



## Options guide

<b>Abbreviation</b>	<b>Definition</b>
<i>S</i>	The underlying asset's price (the Rhea Crypto20 index in this case).
<i>X</i>	The strike price – the price at which the option contract will be executed.
<i>C, c</i>	The call option premium – the price at which a call option contract can be bought. Capital letter for an American option, minuscule for European.
<i>P, p</i>	The put option premium – the price at which a put option contract can be bought. Capital letter for an American option, minuscule for European.
<i>Risk-free rate</i>	The return of an investment with no risk, most commonly used is the 10-year US government bond.

### 1. What are options?

An option is a derivative instrument, which gives its owner the right, but not the obligation, to either buy or sell an underlying asset at a given price (**strike price X**). In finance, buyers can choose whether to exercise the option, but sellers are obliged to perform if the buyer exercises it. However, our options will be cash-settled i.e. there will only be a transfer of profits between the buyer and seller without a transfer of ownership.

Now, we will quickly go over the option basics:

#### 1.1. Option types, parties and positions - there are two types of options:

- Call option – the owner has the right to purchase the underlying asset at a specific price for a specific time period.
- Put option - the owner has the right to sell the underlying asset at a specific price for a specific time period.

There are two parties in an options transaction – an option buyer and an option writer (seller). Since there are two option types and parties, there are four possible positions:

- Long call: the buyer of a call option – has the right to buy an underlying asset.
- Short call: the writer of a call option – has the obligation to sell the underlying asset.
- Long put: the buyer of a put option – has the right to sell the underlying asset.
- Short put: the writer of a put option – has the obligation to buy the underlying asset.

Options resemble forward agreements in many ways, yet they have some notable differences. We have seen so far the voluntary execution on the buyer's side and the mandatory sale on the writer's side, but we will now dive into the other aspects of options which make them very flexible instruments.

## 1.2. Six factors which determine option prices and payoffs

- 1.2.1. **Price of the underlying asset** – in our case, the underlying asset is the Rhea Crypto 20 index. The higher the price at the expiration date, the higher the value of a call option and the lower the value of a put option.
- 1.2.2. **The strike price** – a higher strike price decreases the value of call and increases that of a put.
- 1.2.3. **The risk-free rate** – a higher risk-free rate will increase calls and decrease puts. To understand why, consider this: a call option is simply a purchase at a future date and since you pay at expiration, the funds can be used to earn the risk-free rate. The higher the interest rate, the higher the return. Inversely, a put option is a delayed sale; therefore, a higher interest rate makes it less attractive to delay the sale, as the proceeds can be used to earn the risk-free rate.
- 1.2.4. **Volatility of the underlying** – an increase in volatility of the underlying asset increases the values of both calls and puts and vice versa. Volatility gives options more value, as larger moves in the price of the underlying asset translate to higher probabilities that these options will return a profit.
- 1.2.5. **Time to expiration** – the longer the time to expiration of an option, the higher the volatility, therefore time increases the values of calls and puts and vice versa. A longer-term option has more time to go in-the-money.
- 1.2.6. **Costs and benefits of holding the asset** – in equity, fixed income and commodity markets, there are costs and benefits of holding the underlying asset (dividend, interest payments and convenience yield). Benefits will decrease the value of call, but increase the value of a put and vice versa. Some cryptocurrencies have holding benefits, but their prices are not downward adjusted like equity shares are on their ex-dividend dates.

Before we move on, the table below quickly summarizes the six factors we just described. Some of these factors do not apply in the same way for cryptocurrencies. The higher the factor, the:

*Table 1 Six Factors in option pricing*

<b>Factor</b>	<b>Call</b>	<b>Put</b>
<i>Price of the underlying asset (S)</i>	+	-
<i>Strike Price (X)</i>	-	+
<i>Risk-free rate (i)</i>	+	-
<i>Volatility of the underlying</i>	+	+
<i>Time to expiration</i>	+	+
<i>Costs/benefits</i>	+ / -	- / +

- 1.3. **Option style** – the style defines the dates on which an option may be exercised. There are two basic types:
  - 1.3.1. **European option** – can only be exercised at the expiration date, which is a pre-defined point in time.
  - 1.3.2. **American option** – may be exercised at any point in time before the expiration date. An American option's intrinsic value is always equal to or larger than the value of a European option with the same characteristics, simply because it can be exercised at any time until maturity.
  - 1.3.3. **Other** – Bermuda, Asian and Barrier options are among the most famous out of a multitude of option styles.

1.4. **Moneyness** – a description of an option’s intrinsic value. If upon an immediate exercise an option can generate a positive payoff, then it is **in-the-money**. If a loss will be the result of immediate exercise, then it is **out-of-the-money**. The last two happen when the price of the underlying asset is different from the strike price, thus resulting in a positive or negative payoff. When the underlying’s price is equal to the strike price, then the option is **at-the-money**.

