Options Risk Calculator

User Documentation

English

Wolfgang Boehme

wolfgang.boehme@economic-modeling.de

www.economic-modeling.de

25 October 2026

The documentation on this website was developed with the support of the AI Claude (Anthropic).

Table of Contents

1 Getting Started **2**

1.1 Interface Layout . . . 2

1.2 Step-by-Step: First Calculation . . . 2

1.3 Data Input: Three Methods . . . 2

1.3.1 1. Manual Input . . . 2

1.3.2 2. CSV Upload . . . 2

1.3.3 3. Live Market Data (Twelve Data + FRED) . . . 3

2 Underlyings **3**

2.1 Overview . . . 3

2.2 FX: Garman-Kohlhagen . . . 3

2.3 Zero-Coupon Bond . . . 4

3 Pricing Models **4**

3.1 Black-Scholes . . . 4

3.2 Binomial Tree (Cox-Ross-Rubinstein, $N = 100$) . . . 4

4 Option Types **4**

5 Outputs and Risk Measures **5**

5.1 Option Price and Break-Even . . . 5

5.2 Greeks . . . 5

5.3 Value at Risk and CVaR . . . 5

5.3.1 Monte Carlo VaR and CVaR (Expected Shortfall) . . . 5

5.3.2 Parametric VaR (Delta-Normal) . . . 6

5.4 P&L Scenarios . . . 6

6 CSV Format for Import and Export **6**

6.1 Import (Upload) . . . 6

6.2 Export . . . 6

7 Worked Example: FX Option EUR/USD, Call **7**

7.1 Input . . . 7

7.2 Calculation . . . 7

7.3 Greeks . . . 7

7.4 Risk Measures . . . 8

7.5 P&L Scenarios . . . 8

8 Frequently Asked Questions 8

Getting Started

Interface Layout

The calculator is divided into two areas:

- **Sidebar (left):** All inputs – live data, CSV upload, underlying, model, option parameters.
- **Main area (right):** Results in two tabs – *Results* and *Binomial Tree*.

Step-by-Step: First Calculation

1. Select underlying and pricing model (panel *Underlying & Model*).
2. Select option type (Call, Put, Spread, Butterfly).
3. Enter market parameters: Spot, Strike, Volatility σ, Interest rate r, Maturity T.
4. Click **Calculate**.
5. Read results in the *Results* tab; view the binomial tree in the *Binomial Tree* tab.
6. Optional: **Export CSV** for all results as a file.

Quick start: The *Load example data* button fills all fields with a DAX call example (ATM, $\sigma = 20\%$, $r = 3\%$, $T = 90$ days) and calculates immediately.

Data Input: Three Methods

1. Manual Input

Fill in all fields directly. Required fields: Spot, Strike K_1, Volatility, Maturity.

2. CSV Upload

Upload a file with the following column headers (case-insensitive):

Column	Description	Example
`underlying`	Underlying type	`FX (EUR/USD)`
`spot`	Spot price	`1.0800`
`strike`	Strike K_1	`1.0800`
`vol`	Volatility in %	`8.00`
`rate`	Interest rate r in % (continuous)	`3.00`
`rf`	Foreign rate in % (FX only)	`2.50`
`tenor`	Maturity in days	`90`

The `underlying` column is detected automatically and the underlying selector is set accordingly.

3. Live Market Data (Twelve Data + FRED)

1. Enter a ticker symbol (examples: `AAPL`, `EURUSD`, `GC=F` for Gold).
2. Enter your Twelve Data API key (free account at `https://twelvedata.com`).
3. Select data type: Stock/Index, FX, ETF.
4. Click **Load market data**.

