Berkeley IEOR + Wells Fargo BADSS Case Competition

Case Competition Overview

Introduction

Welcome to the Berkeley Algorithm Design & Systems Solutions (BADSS) Case Competition, hosted by the Berkeley IEOR Department in collaboration with Wells Fargo. This case competition provides participants with an opportunity to showcase their skills in algorithm design, optimization, and data analysis while solving real-world problems in the financial sector. Over the course of two weeks, participants will develop and refine optimization models and test their efficacy during the final in-person event day.

Background

About Wells Fargo

Wells Fargo is one of the largest financial services companies in the United States, offering a wide range of banking, investment, and mortgage products. With a commitment to innovation, Wells Fargo leverages cutting-edge technologies to optimize its operations and provide exceptional service to its customers.

About the Topic

The focus of this case is to use optimization techniques to find equity derivative hedges for market scenarios. Equity derivatives (or stock options) are financial instruments that may be used to create profitable strategies for a wide variety of market scenarios. Listed options are seeing tremendous growth, with a record 10.4 billion contracts traded in 2024. For each index or stock name, there may be hundreds of available options to trade. By evaluating the option market as a large set of data, we aim to create a method to help us decide which options are the best ones to use.

While this case is applied to managing equity derivative portfolio risk, these techniques can be applied to a wide variety of use cases. Asset managers, portfolio managers, risk managers, and traders may all want to use options, from simply buying market crash insurance to finding profitable trading strategies. The successful completion of this case is a surefire way to begin an interesting conversation with a risk taking professional.

Team Requirements

- Each team must consist of **3 to 5 members**.
- Teams are encouraged to have diverse skill sets, including algorithm design, data analysis, and presentation skills, to maximize their performance in the competition.

Case Prompt and Objective

What are your options?

First, we need to understand what you need to know about stock options. Options are derivatives based on the price of underlying securities. *Call* options will return a positive payoff if, at *expiration or maturity*, the *underlier* finishes at a price higher than the *strike. Put* options make money if stock price goes down, and will profit if, at *expiration*, the *underlier* finishes below the *strike*. The payoff is as such:

Call payoff = max(S – K, 0)

Put payoff = max(K – S, 0)

Where

S = stock price of the underlier at maturity

K = strike price of the option

The payoff at expiration, given above, is called the option *intrinsic value.* During the life of the option, before expiration, the option value will fluctuate with respect to many market factors. The underlying price, interest rates, and option implied volatility are all factors in the price of an option. Option prices, also called *premium*, are always higher than intrinsic, but as time passes and we approach the expiration of an option, it will converge to the *intrinsic value.*

For example, an AAPL 20Dec2024 250 Call, means a call option on AAPL stock, that expires on December 20, 2024, with a strike of $250.

Remember, the payoff/intrinsic value = max(S – $250,0)

On December 2^{nd}

1. AAPL stock closed at a price of $239.59
2. AAPL 20Dec2024 250C option closed at $0.72.

The option premium was $0.72. But what was the option intrinsic value?

Intrinsic = max ($239.59 - $250.00, 0) = 0

This option is *out-of-the-money*. But of course, AAPL could rally above $250 by December 20th, so given there's a chance, the option has a premium people are willing to pay.

On December 20th

1. AAPL stock closed at a price of $254.49
2. AAPL 20Dec2024 250C option expired, *in-the-money*. The payoff of the option = max($254.49 - $250.00, 0) = $4.49

So indeed this option was worth something. Paying $0.72 with a final payout of $4.49, well that's making over 6x your initial investment. Of course this option could have finished out of the money and been worth $0 at expiration.

A few takeaways to point out here. The premium on December 2nd of $0.72 is based on market forces that can be described with option pricing theory, relating to Black-Scholes pricing and implied option volatility. For the scope of this case, we will not be discussing option pricing theory. We will consider that the premium of an option can change day-to-day, and at expiration the option is worth the intrinsic value.

Option Market Nomenclature

The given option data has the below format. Market listed options have a multiplier of 100, called *contract size*. That means one contract represents 100 shares, and all prices and payoffs are multiplied by 100. For example, buying an AAPL 01Jan25 225 call, the premium is $4.8 per contract. One contract costs 100 * $4.80 = $480.00. This gives a payoff of 100 * max(S - $225,0) at expiration. For an ask size of 4753, if you purchased all the available options, that would cost 4753 * $4.80 * 100 = $2,281,440 of premium.

