Brock Fassnacht

Mat 479

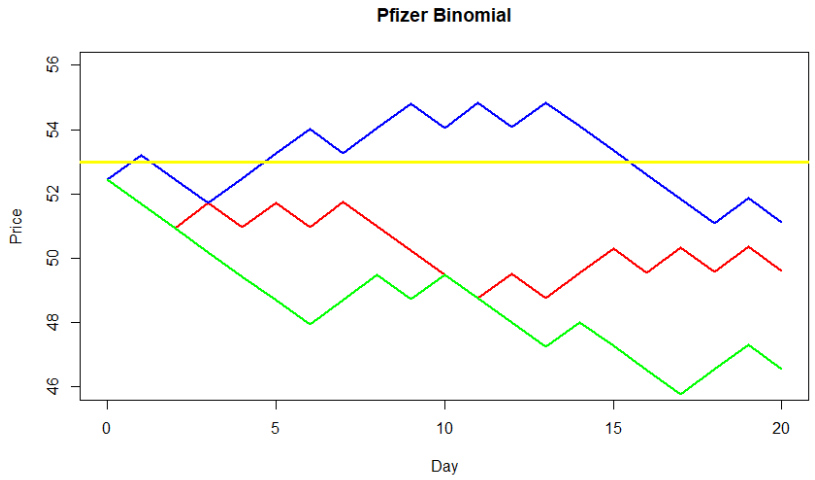
12 May 2022

Final Report

For all data for the stocks Visa, Pfizer and Mcdonald's that I used in my models, I got from using R. Starting with the basic data that I used for my Binomial model. (i)To calculate the percent of days the stock moved up, I looped through the closing prices and calculated each daily return by taking the natural log of the closing price minus the natural log of the closing price the day before and added all those returns to a list. Then I made a counter and looped through the list of daily returns and added one to the counter if the return was positive. I then divided the counter by 60 to get my results. (ii) I did something similar to get the daily absolute change in price. I looped through the closing prices again and took the absolute value of the change in prices each day and added it to a variable. I divided that variable by 60 again to get my absolute change in prices. (iii & iV) Instead of taking the absolute value of the change in price like in ii, I made an if statement that added the return to one variable if it was positive, and another if it was negative. Then divide the positive one by how many "up days" I got from the first, and the negative one by the amount of "up days" - 60. (V) To calculate the average log returns, I used a similar loop from the first calculation, but instead of using a counter, I just added all the returns into one variable. I took that variable and divided it by 60 to get the average log returns. (vi) I looped one more time to get a list of log returns and used the var() function in R to get the variance.

For the Binomial models, inside a loop, I created a random variable using, runif(1, min=0, max=1). If that random variable was less than the percent of days the stock moved up, I added the average daily move on up days to the initial stock price. And if it was greater than the

percent of days the stock moved up, I subtracted the average stock move on down days. For each iteration of the loop I added the stock price to a list and then graphed it to get something like this.



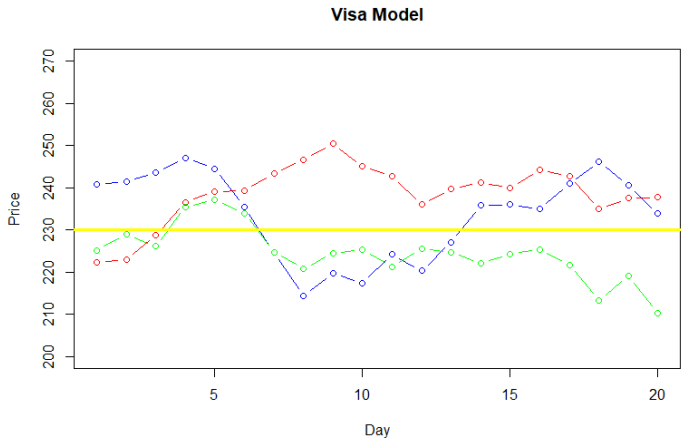
Then, I ran that loop 5000 times and took the price on the 15th day (April 22nd) to calculate the average modeled price of the stock for the binomial model. Also, using an if statement, I calculated the average value of the call option by subtracting the modeled price on the 15th day by the strike price. If the difference was greater than 0 I added the difference to a variable, and if it was negative I added nothing. I then divided that variable by 5000 to get the modeled option price. For every binomial model I ran, my predicted option prices were less than the black-Scholes, continuous model and market value. I believe the reason for this is because we have been in a very volatile market the last 4 months and I do not think the Binomial model captures that as well as the other models do.

Next, I did the continuous models. I took the square root of the variance that I calculated from earlier and multiplied it by the square root of 252 to annualize it. I also used the average

daily returns that I calculated above as well. I used the following code that got me one iteration of the model.

```
Vsigma = 0.3500035
simV_returns <- cumsum(Vsigma*sqrt(1/252)*rnorm(20) + .0001886)
fixedV_returns = simV_returns-Vsigma^2*(1/252)/2
simV_price <- 223.95*exp(fixedV_returns)
```

I did this three times and plotted to get something like this:



I then ran the model 5000 times in a for loop, just like I did in the binomial model to get the average predicted stock prices and option prices for stock. The predicted price for the continuous models I ran were fairly close to the Black-Scholes and market prices.

Then I used the black scholes equation to get a third predicted option price. I used the same volatility (standard deviation) as from previous models, used 15 as T, and .026 as a risk free rate. My code looked like this:

```
inprice <- 223.95
k <- 230
T <- 15
r <- .026
vol <- Vsigma
```

```
w <- (log(inprice/k)+(r+vol^2/2)*(T/252))/sqrt((T/252)*(vol^2))

optionpriceV <- (inprice*pnorm(w))-k*exp(-r*T/252)*pnorm(w-vol*sqrt(T/252))
```

When comparing this to the market prices, I noticed that all the Black-Scholes option prices I calculated were higher than the market prices. I looked at the implied volatility for those option prices and they were all lower than the volatility I calculated and used for the model, which makes sense why the market prices were lower.

