The University of Hong Kong

FITE7405: Techniques in Computational Finance

Assignment 3 – Mini Option Pricer

Project Report

Group 30

Member Details

#	Member Name	SID
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Team Contributions

#	Member	Contribution
1	Abhimanyu Bhati	• Implementation of american_binomial, arithmetic_asian_mc, arithmetic_basket_mc, kiko_quasi models and test_scripts file • GUI optimization • Drafting of report.
2	Sameer Kabani	• Implementation of black_scholes, geometric_asian, geometric_basket, implied_volatility models and drafted test cases • Implementation of GUI • Setting up of GitHub repository, readme, documentation.

Instructions To Run Project

1. Clone the Repository

```
git clone https://github.com/sk1805/FITE7405-Assignment-3.git

cd FITE7405-Assignment-3
```

2. Create and Activate Virtual Environment

For Windows:

```
python -m venv venv

venv\Scripts\activate
```

For macOS/Linux:

```
python -m venv venv

source venv/bin/activate
```

3. Install Dependencies

```
pip install -r requirements.txt
```

4. Run the Application

```
python app.py
```

5. Access the Application

Open your web browser and navigate to:

http://localhost:8050

6. To run test cases

```
python models/test_scripts.py
```
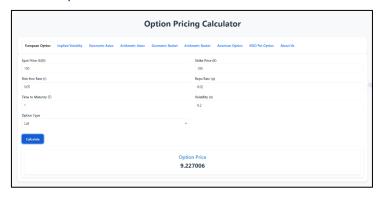
User Interface Description

Figure: Screencap / Instance of our GUI

European Option Tab

- Inputs: Spot price (S(0)), Strike price (K), Risk-free rate (r), Repo rate (q), Time to maturity (T), Volatility (σ), Option type (Call/Put)

- Output: Option price

Implied Volatility Tab

- Inputs: Spot price, Strike price, Risk-free rate, Repo rate, Time to maturity, Option Premium, Option type

- Output: Implied volatility

Geometric Asian Option Tab

- Inputs: Spot price, Volatility, Risk-free rate, Time to maturity, Strike price, Number of observations (n), Option type

- Output: Option price

Arithmetic Asian Option Tab

- Inputs: All Geometric Asian inputs plus Number of simulations (m), Control variate method

- Output: Option price with Standard Error and 95% confidence interval

Geometric Basket Option Tab

- Inputs: Spot prices (S1(0), S2(0)), Volatilities (σ1, σ2), Risk-free rate, Time to maturity, Strike price, Correlation (ρ), Option type

- Output: Option price

Arithmetic Basket Option Tab

- Inputs: All Geometric Basket inputs plus Number of simulations, Control variate method

- Output: Option price with Standard Error and 95% confidence interval

American Option Tab

- Inputs: Option type, Spot price, Strike price, Risk-free rate, Time to maturity, Volatility, Number of steps (N)

- Output: Option price, Early exercise premium, European Price (for comparison)

KIKO Put Option Tab

- Inputs: Spot price, Strike price, Risk-free rate, Time to maturity, Volatility, Lower barrier (L), Upper barrier (U), Number of observations (n), Rebate (R), Calculate Delta (Yes/No)

- Output: Option price with Standard Error, 95% confidence Interval and Delta (optional)

Functionality Description

The codebase is organized into several key components:

Web Interface (*app.py*):

- Implements a Dash web application with Bootstrap styling

- Driver code and handles user input validation and calculation triggers

- Displays results in a user-friendly format

Core Pricing Models (models/ directory):

#	Script Name	Functionality
1	*black_scholes.py*	Implements closed-form Black-Scholes formulas for European options
2	*implied_volatility.py*	Calculates implied volatility using numerical methods
3	*geometric_asian.py*	Implements closed-form formulas for geometric Asian options
4	*arithmetic_asian_mc.py*	Monte Carlo simulation for arithmetic Asian options with control variate
5	*geometric_basket.py*	Closed-form formulas for geometric basket options
6	*arithmetic_basket_mc.py*	Monte Carlo simulation for arithmetic basket options with control variate
7	*american_binomial.py*	Binomial tree method for American options
8	*kiko_quasi_mc.py*	Quasi-Monte Carlo method for KIKO put options
9	*test_scripts.py*	Runs the test cases for the above models

Test Cases

Each pricing model contains test cases in its "__main__" block. To view detailed test results for all models at once, run models/test_scripts.py as per the instructions above.

The results have been truncated to 4 decimal places below for brevity.