Date	Symbol	Maturity	Strike	Bid Price	Bid Size	Ask Price	Ask Size	Undl Price
1/22/25	AAPL	1/31/25	225	4.7	5346	4.8	4753	222.67
1/22/25	AAPL	1/31/25	227.5	3.75	34	3.8	4096	222.67
1/22/25	AAPL	1/31/25	230	2.94	38	2.96	455	222.67
1/22/25	AAPL	1/31/25	232.5	2.29	10	2.3	84	222.67

Date: the valuation date for which the option price and underlying price is determined

Symbol: the stock ticker of the underlier

Maturity: the expiration date of the option

Strike: strike of the option, for calls and puts

Bid Price: the best, or highest, price at which the market is willing to buy

Bid Size: the number of contracts that the buyer is willing to buy at the Bid Price

Ask Price: the best, or lowest, price at which the market is willing to sell

Ask Size: the number of contracts that the seller is willing to sell at the Ask Price

Undl Price: the price of the underlying stock at the close of the respective valuation date

Underlying stock market assumptions

Let's consider a universe of three different US stock index ETFs: SPY (S&P 500), QQQ (Nasdaq 100), and IWM (Russell 2000 Small Cap). SPY is considered the US stock market benchmark, and other stocks or indices can be measured relative to the SPY move. We can use regression to calculate the *beta* of an individual ETF. This can be considered a ratio of the volatility with respect to SPY.

The 1 year beta to SPY is given as below:

	beta
SPY	1
IWM	1.21
QQQ	1.36

For example, if SPY moves +1.0% in 1 day, we can estimate that respectively IWM +1.21% and QQQ +1.36%.

Ground rules

Participants will:

1. Review the provided dataset. The dataset contains call options for the underliers: SPY, QQQ, IWM. The timeframe of the date is between April 11, 2024 – May 10, 2024. For each day during this time, you will be given a variety of options with expirations from 1 day to 2 weeks from the valuation date.
2. For each individual day, suppose a scenario for spot move given below:

	beta	%move
SPY	1	+3.0%
IWM	1.21	+3.6%
QQQ	1.36	+4.1%

   For example if on April 11, 2024, SPY closed at $518.00, then we plan for the scenario that the next day on April 12, 2024, SPY will close at $518.00 * 103.0% = $533.54
3. Create a function to calculate the intrinsic *Exposure* of an option after the 2) scenario. We will only be using the intrinsic value to calculate this Exposure. The Exposure will be the difference of intrinsic value between the two days. For example between day0 and day1, $Exposure_{day0} = \max(S_{day1} - K, 0) - \max(S_{day0} - K)$.
4. Let us define the magnitude of *Exposure* as the potential PnL from 2) scenario. Look at an example with the option below. Consider a valuation date of 4/11/24, meaning we pretend that the current date is 4/11/24 when considering this option data. Below is an option that expires in one day, 4/12/24. If we buy 1000 contracts, the *premium* paid is 1000 * $1.75 * 100contract size = $175,000 in premium.

Date	Symbol	Maturity	Strike	Bid Price	Bid Size	Ask Price	Ask Size	Undl Price
4/11/24	SPY	4/12/24	518	1.73	2226	1.75	1781	518.00

If SPY gains 3% the next day, spot price would be 1.03 * $518.00 = $533.54. Using Exposure function described in 3)
Exposure = 1000* 100 *[max($533.54 - $518.00, 0) – max($518.00 - $518.00, 0)] = $1,554,000.
For our exercise, we will consider that this exposure is $1,554,000. To recap, we paid a *premium* of $175,000 to gain an *exposure* of $1,554,000 for the next day. Note that we are separating the concept of *premium* and *exposure*.

5. Option premium is our cost, and it represents the market value of the option. Options can be bought and sold, and respectively the payout will be paid to the buyer by the seller. We will keep track of the premium change for the options selected in our portfolio. That means the *premium* PnL of a position is the change of the premium price from one day to another, for example buying 1000 contracts of the SPY 15Apr24 518C on 4/11/2024 to 4/12/2024 means the premium PnL = bid price$_{\text{day1}}$ – ask price$_{\text{day0}}$ = 1000 * (0.28 – 2.59) * 100contract size = -$2,310,000.

Date	Symbol	Maturity	Strike	Bid Price	Bid Size	Ask Price	Ask Size	Undl Price
4/11/2024	SPY	4/15/2024	518	2.57	369	2.59	1772	518
4/12/2024	SPY	4/15/2024	518	0.28	1847	0.29	1984	510.85

Note that if we own an option (we have long a position), we will use the bid prices to evaluate the premium; this means the price in which we can sell our long position. Conversely, if we sell an option (we have a short position), then we use the Ask Prices to evaluate the premium, which means these are the prices we can transact and buy our position back. In the above example, our initial purchase price on day0 was at the ask price of $2.59, and on day1 the bid price was $0.28.

6. We do not want to create an option combination that will result in any negative *exposure* for any possible market scenario. That means if the market moves higher than scenario 2), we should not lose money.

