The opening price of the SPY index.
- **High**: The highest price reached during the trading day.
- **Low**: The lowest price reached during the trading day.
- **Close**: The closing price of the SPY index.

This data overlaps with the options data, allowing competitors to implement strategies that hedge or track movements in the underlying index.

3.3 Usage

Participants will receive one 3-month period of options and index data for training their strategies. Three distinct 3-month periods will be used for testing. Successful strategies will demonstrate consistent performance across all testing periods (which vary by average VIX).

4 Rules

4.1 Order Limits

Orders must respect the available bid/ask sizes in the options data. Competitors are required to account for both slippage and transaction costs:

- **Slippage**: Assume slippage is 0.1% of the order size.
- **Transaction Costs**: Each contract incurs a transaction cost of $0.50.

Partial fills are allowed, and competitors must handle any unfilled portions of their orders within these constraints.

4.2 Trading Window

No trades are allowed past the day before the option's expiration. Any attempt to place trades on the expiration day will be rejected.

4.3 Position Liquidation

If participants hold any open positions at the close of the trading window, these positions will be liquidated at a penalty:

- **Long positions** will be liquidated at **90%** of their current value.
- **Short positions** will be liquidated at **110%** of their current value.

4.4 Margin Requirements

To ensure appropriate risk management, the following margin requirements apply:

- **Put Options**: The margin requirement is the premium paid plus 10% of the option's strike price.
- **Call Options**: The margin requirement is the premium paid plus 10% of the underlying index's opening price.

For example, selling a put with a strike price of 3500 for $50 requires $(50+0.1\times3500)\times100$=$40,500 in margin.

Trades violating margin requirements will be canceled, and positions may be liquidated to restore margin compliance.

In addition, please note that any option positions that are in the money on the expiration date will be automatically exercised using the opening price of the indices on the expiration date, with the cash settlement being credited to or debited from your portfolio depending on whether it was a long or short position respectively. When your short positions are settled on the expiration date, the corresponding margin amounts will be freed and available for use in future trades.

Moreover, in case the losses from a short position cross your minimum margin amount, your remaining long and short positions will be randomly liquidated until you meet the minimum margin amount. In case this amount is not met after having liquidated all your other options positions, you will be not allowed to conduct more trades.

5 Output

Participants must submit their trades via the following format. The output should be a **DataFrame** with the following columns:

- **Datetime**: The exact date and time of the trade.
- **Option Symbol**: The unique identifier for the option being traded.
- **Action**: The type of order (Buy or Sell).
- **Order Size**: The number of contracts bought or sold.

The option symbol format must strictly adhere to the structure:

`SPX[Expiration Date][Option Type][Strike Price]`

This structure combines the option's underlying, expiration date, option type (call or put), and strike price. It is essential that all submissions strictly adhere to this format for the strategy to be evaluated. A file with example orders is included in the github for your reference.

6 Evaluation

You will submit a python file containing the code for your strategy. Refer to the starter code in the GitHub for structuring your submission. We will be using gradescope to handle submissions and will send you the link via email before the submission deadline. An autograder will check if your submission compiles to ensure only strategies adhering to the conventions are assessed.

Participants' strategies will be evaluated based on the following performance metrics:

6.1 Total Return

$$\text{Total Return} = \left(\frac{\text{Final Portfolio Value} - 100,000,000}{100,000,000} \right) \times 100$$

This metric reflects the percentage gain or loss relative to the initial capital of $100,000,000.

6.2 Max Drawdown

$$\text{Max Drawdown} = \frac{\text{Maximum Peak Value} - \text{Minimum Trough Value}}{\text{Maximum Peak Value}}$$

Max drawdown measures the largest loss from peak to trough (on a daily basis) observed during the strategy's execution. Strategies are penalized for large declines in portfolio value, even if the position recovers.

6.3 Sharpe Ratio

$$\text{Sharpe Ratio} = \frac{\text{Average Portfolio Return} - \text{Risk Free Rate of 3\%}}{\text{Standard Deviation of Portfolio Returns}}$$

The Sharpe ratio measures the risk-adjusted return of the strategy, accounting for the strategy's volatility.

6.4 Consistency Score

$$\text{Consistency Score} = \text{Standard Deviation of Total Returns Across Testing Periods}$$

This metric reflects how consistently the strategy performs across different testing periods.

6.5 Final Score

$$\text{Final Score} = \text{Average of} \left(\frac{\text{Total Return}}{\text{Max Drawdown}} \times \text{Sharpe Ratio} \right)$$

The final score combines the strategy's total return, risk management, and consistency to provide an overall evaluation.

6.6 Ranking

Participants will be ranked based on their **Final Score**. In the event of a tie, the **Consistency Score** will be used as a tiebreaker.