Finance Bootcamp

Pritam Dalal

Agenda

1. Preliminary discussion of project and groups.
2. Discussion - work load check-in.
3. Dicussion - now that you've seen a little Python, how are you envisioning trying to use it?
4. Finance Bootcamp - a whirlwind tour of the finance you'll need for this class.
    - please view this as a conversation
    - ask questions and share perspectives
5. Q & A - anything class related is fair game.
    - tutorial material
    - homeworks
    - python in other courses or at work
    - general data analysis in finance

Project and Groups

1. I will assign the project next week - 10/8.
2. The project will be due four weeks later - 11/5.
3. You can choose your own groups - of any size (including solo).
   - e-mail me your group members
   - if you don't have a group, and you want one, e-mail me and I can assist in finding you one
4. You can choose your own project, or I will have one for you to work on.
5. Trade-Off:
   - your own: learn more, less guidance, maybe harder
   - mine: learn less, more guidance, maybe harder

Discussion: Workload Check-In

I want to get a sense for the following:

1. How many people are bored and need more work to do?
2. How many people are overwhelmed and have barely made a dent into the reading and/or homework?

Plan moving forward:

1. The next major topic I will present is visualization. After that, we'll jump into the machine learning material.
2. Between the project and homeworks that I have posted, I think there is enough coding practice to keep you occupied until the projects are due.

Discussion: Python Check-In?

1. How does Python compare to your other data analysis tools: Excel, R, Matlab, SQL.
2. Do you have any projects that you want to use Python to complete?
3. Does anyone have ideas for the project for the class that they want to share or discuss.

Some Additional Python Resources

1. Practical Business Python (pbpython.com) - a blog that is particularly relevant to this class.

2. Talk Python To Me - a weekly podcast, topics vary but the the ones focused on data analysis and business applications will probably be of interest.

3. Python for Finance - Yves Hilpisch

4. Python for Data Analysis - Wes McKinney (comprehensive but a bit boring)

5. Automate the Boring Stuff - a well written intro to programming text, that teaches Python as a general programming language, but focuses on automating workflows.

6. Data Science from Scratch - Joel Grus, builds up a lot of machine learning algorithms from scratch, which is different than how `sklearn` is often taught.

Stocks

- Represents fractional ownership in a company.
- Entitles you a share of the future profits of that company.
- Limited liability so their price can never be zero.
- Traded on exchanges via complex auction mechanisms to match buyers and sellers.
    - trade prices can fluctuate from trade to trade
- Some pay dividends, which in the near-term reduces the share price in the amount of the dividend.

ETFs

- Investment pooling mechanism like a mutual fund, but usually simpler (more passive) and cheaper to manage.
- Shares of these funds trade on exchanges in the same way the stocks do.
  - unlike mutual funds which you could only exit once a day
- Examples: SPY, IWM, GLD, XLF
- Pays dividends similar to stocks.

ETFs and Stocks

- These will be the two kinds of option underlyings we will consider in this class.
- We will mostly focus on ETFs.
  - This is to avoid the complications surounding earnings announcements.
- When I use the term *stock* I will be referring to stocks and etfs collectively.
- If the distinction is important in a particular situation, I will make it clear.

Stock PNL

- $\mathcal{S}$ - some stock.
- $t_1, \ldots t_n$ - consecutive trading days.
- We purchase one share in the middle of day t_1, for a purchase price of S^o.
- We hold that share until day t_n, at which time we sell it for S^c.

- Our price data consists of closing prices $S_1, \ldots S_n$.

Stock PNL

Daily: D_i - the *daily PNL* for the trade as of end-of-day t_i.

TTD: C_i - the *trade-to-date PNL* for the trade as of end-of-day t_i.

$$D_i = \begin{cases} S_1 - S^o & i = 1 \\ S_i - S_{i-1} & 1 < i < n \\ S^c - S_{n-1} & i = n \end{cases}$$

$$C_i = \begin{cases} \sum_{k=1}^{i} D_k & i < n \\ \\ \sum_{k=1}^{n-1} D_k + (S^c - S_{n-1}) & i = n \end{cases}$$

Stock Price Returns

- Let $\mathcal{S}$ be a stock; let $t_0, \ldots, t_1$ be consectutive trading days.
- And let S_i be the close price for trade date t_i.
- Let t_i and t_j be trading days with $0 < i < j$. The **return** of stock $\mathcal{S}$ between t_i and t_j is denoted $r_{i,j}$ and is defined to be

$$r_{i,j} = \frac{S_j - S_i}{S_i} = \frac{S_j}{S_i} - 1.$$

- When $j = i + 1$, meaning that t_i and t_j are consecutive trading days, then this return is called the **one day return** and is denoted r_j.