Objective

1. With the ground rules above, create an optimization and/or trading strategy that maintains a minimum *exposure* of +$10,000,000 gain with scenario 2) and at the same time minimizes the cost throughout the April 11 – May 11 timeframe. That means if the strategy buys options that expire the next day, these options will not have any further exposure, and you may need to buy more options. If you wish to transact options, the Bid/Ask prices for each respective day will represent the prices you can transact, limited by the Size displayed, ie. you cannot buy or sell more than the respective Bid/Ask Size. To be clear, each day may have a premium cost, and the optimization should minimize the total option premiums paid over a month, not necessarily minimizing one specific day. Of course, as you'll see, the market does not actually behave in scenario 2). Our goal is to give ourselves the potential to profit *if* this event does indeed happen. And in the meantime, we want to spend the least amount of option premium to have this profit

opportunity. Each and everyday should keep a minimum exposure of +$10,000,000 for the next scenario 2).

2. Options bought and sold will have profit or losses. Keep track of the premium PnL, described in Ground Rules 5), for all options. If an option expires worthless, the PnL loss is simply the premium spent.
3. The first dataset given will be the Training dataset. Develop your model on this dataset. Present how you developed your optimization strategy with the Training dataset. Show that the optimization works.
4. During the in-person event, you will be given a new Test dataset to run the model. You will calculate the cost of the strategy. After running the optimization with the in-person Test dataset, evaluate and report the efficacy of the strategy.
5. Create an 8 minute presentation with the following details:
    a. Use PowerPoint, Google slides, Canva, or equivalent to include effective visual aids.
    b. Contain Model performance metrics (see rubric guidelines below).
    c. Explain why the approach was chosen and the final design.
    d. Contain implementation and usability info.
    e. Give a short overview or demonstration on how your method works. Give a sample demonstration for one date, that the option exposure is the specified $10,000,000. How do you optimize over all dates?
    f. The final results should show the total cost over the month, as well as details of the cost for each day.
    g. Any insights or opinions gained through this exercise? Or any suggestions to make a better scenario to optimize?
    h. Finally, as you run the in-person Test data, compare the results to your Training data. Why do you think the costs are different?
    i. Give a summary wrap up on why the team's model should win.
    j. Presentation should be given with minimal filler words (um, ah, eh), with confidence, and should be clear and logical.

Access to Data

Datasets are proprietary to Wells Fargo and are not to be distributed for any use outside of this case competition.

The dataset includes:

- **Training Data:** Data will be available in .csv file in the same format as described above. This spans ~ 1 month of SPY, IWM, and QQQ call option market.
- **Test Data:** A separate dataset will be provided the day of the competition. This will be in the same .csv format. The timeframe will also be ~ 1 month in length but will not be the consecutive May-June timeframe. The exact timeframe will be disclosed on the contest date.

Instructions and Timeline

Instructions

1. Download and explore the dataset.
2. Develop an optimization algorithm addressing the prompt.
3. Submit your preliminary results and model documentation by In-person event on 3/1.
4. Prepare for live testing and a presentation during the in-person event.

Timeline

- Sign-ups open: 1/24
- Sign-ups close: 2/12
- Case + data sent to registered teams: 2/14
- Virtual office hours: 2/21 1-3 PM PT - https://berkeley.zoom.us/my/kerger
- In-person event day: 3/1, 9-4:30 PM PT

Schedule of the In-Person Event

Time	Saturday, March 1, 2025
9:00-9:30am	Check In / Breakfast
9:30-10:00 am	Opening remarks
10:00-10:30am	Workshop 1 (AI to Optimize w/ IEOR Prof Kerger)
10:30-11:00am	Break + Work Time
11:00-11:30pm	Wells Fargo Info Session
11:30-12:30pm	Lunch Break + Test Data Released
12:30-1:45pm	Work Time + Open Networking
1:45-3:30pm	Presentations

3:30-4:00pm	Judging Deliberations + Networking
4:00-4:30pm	Closing Remarks + Awards

Judging Criteria

The competition will consist of two rounds. The top 9 teams from the first round will proceed to the second round.

The first round will only be the evaluation of the Training data. Judges will prompt teams to train the model on an in-sample period, and the evaluation will proceed with an out-of-sample period. The teams will be ranked on the results, and the top 9 teams will proceed to the second round.

The second round will release the Test data to the top 9 teams. The teams will run the model on the new Test data and prepare a presentation. The criteria for judging the teams' performance are the following:

1. First round performance (10%): Ranking of first round results
2. Model Performance Metrics (20%): Effectiveness, robustness, scalability, efficiency.
3. Model Design and Approach (30%): Creativity, innovation, proper assumptions, complexity vs. simplicity
4. Implementation and Usability (10%): Ease of implementation, documentation and clarity, error handling
5. Presentation and Explanation (20%): Clarity of explanation, visualizations, storytelling
6. Real-Time Testing (10%): Adaptability, speed of adjustment

Event Location

The location of the event will be shared via email prior to Feb 28th. The event will be taking place on UC Berkeley campus.

FAQs and Support

For any questions or technical issues, please contact Case Competition Coordinator Adarsh Gupta (adarshgupta@berkeley.edu), Wells Fargo case contact Harry Yeh (harry.yeh@wellsfargo.com), or IEOR Department Marketing Director Goldie Negelev.

Acknowledgments

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