The following fields are filled automatically:

Field	Source	Availability
Spot price	Twelve Data	Free plan and above
Implied volatility (ATM)	Twelve Data Options Chain	Standard plan and above
Risk-free rate (3M T-Bill)	FRED API	Always, no key required
Strike	= Spot (ATM default)	Automatic

Note: Implied volatility from the options chain is not included in the free Twelve Data plan. The spot price and the FRED interest rate are always available. The rate refers to the US 3-month T-Bill – for European underlyings a manual adjustment to the Euribor is recommended.

Underlyings

Overview

Underlying	Pricing formula	Special feature	Example ticker
Stock	Standard BS	—	`AAPL`, `SAP`
Index	Standard BS	no dividend	`SPX`, `DAX`
FX	Garman-Kohlhagen	r_f active	`EURUSD`
Commodity	Standard BS	—	`GC=F` (Gold)
ZCB	$S = N \cdot e^{-yT}$	Yield input	—

FX: Garman-Kohlhagen

For FX options the spot price is adjusted by the foreign interest rate r_f:

$$S^* = S \cdot e^{-r_f T}, \qquad C_{\text{GK}} = S^* \, \Phi(d_1) - K \, e^{-rT} \, \Phi(d_2)$$

$$d_1 = \frac{\ln(S/K) + (r - r_f + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, \qquad d_2 = d_1 - \sigma\sqrt{T}$$

r = domestic rate (e.g. USD), r_f = foreign rate (e.g. EUR). For `EURUSD`: r = USD rate, r_f = EUR rate (Euribor).

Zero-Coupon Bond

Input: face value N and yield y (continuous). The spot price is calculated automatically:

$$S_{\text{ZCB}} = N \cdot e^{-yT}$$

Standard BS options are then applied. σ denotes the price volatility of the bond.

Pricing Models

Black-Scholes

$$d_1 = \frac{\ln(S/K) + (r + \frac{1}{2}\sigma^2)T}{\sigma\sqrt{T}}, \qquad d_2 = d_1 - \sigma\sqrt{T}$$

$$C = S\,\Phi(d_1) - K\,e^{-rT}\,\Phi(d_2), \qquad P = K\,e^{-rT}\,\Phi(-d_2) - S\,\Phi(-d_1)$$

Assumptions: European option, constant volatility, no dividend, continuous compounding.

Binomial Tree (Cox-Ross-Rubinstein, $N = 100$)

$$u = e^{\sigma\sqrt{\Delta t}}, \quad d = 1/u, \quad p = \frac{e^{r\Delta t} - d}{u - d}, \quad \Delta t = T/N$$

$$V_{j,i} = e^{-r\Delta t}\left[p \cdot V_{j+1,i} + (1-p) \cdot V_{j+1,i+1}\right]$$

Suitable for: American options, more exotic structures. Converges at $N = 100$ to less than 0.01% deviation from Black-Scholes.

The **Binomial Tree** tab shows the tree for $N = 6$ (readable display):

- **Green** = ITM nodes (option value > 0)
- **Light grey** = OTM nodes (worthless at expiry)
- Upper number = spot price, lower number = option value
- Click a node for detailed information

Option Types

Type	Payoff at expiry	Price	Strikes
Call	$\max(S_T - K_1,\ 0)$	$C(K_1)$	K_1
Put	$\max(K_1 - S_T,\ 0)$	$P(K_1)$	K_1
Bull Call Spread	$\max(S_T - K_1, 0) - \max(S_T - K_2, 0)$	$C(K_1) - C(K_2)$	$K_1 < K_2$
Bear Put Spread	$\max(K_2 - S_T, 0) - \max(K_1 - S_T, 0)$	$P(K_2) - P(K_1)$	$K_1 < K_2$
Butterfly	$C(K_1) - 2C(K_2) + C(K_3)$	Sum	$K_1 < K_2 < K_3$

For spreads and butterfly the additional strike fields (K_2, K_3) appear automatically.