Stock Price Volatility

- Let $\mathcal{S}$ be a stock.
- Let $r_1, \ldots, r_n$ be the price returns of $\mathcal{S}$ for consecutive trading days $t_1, \ldots t_n$.
- Then the volaility of these returns is their annualized standard deviation:

$$\sigma = \mathsf{SD}((r_1, \ldots, r_n)) \cdot \sqrt{252}.$$

Options Context

- *Options* are financial contracts that show up everywhere in finance.
- They can be viewed as the building blocks of many other financial instruments.
- The theory of option pricing is the starting point for much of quantitative finance.
- Much of the data that we are going to analyze in this class will be options related.

Options are Insurance Contracts

- **Options** are simple **insurance** contracts wrapped around other financial assets.
- The financial asset that is being insured is called the *underlying*.
- The types of underlyings that we are going to discuss in this class will be stocks and ETFs.
- The essential concepts are the same for other underlyings like interest rates, futures, or barrels of oil.

American Option Contract Specification

- There are two types of American options: calls and puts.
- Both types are defined by three contract features:
  - underlying stock
  - strike price
  - expiration date
- **Call:** a contract that gives the right, but not the obligation, to **buy** a share of the underlying, at the strike price, at any time before the expiration date.
- **Put:** a contract that gives the right, but not the obligation, to **sell** a share of the underlying, at the strike price, any time before the expiration date.

Early Exercise of American Options

- If you exercises the right that an American option gives you prior to expiration, this is known as *early exercise*.
- As it turns out, it is almost never optimal to early exercise an American option.
- Therefore, it makes to talk about the terminal *payoff* of an option:
  - the value of exericising at the time of expiration
- This is the same as saying there is effectively no difference between and American option an a European option.

Option Payoff Functions (1 of 4)

- Suppose the current time is t.
- Consider a put and call on the same underlying stock, both with expiration $T > t$.
- Suppose they both have strike K.
- Let S_T be the price of the stock at the time of expiration.
- Let π_p be the put buyer's payoff, and let π_c be the call buyer's payoff.

Option Payoff Functions (2 of 4)

- Put Buyer Payoff: $\pi_p(S_T) = max\{(K - S_T), 0\}$
- Call Buyer Payoff: $\pi_c(S_T) = max\{(S_T - K), 0\}$
- **Exercise:** convince yourself that the above is true given the contract specification of American puts and call.
- **Exercise:** graph π_p and π_c as a function of S_T.
- **Exercise:** Write the expressions for seller's payoff of both puts and calls. Draw the graphs.

Option Payoff Functions (3 of 4)

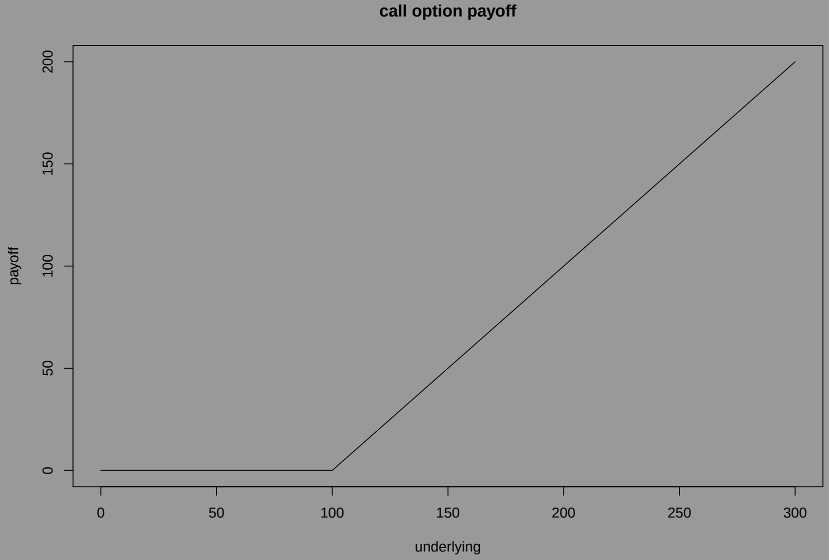
- Consider π_c and π_p as functions of $S_T \in (0, +\infty)$.
- Both functions are differentiable at all points except for $S_T = K$.
- **Exercise:** What are the two values of $\frac{d\pi_c}{dS_T}$?
- **Exercise:** What are the two values of $\frac{d\pi_p}{dS_T}$?

Option Payoff Functions (4 of 4)

- Let's say it's time $t < T$, and S_t is the current price of the stock.
- **Exercise:** If you own the put, which inequality do you hope is true between S_t and S_T. What ineqality do you hope holds true between between S_T and K?
- **Exercise:** If you own the call, which inequality do you hope is true between S_t and S_T? How about between S_T and K?