Black Scholes (European Options)

At-the-money

S	K	r	q	T	sigma	type	**Option Price**
100	100	0.05	0.05	3	0.3	call	**17.6434**
100	100	0.05	0.05	3	0.3	Put	**17.6434**

Out-of-the-Money

S	K	r	q	T	sigma	type	**Option Price**
100	110	0.05	0.05	3	0.3	call	**14.5256**
100	90	0.05	0.05	3	0.3	Put	**12.7930**

In -the-Money

S	K	r	q	T	sigma	type	**Option Price**
100	90	0.05	0.05	3	0.3	call	**21.4001**
100	110	0.05	0.05	3	0.3	Put	**23.1327**

Implied Volatility

S	K	r	q	T	Option Premium / Market Price	type	**Imp Vol.**
100	100	0.05	0.05	3	10	call	**0.1687395906**
100	100	0.05	0.05	3	10	put	**0.1687395906**

Geometric Asian

S0	sigma	r	T	K	n	type	**Option Price**
100	0.3	0.05	3	100	50	call	**13.2591**

100	0.3	0.05	3	100	100	call	**13.1387**
100	0.4	0.05	3	100	50	call	**15.7598**
100	0.3	0.05	3	100	100	put	**8.43108**
100	0.4	0.05	3	100	50	put	**12.5587**
100	0.3	0.05	3	100	50	put	**8.48270**

Arithmetic Asian MC

Max Simulations = 100,000. Control Variate = geometric

S0	sigma	r	T	K	n	type	**Option Price**
100	0.3	0.05	3	100	50	call	**14.73409**
100	0.3	0.05	3	100	100	call	**14.61921**
100	0.4	0.05	3	100	50	call	**18.21373**
100	0.3	0.05	3	100	100	put	**7.747432**
100	0.4	0.05	3	100	50	put	**11.27977**
100	0.3	0.05	3	100	50	put	**7.799341**

Geometric Basket

S1	S2	sigma1	sigma2	r	T	K	rho	type	**Option Price**
100	100	0.3	0.3	0.05	3	100	0.5	put	**11.4915**
100	100	0.3	0.3	0.05	3	100	0.9	put	**12.6223**
100	100	0.1	0.3	0.05	3	100	0.5	put	**6.5863**
100	100	0.3	0.3	0.05	3	80	0.5	put	**4.7115**
100	100	0.3	0.3	0.05	3	120	0.5	put	**21.2891**
100	100	0.5	0.5	0.05	3	100	0.5	put	**23.4691**
100	100	0.3	0.3	0.05	3	100	0.5	call	**22.1020**
100	100	0.3	0.3	0.05	3	100	0.9	call	**25.8788**
100	100	0.1	0.3	0.05	3	100	0.5	call	**17.9247**
100	100	0.3	0.3	0.05	3	80	0.5	call	**32.5362**
100	100	0.3	0.3	0.05	3	120	0.5	call	**14.6854**
100	100	0.5	0.5	0.05	3	100	0.5	call	**28.4493**

Arithmetic Basket

Max Simulations = 100,000. Control Variate = geometric

S1	S2	sigma1	sigma2	r	T	K	rho	type	**Option Price**
100	100	0.3	0.3	0.05	3	100	0.5	put	**10.5710**
100	100	0.3	0.3	0.05	3	100	0.9	put	**12.4274**
100	100	0.1	0.3	0.05	3	100	0.5	put	**5.5166**
100	100	0.3	0.3	0.05	3	80	0.5	put	**4.2480**
100	100	0.3	0.3	0.05	3	120	0.5	put	**19.8765**
100	100	0.5	0.5	0.05	3	100	0.5	put	**21.0731**
100	100	0.3	0.3	0.05	3	100	0.5	call	**24.4945**
100	100	0.3	0.3	0.05	3	100	0.9	call	**26.3523**
100	100	0.1	0.3	0.05	3	100	0.5	call	**19.4293**
100	100	0.3	0.3	0.05	3	80	0.5	call	**35.3863**
100	100	0.3	0.3	0.05	3	120	0.5	call	**16.5873**
100	100	0.5	0.5	0.05	3	100	0.5	call	**34.9757**

American Binomial

S	K	r	T	sigma	N	type	**Option Price**
50	40	0.1	2	0.4	200	put	**3.4184**
50	50	0.1	2	0.4	200	put	**7.4676**
50	70	0.1	2	0.4	200	put	**20.8314**

KIKO QMC

S	K	r	T	sigma	L	U	R	n	delta	**Option Price**
100	100	0.05	2	0.2	80	125	1.5	24	True	**5.9636**
100	100	0.03	2	0.2	75	105	5	24	True	**7.5685**

Results

Black Scholes

If S == K, and r ==q, then price will be the same for both call and put option

When S not equal to K:

Option	K ↑
Call	Decreases
Put	Increases

Implied Volatility

If S == K, and r ==q, then volatility will be the same for both call and put option

Geometric Asian & Arithmetic Asian

Option	Case: Averaging Frequency ↑ (n)	Case: Volatility ↑ (σ)
Call	Decreases	Increases
Put	Decreases	Increases

Geometric Basket & Asian Basket

Option	Case: Strike Price ↑	Case: Correlation ↑	Case: Volatility ↑
Call	Decreases	Increases	Increases
Put	Increases	Increases	Increases

American Binomial

Price increases as **K** increases for Put options

KIKO QMC

Option	r ↑	L ↓	U ↓	R ↓
Put	Decreases	Increases	Increases	Increases