Outputs and Risk Measures

Option Price and Break-Even

The theoretical option price is calculated according to the selected model. The discount factor e^{-rT} is always displayed. Break-even points:

Option type	Break-even
Call	$K_1 + \text{Premium}$
Put	$K_1 - \text{Premium}$
Bull Call Spread	$K_1 + \text{Premium}$
Bear Put Spread	$K_2 - \text{Premium}$
Butterfly	K_2 (approximation)

Greeks

Greek	Symbol	Meaning	Unit
Delta	Δ	Price change per +1 spot	—
Gamma	Γ	Delta change per +1 spot	—
Theta	Θ	Time decay	per calendar day
Vega	ν	Price change per +1% volatility	per 1% σ
Rho	ρ	Price change per +1% rate	per 1% r

Value at Risk and CVaR

The calculator computes three different risk measures and displays them side by side:

Monte Carlo VaR and CVaR (Expected Shortfall)

Simulation of $N = 20\,000$ paths:

$$S_T^{(k)} = S \cdot \exp\Big[(r - \tfrac{1}{2}\sigma^2)T + \sigma\sqrt{T}\,Z^{(k)}\Big], \quad Z^{(k)} \sim \mathcal{N}(0,1)$$

$$\pi^{(k)} = \text{Payoff}(S_T^{(k)}) - \text{Premium}$$

$$\text{VaR}_\alpha = -\pi^{(\lfloor \alpha N \rfloor)}, \qquad \text{CVaR}_\alpha = -\frac{1}{\lfloor \alpha N \rfloor} \sum_{k=1}^{\lfloor \alpha N \rfloor} \pi^{(k)}$$

CVaR (Expected Shortfall) is the *mean* loss in the worst $\alpha\%$ of scenarios and is always $\geq \text{VaR}_\alpha$.

Parametric VaR (Delta-Normal)

Linear approximation via Delta:

$$\sigma_\Pi = |\Delta| \cdot S \cdot \sigma \cdot \sqrt{T}, \qquad \text{VaR}_\alpha^{\text{par}} = \sigma_\Pi \cdot z_\alpha$$

$$z_{95\%} = 1.6449, \qquad z_{99\%} = 2.3263$$

Note on VaR identity: For long options with short maturity (ATM or OTM), $\text{VaR}_{95\%}$ and $\text{VaR}_{99\%}$ can be identical. This is mathematically correct: if more than 5% of paths expire worthless, the loss at both quantiles is the same (= total loss of premium). The CVaR then shows the differences, as it averages over all bad scenarios. The parametric VaR is always distinct, as it assumes a normal distribution of P&L.

P&L Scenarios

The scenario table shows nine spot movements at expiry: $-30\%, -20\%, -10\%, -5\%, 0\%, +5\%, +10\%, +20\%,$ +
Per scenario: spot, payoff, net P&L (after premium), return in %.

CSV Format for Import and Export

Import (Upload)

Minimum CSV for a simple stock call option:

```
underlying,spot,strike,vol,rate,tenor
Stock (DAX),18500,18500,18.50,3.00,90
```

For FX (with foreign rate):

```
underlying,spot,strike,vol,rate,rf,tenor
FX (EUR/USD),1.0800,1.0800,8.00,3.00,2.50,90
```

Export

The export button generates a CSV with all parameters and results: parameters, discount factor, option price, break-even, Greeks, VaR/CVaR (MC and parametric), foreign rate, and all nine P&L scenarios.

Worked Example: FX Option EUR/USD, Call

Input

Parameter	Symbol	Value
Underlying	—	EUR/USD (FX)
Option type	—	Call (Vanilla)
Model	—	Black-Scholes (Garman-Kohlhagen)
Spot	S	1.0800
Strike	K	1.0800 (ATM)
Domestic rate	r	3.00% (USD, continuous)
Foreign rate	r_f	2.50% (EUR, continuous)
Volatility	σ	8.00%
Maturity	T	90 days = 0.24658 years