1.5. **Option premium** – to buy a call/put option, the buyer has to pay a premium (or simply put the price of the product) in order to obtain the right to buy/sell the underlying at the strike price. Inversely, the option writer receives this premium the moment he sells it, but later has to serve as a counterparty to the buyer. The premium is equal to the sum of the intrinsic value and the time value. Here is what the last two mean:

1.5.1. **Intrinsic value** – this is simply the maximum of zero and the amount the option is in-the-money. If a call option is in-the-money it will be worth  $S-X$ . For an in-the-money put, the intrinsic value will be  $X-S$ . If an option is out-of-the-money, it will be worth 0.

1.5.2. **Time value** – the premium that an investor is willing to pay over the intrinsic value of an option based on the probability it will increase in value.

An option’s value can never be negative. To put this in perspective, here is the option price for a call and a put in a formula:

$$c = \text{Max} [(S-X), 0]$$

$$p = \text{Max} [(X-S), 0]$$

1.6. **Payoffs** – Table 2 below summarizes the payoffs for each of the four option types:

*Table Error! Use the Home tab to apply 0 to the text that you want to appear here.Error! Use the Home tab to apply 0 to the text that you want to appear here.-2: Opportunities and risks*

	$S < X$	$S = X$	$S > X$	<b>Opportunity</b>	<b>Risk</b>
<i>Long call</i>	-c	-c	$S-X-c$	Unlimited profits	Loss equal to c
<i>Short call</i>	+c	+c	$-(S-X)+c$	Immediate gain	Unlimited loss
<i>Long put</i>	$X-S-p$	-p	-p	Limited loss	Limited gain
<i>Short put</i>	$-(X-S)+p$	+p	+p	Immediate gain	Limited gain

The first two columns represent the three possible scenarios at the expiration date of an option. At maturity, the asset’s price will either be lower than, equal to or higher than the strike price.

**$S < X$ :** at this point, the buyer of a call option will not choose to exercise, thereby resulting in a loss equal and capped to the option’s price. Inversely, the call writer gains the call price. All put options with strikes prices equal to X will be exercised, resulting in a gain for long puts and losses for shorts.

**$S = X$ :** P&Ls are made up only of the option premiums.

**$S > X$ :** As the asset’s price surpasses the strike, all call options with strike X get exercised, thus resulting in a profit for buyers and a loss for writers. No puts with strike X are exercised.

The last two columns in the table summarize the conclusions for each position:

- ® Long call: Unlimited gain and loss is limited to call price.
- ® Short call: Immediate, but capped gain and unlimited loss.
- ® Long put: Gain is capped to  $X-p$  if the asset’s price reaches 0 and loss capped to put price.
- ® Short put: Immediate, but capped gain, however loss is limited to  $p-X$ .

Figures 1 and 2 below provide a visualization of the payoffs for call and put options.