Looking at an option for Visa Expiring on May 20th, 2022:

Visa closed today, May 11th, at 196.72. We are going to be looking at the $200 call expiring in 7 trading days, May 20th. I will be using prices from January 1st 2022, to May 11th 2022. After looking at the data from all 3 models, I would suggest not buying the stock. The Binomial model gave a price of 1.45 and the continuous model gave 2.53, which is well less than the trading price of 3.35. Both of the models predicted the stock to be around $194.5 a share in 7 trading days from now. The Black Scholes gave 3.41, which did however come in line with the trading price of 3.35. With all the information given I cannot suggest that buying the option would be a smart investment.

Data for the binomial -

46.067% days up

Up 3.42 on up days

Down -3.50 on down days

Avg daily rets = -0.001510288

Standard deviation = 0.3654338 (volatility)

Binomial model Results : 194.50 avg price, 1.45 opt price

Continuous Results: 194.81 avg price, 2.53 opt price

Black-Scholes : 3.41

Written copy of Presentation

Slide 1: MAT 479 Capstone project

Slide 2: Current Information on Visa -

- Visa is a multinational financial services corporation based in Foster City, California. It facilitates electronic funds transfers primarily through Visa branded credit, debit and prepaid cards.
- Amazon, the world's largest retailer, stopped accepting Visa credit cards in certain areas of the world due to the high fees. This was resolved February as both companies reached an agreement.
- Most of the world is reopening from the Covid-19 pandemic which will increase travel and spending which directly benefits Visa.

Slide 3: Current info on Mcdonald's -

- Mcdonald's is a multinational fast food corporations founded in 1940, and is based in San Bernardino, California. They currently have more than 38,000 locations in over 100 countries.
- For the first time in 8 years Mcdonald's expects to open more locations than it closes in the United States.
- Mcdonalds temporarily closed 850 locations in Russia during March due to the Russia - Ukraine conflict.

Slide 4: Current info on Pfizer -

- Pfizer is an American pharmaceutical and biotechnology company founded in 1849 by two German immigrants.
- Pfizer develops and sells hundreds of drugs and treatments; most notably their COVID -19 vaccine that they developed with a German biotech company, BioNTech.
- CDC recommended in March a 4th dose for people over the age of 50. Meanwhile Covid Cases in the United States have gone down dramatically since February.

Slide 5: Overall market sentiment -

- End of 2021 stocks were at record highs
- Inflation rate is about 8% which is the highest seen in 40 years
- Fed is raising interest rates for the first time since 2018
- GDP was negative in first quarter 2022
- Most stock indexes are down over 10% from their all time highs in November of 2021

Slide 6: Visa Data

% days stock moved up - 48.3%

Avg daily absolute change in price - 3.25

Avg daily stock move on up days - 3.40

Avg daily stock moves on down days - -3.1

Avg Daily returns - .0001886

Var of daily returns - .00048612

Slide 7: Visa Binomial

224.63 Simulated stock price

2.73 Avg call value at expiry

Iterations- 5000

Slide 8: Visa Continuous

225.26 Sim stock price

5.73 Avg call value at expiry

Iterations 5000

Slide 9: Comparison

Binary Model	2.73
Continuous Model	5.73
Black Scholes	5.21
Market bid, ask price	(1.54, 3.40)

MARKET PRICE (4/22 $230 call)	3.25

- On April 22, Visa's closing price was 208.17, so the call expired worthless.
- Implied volatility was 29.75, which was lower than the .35 that I used (which is why the black scholes gave a higher option price than market)

Slide 10: Mcdonald's data

% days stock moved up - 35%

Avg daily absolute change in price - 2.35

Avg daily stock move on up days - 2.9

Avg daily stock moves on down days - -2.06

Avg Daily returns - -.00126

Var of daily returns - .000171

Slide 11: Mcdonald's Binomial

244.24 Simulated stock price

.59 Avg call value at expiry

Iterations- 5000

Slide 12: Mcdonalds's Continuous

244.74 Sim stock price

1.45 Avg call value at expiry

Iterations 5000

Slide 13: Comparison

Binary Model	.64
Continuous Model	1.45
Black Scholes	2.78
Market bid, ask price	(1.42, 1.69)
MARKET PRICE (4/22 $255 call)	1.97

- On April 22, Mcdonald's closing price was 250.17, so the call expired worthless.
- Implied volatility was .1807, which is less than the .21 I used (which is why my B.S. price is higher than market)

Slide 14: Pfizer Data

% days stock moved up - 45%

Avg daily absolute change in price - .76

Avg daily stock move on up days - .77

Avg daily stock moves on down days - -.75

Avg Daily returns - -.001287

Var of daily returns - .0003189

Slide 15: Pfizer Binomial

51.42 Simulated stock price

.55 Avg call value at expiry

Iterations- 5000

Slide 16: Pfizer Continuous

51.51 Sim stock price

.84 Avg call value at expiry

Iterations 5000

Slide 17: Pfizer Comparison

Binary Model	.55
Continuous Model	.84
Black Scholes	1.22
Market bid, ask price	(.80, .88)
MARKET PRICE (4/22 $53 call)	.85

- On april 22, the closing price was 48.17, so the call expired worthless
- Implied volatility was .26, compared to my calculation of .28, which is why my B.S. price is higher than market