OPTIONS TRADING TUNNELS METHODOLOGY

INFORMAÇÃO INTERNA

SUMÁRIO

TRADING TUNNELS METHODOLOGY

In the methodology of trading tunnels for stock options, ETFs, futures and index, to determine the limits of the auction and rejection tunnel, the Black&Scholes formula is used, according to the following information.

Lower limit of the auction tunnel, the minimum value of its underlying asset calculated in a time window will be inserted in the pricing formula for options of the calls type, and for options of the put type, the maximum value of its underlying asset calculated in a time window will be inserted. time window. The volatility entered into the pricing formula for both call and put options will be shocked to the downside. The same method applies to determine the lower bound of the rejection tunnel, using a volatility shock different from that used for the auction tunnel.

Upper limit of the auction tunnel, the maximum value of its underlying asset calculated in a time window will be inserted in the pricing formula for options of the calls type, and for options of the put type, the minimum value of its underlying asset calculated in a time window will be inserted. time window. The volatility entered into the pricing formula for both call and put options will be shocked to the upside. The same method applies to determine the upper limit of the rejection tunnel, using a volatility shock different from that used for the auction tunnel.

INPUT:

a) Volatility

Volatility surfaces are required to calculate the trading tunnels (auction and rejection) for options on stocks, ETFs, futures and index. Volatilities are calculated by the Pricing Management. Volatilities may be updated during the trading session.

b) Price of underlying asset

In the methodology, the minimum and maximum value in which the underlying asset traded in a time interval are calculated. These minimum and maximum values will be used to determine the trading tunnels (auction and rejection). As with volatilities, the price of the underlying asset can also experience a shock to the maximum and minimum price of the underlying asset.

The determination of the price of the underlying assets has different methodologies for different types of instruments. Descriptions of the methodologies to be used follow below.

METHODOLOGY FOR DETERMINING THE PRICE OF OBJECT ASSETS:

a) Options on stocks and ETFs

Stock and ETF options will use the traded price of their respective underlying asset during the trading session.

b) Options on futures

The following methodology will be used to calculate the price of the underlying asset for options on futures: a “pivot month” will be defined for each contract, that is, the most liquid month of expiry. The settlement price of each month will then be calculated and the differences between the settlement prices and the settlement price of the pivot month will be calculated. Finally, for the pivot months, their respective prices negotiated during the trading session will be used as the value of the underlying asset, and for the other contract months, the differences calculated previously will be added to the price at which the pivot month was traded.

Below is an example of the calculations of the underlying asset with dollar futures where the DOLK37 expiration is the pivot:

Table - Price of the underlying assets for options on the dollar				
Dollar Foward	**Price of Underlying Asset**	**Settlement Price**	**Difference between settlement Price**	**Notes**
DOLK37	3135,00	3161,297	-	The price of the object asset is the price of the last trade of DOLK37
DOLM37	3159,38	3185,677	24,38	The price of the object asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 24.38)
DOLN37	3180,59	3206,892	45,59	The price of the object asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 45.59)
DOLQ37	3199,73	3226,026	64,73	The price of the object asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 64.73)
DOLU37	3220,90	3247,202	85,90	The price of the underlying asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 85.90)
DOLV37	3236,84	3263,135	101,84	The price of the object asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 101.84)
DOLX37	3254,47	3280,766	119,47	The price of the underlying asset is the difference of adjustments added to the price of the last trade of DOLK37 (3,135 + 119.47)

c) Options on IDI e ITC

In order to calculate the underlying asset of options on IDI and ITC, the formula described below will be adopted, using the ***DI1 rates*** (for options on IDI) and ***OC1*** (for options on ITC) traded in the current session and ***using the Spot index***:

$$IDI/ITC_f = IDI/ITC_s \times \left(1 + r_{DI/OC\ 1}\right)^{DU/252}$$

Where IDI/ITC_f corresponds to the ***Forward Index*** of reference (asset object of options), IDI/ITC_s corresponds to the ***Spot Index***, $r_{DI/OC\ 1}$ the rate considered e DU the number of working days until the expiration date.

Below is an example of the calculation of the underlying asset for options on IDI maturing in September 2022:

$$IDI_{f\ SEPT/22} = IDI_s \times \left(1 + r_{DI1\ SEPT/22}\right)^{DU/252}$$

$$IDI_{f\ SEPT/22} = 233.669{,}55 \times (1 + 0{,}10165)^{102/252}$$

$$IDI_{f\ SEPT/22} = 243.194{,}341$$

d) Options on Gold

Options on gold will use the future OZ1D as the underlying asset.

e) Options on Index

The methodology for calculating the price of the underlying asset of index options is similar to the methodology for calculating the price of the underlying asset for futures options: we calculate the difference between the adjustments of the futures indices with the pivot index (month of greater liquidity) and we add this difference to the price of the last pivot index trade.

To calculate the price of the underlying asset of an index maturing in an odd month, we must interpolate the adjustments between the two index with maturities closest to it and perform the methodology described above.