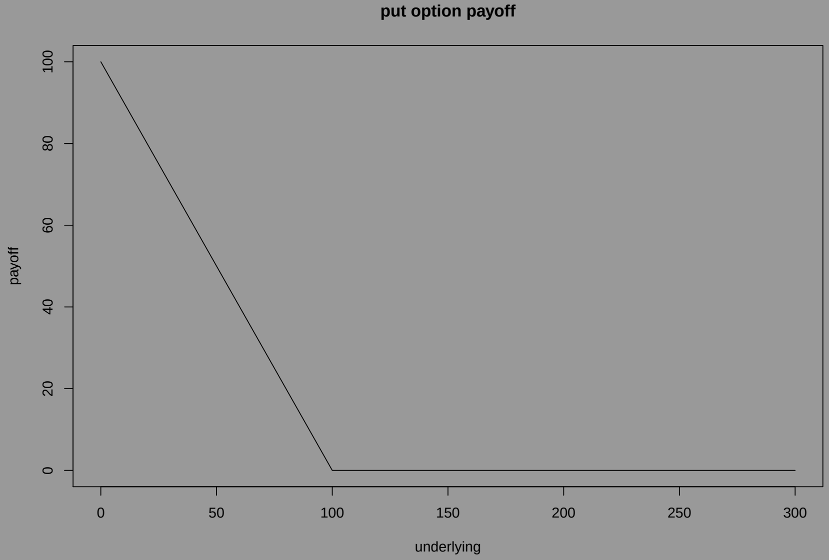
Call Payoff Graph

Strike $= 100$



Put Payoff Graph

Strike = 100



Options Always have Positive Value

KEY FACT: As the buyer of an option, your downside is limited and your upside is unlimited. Therefore, you must always pay to buy an option position.

KEY FACT: As the seller of an option, your upside is limited and your downside is unlimited. Therefore, you must alway receive money to sell an option position.

Strangle

- Let $\mathcal{S}$ be some stock who's current prices is S_0.
- Consider a two strike prices K_p and K_c where we have that:

$$K_p < S_0 < K_c.$$

- Suppose the two strikes are roughly equidistant from the spot price S_0.
- Consider the combined position of a put and a call with:
  - $\mathcal{S}$ as their underlying
  - K_p and K_c their respective strikes
  - both with the same expiration.
- This combined position is called a *strangle*.

Short Strangle PNL Graph

DRAW ON BOARD

Short Strangle Position

- Suppose you sell a strangle.
- You recieve premium because you are an option seller.
- You make payouts of the underlying moves beyond your strikes.

- If the underlying doesn't move too much, the trade is profitable.
- If the underlying has a large gain or loss, as a strangle seller, you will experience losses that are extremely large.

Delta Hedging

- Delta-hedging is a risk management strategy that you can apply to a short strangle.
- Delta hedging involves dynamically buying and selling the underlying in a systematic way.
- The PNL of a naked option position is a function of the single-period absolute return - the expiration price variablility.
- The PNL of a delta hedged position is a function of the daily standard deviation of the returns - the variability of the *price path* to expiration.
- The PNL variability of a delta-hedged strangle position will be lower the than that of a naked strangle position.

Option PNL

- A couple of things to keep in mind when analyzing option PNLs.
- Much larger bid/ask spread (realtive to instrument value) than stocks.
- More important to account for bid/ask spreads when doing any kind of PNL analysis.

Option PNL

- Suppose you trade an option $\mathcal{O}$ at a price P on trade-date T_1.
- Suppose you hold the option until expiration, which is trade-date T_n.
- The letter i will serve as an index over the trade-dates, so $i = 1, \ldots, n$.

Option PNL

- Let B_i and A_i be the end-of-day bid/ask prices of the option for trade-date T_i.
- Note that $B_n = A_n =$ option-payoff $= \Pi$
- D_i - daily PNL for the trade as of end-of-day T_i.
- C_i - trade-to-date (cummulative) PNL for the trade as of end-of-day T_i.
- **Intuition:** The cummulative PNL on a trade is how much money you make if you unwind the trade at current market values.

Option PNL

Long Option PNL - Marking to Bid

$$D_i = \begin{cases} B_1 - P & i = 1 \\ B_i - B_{i-1} & 1 < i < n \\ \Pi - B_{n-1} & i = n \end{cases}$$

$$C_i = \begin{cases} \sum_{k=1}^{i} D_k & i < n \\ \\ \sum_{k=1}^{n-1} D_k + (\Pi - B_{n-1}) & i = n \end{cases}$$

Option PNL

Short Option PNL - Marking to Ask

$$D_i = \begin{cases} P - A_1 & i = 1 \\ A_{i-1} - A_i & 1 < i < n \\ A_{n-1} - \Pi & i = n \end{cases}$$

$$C_i = \begin{cases} \sum_{k=1}^{i} D_k & i < n \\ \\ \sum_{k=1}^{n-1} D_k + (A_{n-1} - \Pi) & i = n \end{cases}$$

Portfolio PNL

- It is rare that you will calculate the PNL of a single stock trade or a single option trade.
- Rather, you will want to calculate the PNL of a portfolio consisting of many different option and stock trades of various sizes.
- The daily/TTD PNL of a collection of trades is simply the sum of the daily/TTD PNL of the individual trades.
- `df_trade_pnl.groupby("trade_date").agg(np.sum)`.