**More of a smirk than a smile**

Describe the smile curve in equities.

The black-scholes equation can be used to theoretically price an option. Given the parameters of the price of an underlying asset, strike price, time to maturity, risk-free interest rate, and implied volatility the theoretical price of an option contract can be attained. All these parameters seem to be attainable to get a price of a contract, but it is not. The mystery comes to implied volatility. Historical volatility and implied volatility are not the same. The first uses historical price movement of an asset to calculate a deviation from the mean price given a period. Implied volatility is back calculated and shows what the market believes the volatility will be in the future. This goes against the black-scholes method assuming that volatility is constant for an asset. Pricing models for stocks have fat tail distributions meaning that the unlikely price movements are more likely to happen than a typical normal distribution. This causes the pricing of ITM and OTM contracts to be sold with higher IV priced in when compared to ATM contracts. Knowing this we can expect to see a curve that looks closer to a smile. It looks more like a smirk and we will experimentally show that.

Setting up MySQL db for SPY using TD ameritrade API.

We are going to look at the SPY ETF as it is heavily traded and can be seen as a nice gauge to look at overall feel of the market for the future. What we’ll do is over a couple of weeks we’ll gather real minute pricing options data from TD Ameritrade for SPY options contracts. Below will be a quick script in gathering that data and inserting it into your own MySQL db.

SCRIPT

The script above has gathered us minute options pricing for SPY 20 above and 20 below the ATM contract. Since the ATM contract changes over time the constant above and below of 20 serves as a window of contracts to look at. Looking back, I would have liked to track a fixed percentage from the ATM contract, but we’ll make do with what we have.

Explain how to calculate implied volatility

Now that the option pricing data is available, we will calculate the implied volatility. Below is the Black-Scholes pricing model for a call option.

A picture containing text

Description automatically generated

Diagram

Description automatically generated with low confidence

Diagram

Description automatically generated with medium confidence

C = Call option price

S = Underlying asset price

K = Strike price

T = Time to maturity

r = Risk free interest rate

Sigma = Implied volatility

N(x) = Normal density function

What we are after is sigma as the other parameters are already known. A simple method we’ll be using to solving for sigma is plugging in a value and seeing if it outputs a tolerable call option price. Below is the code that calculates for our sigma.

Making an animation from the gathered implied volatility

Once we have obtained the implied volatility values, we can create an animation to watch it as time passes. Below is the code in creating an animation of SPY contracts implied volatility with respect to percentage from strike value.

How this process can be utilized in the future through gathering more data

Above is the animation of what we wanted and we can see how the curve changes as time passes. A few days may not seem too interesting. But if you were to continue to collect this data and keep track of a relative curve you can then create a reference curve for the SPY. With this reference you can compare day to day SPY contract implied volatility to historical implied volatility. That can be used as a qualitative gauge at how the market is. Meaning if the current curve is higher than the reference it shows that the contracts are being sold at a premium due to iv being higher, with lower than reference meaning the opposite.