Example:

Table - Price of underlying assets for index options						
Expire Date	**Index Forward**	**Price of underlying asset**	**Settlement Price**	**Difference between Settlement price**	**Days (DS)**	**Notes**
05/17/2022	INDK22	64.955	-	-414,5	16	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (-414.5 + 65,370)
06/14/2022	INDM22	65.370	64.509,0		36	Price of the underlying asset is the price of the last trade of INDM22
07/12/2022	INDN22	65.785	64.923,5	414,5	55	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (414.5 + 65,370)
08/16/2022	INDQ22	66.334	65.473,0	964,0	80	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (964 + 65,370)
09/13/2022	INDU22	66.707	65845,9	1336,9	99	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (1,336.9+65,370)

10/18/2022	INDV22	67.181	66320,0	1.811,0	123	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (1,811 + 65,370)

The INDM22 index is pivot and the INDK22, INDN22 and INDU22 indexes are synthetic odd indices. To find the prices of INDK22, INDN22 and INDU22, log-linear interpolation was performed between the closest adjustments and days for withdrawal, for example, to find the price of INDN22, log-linear interpolation between the adjustments and days for withdrawal was performed (DS) of INDM22 and INDQ22.

The Difference Between Adjustments column is the adjustment difference between the desired month and the pivot month, for example, the difference between adjustments of INDN22 is equal to its adjustment subtracted from the adjustment of the pivot month INDM22 (65,785 – 65,370 = 414.5).

The differences between adjustments found must be added to the price of the last trade of the pivot index and be used in the pricing of options as the underlying asset. For example, to obtain the underlying asset of an IBOV11 option that expires in September 2022, you must add 1336.90 to the price of the last trade of INDM22 and use this value (1,336.9 + 65,370 = 67,181.00).

Comments:

- Log-linear interpolation formula used:

$$p(x,y) = y_0 * \left(\frac{y_1}{y_0}\right)^{\frac{x-x_0}{x_1-x_0}}$$

- Where:

  -y_0 represents the adjustment of the previous index
  - y_1 represents the adjustment of the posterior index
  - x represents the days for the withdrawal of the index that we want to find the adjustment

- x_0 represents the days for the withdrawal of the previous index
- x_1 represents the days for the withdrawal of the posterior index

- If there is an odd month prior to the pivot month, we use the negative of the difference between the adjustments for the next even month as the difference between the adjustments for the pivot month.

Tabela – Preço dos ativos objetos para opções sobre dólar						
Expire Date	**Index Forward**	**Price of underlying asset**	**Settlement Price**	**Difference between Settlement price**	**Days (DS)**	**Notes**
05/17/2022	INDK22	64.955	-	**-414,5**	16	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (-414.5 + 65,370)
06/14/2022	INDM22	65.370	64.509,0		36	Price of the underlying asset is the price of the last trade of INDM22
07/12/2022	INDN22	65.785	64.923,5	**414,5**	55	Price of the underlying asset is the sum of the difference between the adjustments and the price of the last trade of INDM22 (414.5 + 65,370)

VOLATILITY SHOCK

A volatility shock is defined as the addition or subtraction of a value to the volatility of an option. If the shock is a percentage, this percentage must be calculated in relation to the volatility of the option and add and/or subtract this value from the volatility. The volatility shock values for lower and upper auction and for lower and higher rejection may differ from each other.

Example of volatility shock calculation:

- Parameterized shocks for a determined option:

Option	Volatility	Bottom auction shock	Top auction shock	Bottom rejection shock	Top rejection shock
IBOVJ38	39,36	10%	20%	40%	50%

- Volatility values used to determine the auction and rejection tunnels with the shocks parameterized according to the table above:

Bottom Auction Volatility	Bottom Auction Volatility	Top Rejection Volatility	Top Rejection Volatility
35,42 (39,36 - 39,36*10%)	47,23 (39,36 + 39,36*20%)	23,62 (39,36 - 39,36*40%)	59,04 (39,36 + 39,36*50%)

SHOCK IN THE PRICE OF THE OBJECT ASSET

A shock to the underlying asset is defined as the addition or subtraction of a value to the price of the underlying asset of an option. If the shock is a percentage, this percentage must be calculated in relation to the maximum and minimum price of the asset object of the option and this value must be added and/or subtracted from the prices in the calculation formula. The shock values on the underlying asset for lower and higher auction and for lower and higher rejection may be different from each other. B3 may, when it deems it necessary, change the shock to the price of the underlying asset, in order to ensure the integrity of the negotiations and the market.