Calculation

Discount factors:

$$e^{-rT} = e^{-0.03\times 0.24658} = 0.99263, \qquad e^{-r_f T} = e^{-0.025\times 0.24658} = 0.99385$$

Adjusted spot (Garman-Kohlhagen):

$$S^* = 1.0800 \times 0.99385 = 1.07336$$

Auxiliary quantities:

$$d_1 = \frac{\ln(1.0800/1.0800) + (0.03 - 0.025 + \frac{1}{2}\times 0.0064)\times 0.24658}{0.08 \times 0.49657} = \frac{0.001568}{0.039726} = 0.0395$$

$$d_2 = 0.0395 - 0.039726 = -0.0003$$

$$\Phi(0.0395) = 0.5158, \qquad \Phi(-0.0003) = 0.4999$$

$$C_{\text{GK}} = 1.07336 \times 0.5158 - 1.0800 \times 0.99263 \times 0.4999 = 0.5536 - 0.5357 = \mathbf{0.0179}$$

Greeks

$$\phi(d_1) = \phi(0.0395) = 0.39890$$

Greek	Result	Interpretation
Δ	+0.5129	Price rises by 0.513 per +1 EUR/USD
Γ	+10.054	Delta change per +1 spot
Θ	−0.000397	Loss per calendar day
ν	+0.2100	Price per +1% volatility
ρ	+0.001320	Price per +1% USD rate

Risk Measures

Metric	Value	Method
$\text{VaR}_{95\%}$	0.0179	Monte Carlo
$\text{VaR}_{99\%}$	0.0179	Monte Carlo (total loss: $> 5\%$ paths OTM)
$\text{CVaR}_{95\%}$	0.0179	Expected Shortfall
$\text{CVaR}_{99\%}$	0.0179	Expected Shortfall
$\text{VaR}^{\text{par}}_{95\%}$	0.02712	Delta-Normal
$\text{VaR}^{\text{par}}_{99\%}$	0.03838	Delta-Normal
Break-even	1.0979	$K + \text{Premium}$

Explanation: Since $r \approx r_f$ and the option is ATM, more than 5% of simulated paths expire worthless at $\sigma = 8\%$ and $T = 90$ days. MC-VaR and MC-CVaR therefore correspond to the total loss of the premium. The parametric VaR (Delta-Normal) assumes a normal distribution of P&L – it always shows distinct values, but overestimates the loss since it approximates the non-linear payoff only linearly.

P&L Scenarios

EUR/USD	Δ Spot	Payoff	Net P&L	Return
0.7560	−30%	0.0000	−0.0179	−100.0%
0.8640	−20%	0.0000	−0.0179	−100.0%
0.9720	−10%	0.0000	−0.0179	−100.0%
1.0260	−5%	0.0000	−0.0179	−100.0%
1.0800	±0%	0.0000	−0.0179	−100.0%
1.1340	+5%	0.0540	+0.0361	+201.7%
1.1880	+10%	0.1080	+0.0901	+503.4%
1.2960	+20%	0.2160	+0.1981	+1106.7%
1.4040	+30%	0.3240	+0.3061	+1710.1%

Frequently Asked Questions

Why are VaR 95% and VaR 99% sometimes identical?
For long options with a limited loss profile (= premium), both quantiles can fall in the same loss range. The CVaR and the parametric VaR then show the differences. See Section 5.3.

Why does the binomial tree (tab) differ from $N = 100$?
The tab displays $N = 6$ for visual readability. The calculation runs internally with $N = 100$.

Implied volatility is not loading.
The options chain is not included in the free Twelve Data plan. Enter volatility manually or upgrade to a paid plan.

The interest rate comes from the US – I need the Euribor.
FRED provides the US 3-month T-Bill rate. For EUR underlyings, manually adjust the rate to the current Euribor after loading.

Can I embed the tool in my website?
Yes, via iFrame:

```
<iframe src="options-risk-calculator.html"
        width="100%" height="800px" frameborder="0"></iframe>
```