Figure 1: Long and short call options P&L

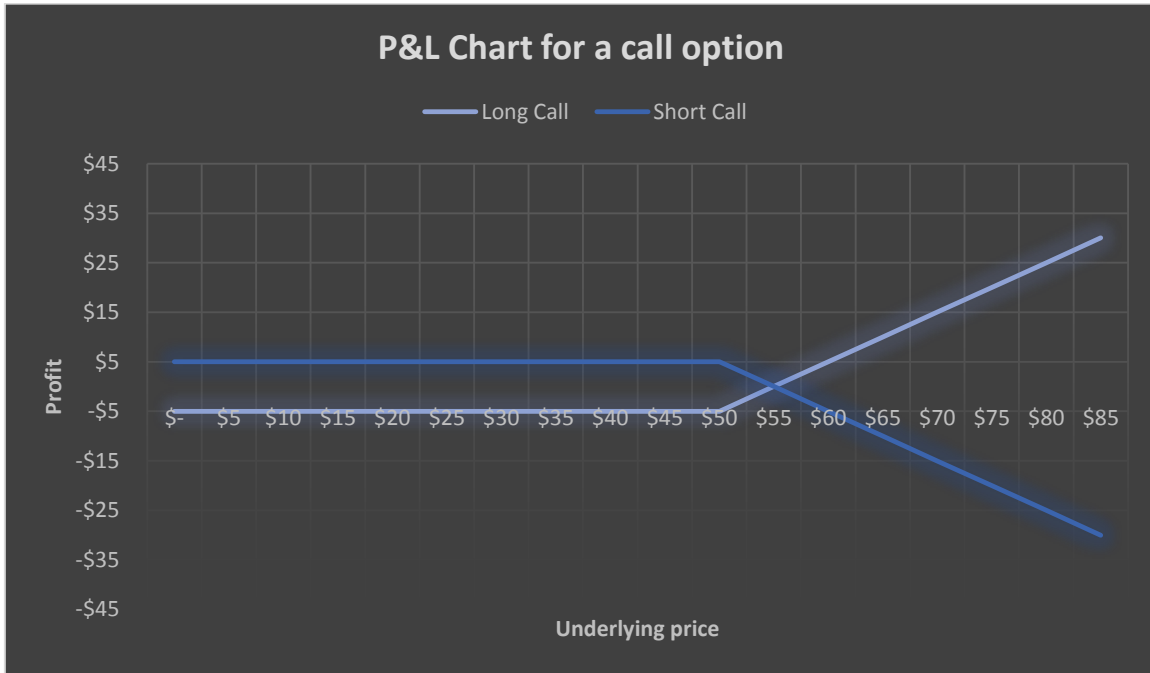
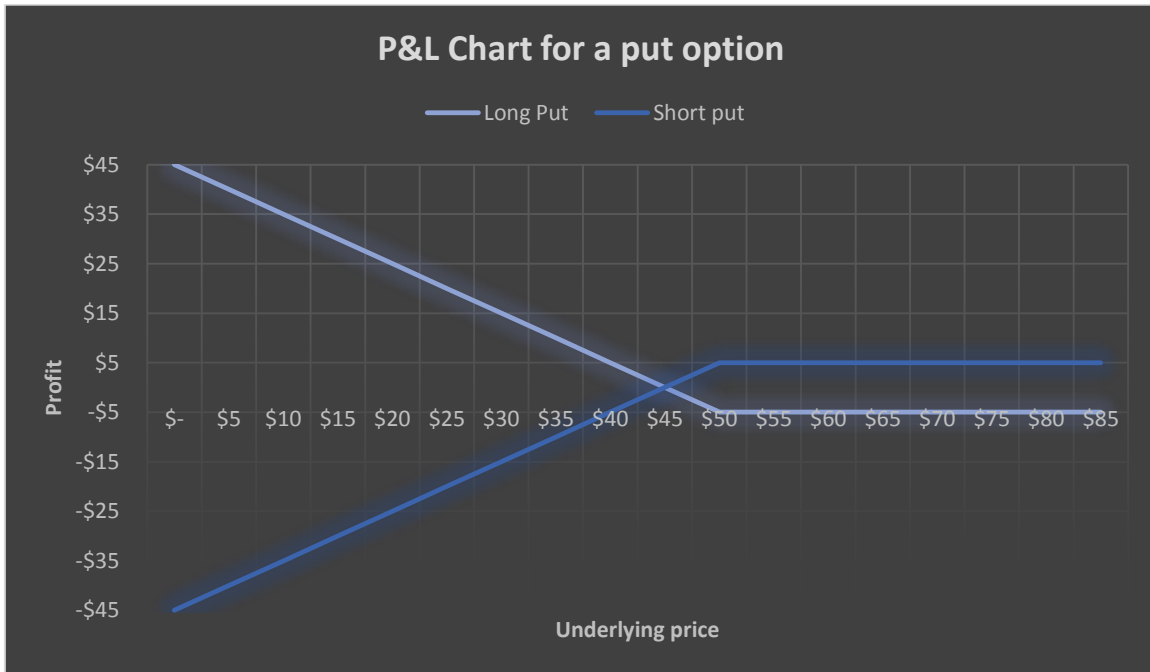


Figure 2: Long and short put options P&L



## 2. How will options be priced on the Rhea platform?

Options will be priced by using the Black-Scholes formula (the most famous model in the world for options pricing). Before diving into the calculation methodology, here are the assumptions that the model makes:

- Ⓡ European options only
- Ⓡ No dividends paid out during option duration
- Ⓡ Markets are efficient
- Ⓡ No transaction costs
- Ⓡ Risk-free rate and volatility are known and constant
- Ⓡ Returns of the underlying asset's price have a normal distribution

Black-Scholes makes many assumptions, some of which seem far-fetched. It is by no means flawless, but every model has limitations. The formula uses a straightforward calculation to obtain the option premium, which is great for creating consistency. For simplicity, we are just going to look at the formula of a call option, as the put calculation is very similar.

$$C = SN(d_1) - N(d_2)Xe^{-rt}$$

where:

$$d_1 = \ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

Abbreviation	Description
$N()$	Normal distribution.
$e$	Exponential term.
$r$	The risk-free rate.
$t$	Time to expiration (in %).
$\ln$	Natural logarithm.
$\sigma$	Standard deviation of the underlying.

## 3. User-friendliness of the Rhea platform

The Rhea options trading platform will be designed to conveniently explain all of the options basics we just described. This way, users will not have to look up terms and formulas while operating on the platform. This document was for informational purposes only and is by no means a must-read for trading options. The Rhea platform will offer users introductory guides, on-the-go help while trading and tips at every step.

The calculations in the Black-Scholes formula will be done automatically by our trading algorithm. The platform guide will give easy to understand examples of how the premiums are computed.