DETERMINATION OF AUCTION AND REJECTION TUNNELS

a) Options on Stocks, ETF and gold

The formula used to determine the auction and rejection tunnels of options on stocks, ETFs and Gold is the Black-Scholes:

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

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

Call option price:

$$C(S,t) = SN(d_1) - Ke^{-rt}N(d_2)$$

Put option price:

$$P(S,t) = Ke^{-rt}N(-d_2) - SN(-d_1)$$

Where:

- S represents the price of the underlying asset
- K represents the exercise price of the option
- r represents the interest rate
- σ represents the volatility of the option
- t represents the expiration time of the option
- $N(d_1)$ e $N(d_2)$ represent accumulated standard normal distribution

b) Options on future and index

The formula used to determine the auction and rejection tunnels of options on futures and index is the Black-76:

$$d_1 = \frac{\log\left(\frac{S}{K}\right) + \left(\frac{\sigma^2}{2}\right) * (t)}{\sigma * \sqrt{t}}$$

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

Call option price:

$$C(S,t) = e^{-rt}(SN(d_1) - KN(d_2))$$

Put option price:

$$C(S,t) = e^{-rt}(KN(-d_2) - SN(-d_1))$$

Where:

- S represents the price of the underlying asset
- K represents the exercise price of the option
- r represents the interest rate
- σ represents the volatility of the option
- t represents the expiration time of the option
- $N(d_1)$ e $N(d_2)$ represent accumulated standard normal distribution

c) Option on IDI e ITC

To determine the auction tunnels and rejection of options on IDI and ITC, the Black-76 formula is used as described above and the following formula is applied to the value found:

$$\frac{1}{(1+r)^{\frac{DU}{252}}}$$

Where r is the interest rate and DU is business days until the option expire.

MINIMUM BAND AMPLITUDE

There are two specific ones (called MBAs): one for the auction tunnel and other tunnels for the absolute rejection values. These values at the option's reference price (arithmetic mean of the lower auction tunnel and the higher education tunnel are obtained with the volatility shock and minimum and maximum price of the active object) to obtain the upper auction and rejection tunnels and subtracted from the option reference price to obtain the auction tunnels and lower options.

the calculation of maximums by the MBA is based on those that can be acquired with the shock of volatility and price and minimum of the underlying asset (methodology described in this document) and considered the only ones with greater amplitude. They are compared with the auction tunnels by the volatility shock and minimum and maximum of the asset and by the MBA and are compared with the rejection tunnels by the volatility shock and minimum and maximum of the asset and by the MBA, or, they may have a tunnel auction object offered by the MBA by volatility shock and minimum and maximum of the active object and creation tunnel by the MBA by shock.

Example:

- Tunnels calculated with the volatility shock and minimum and maximum price of the underlying asset for a given option:

Bottom rejection tunnel	Bottom auction tunnel	Reference price *	Top auction tunnel	Top rejection tunnel
0,01	0,10	0,20	0,30	0,40

* Reference Price: arithmetic average of the lower auction tunnel and the upper auction tunnel:

$$Option\ reference\ price: \frac{0{,}10 + 0{,}30}{2} = 0{,}20$$

- MBAs parameterized for the same option:

MBA of rejection	MBA of auction
0,25	0,05

- Tunnels calculated with MBA:

Bottom rejection tunnel with MBA	Bottom Auction tunnel with MBA	Top Auction Tunnel with MBA	Top Rejection Tunnel with MBA
0,01 (0,20-0,25)	0,15 (0,20-0,05)	0,25 (0,20+0,05)	0,45 (0,20+0,25)

In this example, the auction tunnels obtained with the volatility shock and minimum and maximum price of the object asset will be used and the rejection tunnels with the AMB will be used, as they have greater amplitudes when compared.

OPTIONS ON D11, D12, D13 AND D14

For options on DI futures, a methodology different from that mentioned in this document will be applied. We will use option premiums from the premiums file calculated by pricing management.

These premiums will be our reference prices for the options. Percentages will be applied to these reference prices which, when added and subtracted, will result in the auction and rejection tunnels of these options.

OPTIONS ON COPOM

The methodology for the auction and rejection tunnels for COPOM options is according to the following criteria: The first operation of the day will be via auction. After carrying out the first trade, the absolute value to be added and subtracted will be based on the price of the last trade or the offer with the best bid or ask price, if this is better than the price of the last trade.

Exemplo:

- Values for calculating auction and rejection tunnels:

Bottom Rejection tunnel	Bottom Auction tunnel	Top Auction tunnel	Top Rejection tunnel
-14	-8	+ 8	+ 14

Bottom Rejection tunnel	Bottom Auction tunnel	Midpoint	Top Auction tunnel	Top Rejection tunnel
0,01	2	10	18	24

OPTIONS TUNNELS ON STOCKS, ETF AND INDICES ON EXPIRATION DAY.

On the expiration day, the tunnel of options on stocks, ETFs and indices is not calculated by volatility for the expiring series. The tunnel is now calculated by the intrinsic of the option, adding an absolute value for the upper auction tunnel, and subtracting it for the lower auction tunnel. The absolute value for the reject tunnel is twice the calculated value for the auction tunnel.

Call Expiring		Aboslute value	Type Option	Bottom Tunnel	Top Tunnel.
PETRXXX	R$ 26,00	0,5	Leilão	6,5	7,5
PETRX	R$ 33,00	1	Rejeição	6	8
INTRINSIC	R$ 7,00				