

FITE7407

Assignment 3



Contribution

Name	Contribution
Varun Aditya Balaji (3036383355)	<ul style="list-style-type: none">• Monte Carlo Pricing (Arithmetic Asian Option, Arithmetic Basket Option)• Quasi Monte Carlo Pricing of KIKO options• UI
Sai Navyanth Vobbilisetty (3036384139)	<ul style="list-style-type: none">• Closed Form Pricing(Geometric Asian Option, Geometric Basket Option)• Black Scholes Pricing• Implied Volatility Pricing• Pricing American Options using Binomial Trees

UI Description

The UI is built using the dash framework in python. This framework is built on top of React.js and Flask. We developed our pricing models as python modules and we allow the dash framework code to provide a UI to receive the inputs and call these python modules to compute the result.

To run the UI, please go to the project directory and pip install the requirements.txt file. (pip install -r requirements.txt). Once this is done, please run **python OptionPricer.py** to boot up the UI and go to <http://127.0.0.1:8050/> to view the UI.

The screenshot shows the 'OPTION PRICER' application interface. At the top, there are tabs for different pricing models: Black-Scholes, Implied Volatility, Geometric Asian, Basket Option, MC Arithmetic Asian, MC Arithmetic Basket, QMC KIKO, Binomial Tree, and Stock Chart. The 'Black-Scholes' tab is currently selected. Below the tabs, the 'BLACK-SCHOLES OPTION PRICING' section contains several input fields: 'Spot Price (S)' with a value of 100, 'Volatility (σ)' with a value of 0.2, 'Risk-Free Rate (r)' with a value of 0.05, 'Repo Rate (q)' with a value of 0.01, 'Time to Maturity (T)' with a value of 1, and 'Strike Price (K)' with a value of 100. There is also a dropdown for 'Option Type' set to 'Call' and a 'CALCULATE' button. Below the inputs, the 'OPTION PRICE:' is displayed as '\$9.83'. At the bottom, there is explanatory text about the Black-Scholes model and the formulas for call and put option prices.

OPTION PRICER

Black-Scholes Implied Volatility Geometric Asian Basket Option MC Arithmetic Asian MC Arithmetic Basket QMC KIKO Binomial Tree Stock Chart

Contact Us

BLACK-SCHOLES OPTION PRICING

Spot Price (S) 100 Volatility (σ) 0.2 Risk-Free Rate (r) 0.05 Repo Rate (q) 0.01

Time to Maturity (T) 1 Strike Price (K) 100 Option Type Call x

CALCULATE

OPTION PRICE:
\$9.83

The Black-Scholes model is a mathematical model used for pricing European-style options. It assumes that the price of the underlying asset follows a geometric Brownian motion with constant volatility and drift.

The formula for the price of a call option is given by:

$$C = S * N(d_1) - K * e^{-rt} * N(d_2)$$

For a put option, the formula is:

$$P = K * e^{-rt} * N(-d_2) - S * N(-d_1)$$

where d_1 and d_2 are intermediate calculations.

As seen in the above image, the UI has different tabs for different pricing models. Please click on the correct Tab, and enter the required parameters and click on calculate to get the required result. The UI would also display the logic behind the calculation.

The Stock chart tab gives the 3 month stock price chart of the given Ticker Symbol. Lastly, the contact us tab is meant to provide the details of the project contributors.

Code Description

Monte Carlo Asian Option Pricing (Class)

- *init*: Parameters (S0, T, sigma, control_variate, etc.).
- *geometric_asian_exact*: Closed-form geometric Asian option price.
- *simulate_paths*: Generates GBM stock price paths.
- *compute_payoffs*: Computes Asian option payoffs from paths.
- *monte_carlo_pricing*: Entry point; uses control variate (geometric Asian exact price) if enabled, else returns average simulated price.

Monte Carlo Basket Option Pricing (Class)

- *init*: Parameters (S1(0), S2(0), sigma1, sigma2, rho, control_variate).
- *geometric_basket_price*: Closed-form geometric basket option price.
- *simulate_paths*: Generates correlated GBM paths for two assets.
- *monte_carlo_pricing*: Applies control variate (geometric basket price) if enabled; returns average payoff otherwise.

Quasi Monte Carlo KIKO Option Pricing (Class)

- *init*: Parameters (S_0 , T , σ , timesteps).
- *simulate_paths*: Generates paths using Brownian motion.
- *get_payoffs*: Computes payoffs based on knock-in/out conditions.
- *delta*: Estimates delta via finite difference.
- *monte_carlo_pricing*: Uses Sobol sequences for low-discrepancy paths; returns average payoff.

Closed-Form Pricing Functions

- *geometric_basket_option_price*: Computes price via closed-form formula (inputs: $S1_0$, $S2_0$, σ_1 , σ_2 , r , T , K , ρ , type).
- *geometric_asian_option_price*: Closed-form solution for Asian options (inputs: S_0 , σ , r , T , K , n).

Binomial Tree American Option Pricing (Function)

- *american_option_pricing*: Builds binomial tree for stock prices, computes terminal payoffs, and backward-inducts to determine early exercise value (inputs: S_0 , K , r , T , σ , N , option_type).

European Option Pricing (Class)

- Reused from Assignment 2.
- *Methods*: Black-Scholes pricing (Call/Put), $d1/d2$ calculation, Vega, Implied_volatility via Newton-Raphson.

Test Results

For all test cases we assume $r=0.05$, $T=3$ and $M=100000$

Asian Options

s_0	σ	K	n	Option Type	Geometric Closed Form Price	MC Price for Asian Option with control variate
100	0.3	100	50	call	13.26	14.734
100	0.3	100	100	call	13.14	14.619
100	0.4	100	50	call	15.76	18.214
100	0.3	100	100	put	8.43	7.747
100	0.4	100	50	put	12.56	11.28
100	0.3	100	50	put	8.48	7.799

Parameter Relationships for Closed form

Option	Strike Price \uparrow	Maturity \uparrow	Volatility \uparrow
call	\downarrow	\uparrow	\uparrow
put	\uparrow	\uparrow	\uparrow

Parameter Relationship for MC Pricing:

Option	$\sigma \uparrow$	$K \uparrow$	$T \uparrow$	$N \uparrow$	$M \uparrow$	$r \uparrow$	Control Variate
call	\uparrow	\downarrow	\uparrow	\downarrow	Narrower CI	\uparrow	Narrower CI
put	\uparrow	\uparrow	\uparrow	\downarrow	Narrower CI	\downarrow	Narrower CI

Binomial Tree for American Options

s0	sigma	r	T	K	steps	Option Type	Our Price	Actual Price
50	0.4	0.1	2	40	200	put	3.42	3.418
50	0.4	0.1	2	50	200	put	7.47	7.467
50	0.4	0.1	2	70	200	put	20.83	20.8314

Parameter Relationships:

Option	Strike Price \uparrow	Maturity \uparrow	Volatility \uparrow
call	\downarrow	\uparrow	\uparrow
put	\uparrow	\uparrow	\uparrow

Basket Options

For all test cases we assume $r=0.05$, $T=3$ and $M=100000$

S1(0)	S2(0)	K	sigma1	sigma2	rho	Option Type	Our Closed Form Price	MC Price for Basket Option with control variate
100	100	100	0.3	0.3	0.5	call	22.10	24.483
100	100	100	0.3	0.3	0.9	call	25.88	26.357
100	100	100	0.1	0.3	0.5	call	17.92	19.453
100	100	80	0.3	0.3	0.5	call	32.54	35.382
100	100	120	0.3	0.3	0.5	call	14.69	16.574
100	100	100	0.5	0.5	0.5	call	28.45	34.948
100	100	100	0.3	0.3	0.5	put	11.49	10.566
100	100	100	0.3	0.3	0.9	put	12.62	12.428
100	100	100	0.1	0.3	0.5	put	6.59	5.519
100	100	80	0.3	0.3	0.5	put	4.71	4.25
100	100	120	0.3	0.3	0.5	put	21.29	19.873

100	100	100	0.5	0.5	0.5	put	23.47	21.063
-----	-----	-----	-----	-----	-----	-----	-------	--------

Parameter Relationships for Closed form

Option	Strike Price ↑	Maturity ↑	Volatility ↑	Rho ↑
call	↓	↑	↑	↑
put	↑	↑	↑	↑

Parameter Relationships for MC Pricing

Option	σ ↑	K ↑	T ↑	rho ↑	M ↑	r ↑	Control Variate
call	↑	↓	↑	↑	Narrower CI	↑	Narrower CI
put	↑	↑	↑	↑	Narrower CI	↓	Narrower CI

Quasi Monte Carlo Option

All options are priced using M= 100,000 simulations , N=50 timesteps and S(0) = 100

K	T(years)	r	sigma	L,U	QMC Price	Delta
100	3	0.05	0.3	90,110	6.48	-0.3768
100	3	0.05	0.5	90,110	9.97	-0.4434
120	3	0.05	0.3	90,110	9.94	-0.6158
80	3	0.05	0.3	90,110	3.37	-0.1788
100	5	0.05	0.3	90,110	6.01	-0.2682
100	3	0.01	0.3	90,110	9.86	-0.7854

Parameter Relationships for QMC Pricing

In the case of delta for put, ↓ means more negative and ↑ less negative

Option	σ ↑	K ↑	T ↑	M ↑	r ↑	N
put	↑	↓	↓	Narrower CI	↓	↓
delta	↓	↓	↓	More Stabilized	↑	↓

Extension

We have added an extra tab called stock chart, that can display a graph of the stock price movement of a given ticker symbol in the last 3 months. This can be used to understand the overall trend of the underlying stock and can be used to pick up trends and market sentiment of the underlying stock. This functionality is built using the yfinance library in python and displayed using plotly graphs.

STOCK CHART

Enter Stock Symbol To Get a 3 Month Chart

AAPL

GET CHART

LATEST STOCK PRICE: \$198.15

