OPÇÕES EXÓTICAS
MSc MATEMÁTICA FINANCEIRA 2016/17
EXAME - Resolução
31/07/17 **Duração: 2.5 horas**

CASO 1

a) Deduza a fórmula de avaliação de um *non-deferrable knock-out rebate* para uma *down-and-out option*, assumindo um *geometric Brownian motion* para o preço do activo subjacente e tendo em conta que

$$Q^*\left(\tau_L \in dv \middle| F_t\right) = \frac{-\ln\left(\frac{L}{S_t}\right)}{\sigma\sqrt{2\pi(v-t)^3}} \exp\left\{-\frac{\left[\ln\left(\frac{L}{S_t}\right) - \Psi(v-t)\right]^2}{2\sigma^2(v-t)}\right\} dv$$

é a densidade do 1º tempo de passagem do preço do activo subjacente pela barreira inferior, mas numa medida de probabilidade equivalente Q^* na qual o processo $y_u := \ln\left(\frac{S_u}{S_t}\right)$ segue a seguinte SDE: $dy_t = \Psi dt + \sigma dW_t^{Q^*}$.

Sabemos que

$$KONDR(-1)_t = E_Q\left[\mathrm{Re}^{-r(\tau_L - t)} 1_{\{\tau_L \le T\}} \middle| F_t\right]$$

$$= R\int_t^T e^{-r(v-t)} \times Q\left(\tau_L \in dv \middle| F_t\right).$$

Utilizando a Proposição 55 dos apontamentos,

$$KONDR(-1)_t = R\int_t^T e^{-r(v-t)} \times \frac{-\ln\left(\frac{L}{S_t}\right)}{\sigma\sqrt{2\pi(v-t)^3}} \exp\left\{-\frac{\left[\ln\left(\frac{L}{S_t}\right) - \mu(v-t)\right]^2}{2\sigma^2(v-t)}\right\} dv.$$

Juntando as exponenciais e completando o quadrado da diferença, obtemos:

$$KONDR(1)_t = R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \int_t^T \frac{-\ln\left(\frac{L}{S_t}\right)}{\sigma\sqrt{2\pi(v-t)^3}} \exp\left\{-\frac{\left[\ln\left(\frac{L}{S_t}\right) - \Psi(v-t)\right]^2}{2\sigma^2(v-t)}\right\} dv,$$

sendo $\Psi = \sqrt{\mu^2 + 2\sigma^2 r}$.

Utilizando novamente a Proposição 55 dos apontamentos,

$$KONDR(-1)_t = R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \int_t^T Q^*\left(\tau_L \in dv \middle| F_t\right),$$

onde

$$\tau_L := \inf\{v > t : S_v = L\}$$

continua a ser o 1º tempo de passagem do preço do activo subjacente pela barreira inferior, mas Q^* é agora uma EMM na qual o processo $y_u := \ln\left(\frac{S_u}{S_t}\right)$ segue a seguinte SDE:

$$dy_t = \Psi dt + \sigma dW_t^{Q^*}.$$

Consequentemente,

$$KONDR(-1)_t = R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} Q^*\left[\inf_{t<s<T}(y_s) \le \ln\left(\frac{L}{S_t}\right) \middle| F_t\right]$$

$$= R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \left\{1 - Q^*\left[\inf_{t<s<T}(y_s) > \ln\left(\frac{L}{S_t}\right) \middle| F_t\right]\right\}.$$

Utilizando a equação (124) dos apontamentos,

$KONDR(-1)_t$

$$= R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \left\{1 - \int_{-\infty}^{\infty} 1_{\left\{y_T \ge \ln\left(\frac{L}{S_t}\right)\right\}} \left\{\phi\left(y_T; \Psi\tau, \sigma\sqrt{\tau}\right) - \left(\frac{L}{S_t}\right)^{\frac{2\Psi}{\sigma^2}} \phi\left[y_T; 2\ln\left(\frac{L}{S_t}\right) + \Psi\tau, \sigma\sqrt{\tau}\right]\right\} dy_T\right\}$$

$$= R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \left\{1 - \Phi\left[-\frac{\ln\left(\frac{L}{S_t}\right) - \Psi\tau}{\sigma\sqrt{\tau}}\right] + \left(\frac{L}{S_t}\right)^{\frac{2\Psi}{\sigma^2}} \Phi\left[-\frac{\ln\left(\frac{L}{S_t}\right) - 2\ln\left(\frac{L}{S_t}\right) - \Psi\tau}{\sigma\sqrt{\tau}}\right]\right\}$$

$$= R\left(\frac{L}{S_t}\right)^{\frac{\mu-\Psi}{\sigma^2}} \Phi\left[\frac{\ln\left(\frac{L}{S_t}\right) - \Psi\tau}{\sigma\sqrt{\tau}}\right] + R\left(\frac{L}{S_t}\right)^{\frac{\mu+\Psi}{\sigma^2}} \Phi\left[\frac{\ln\left(\frac{L}{S_t}\right) + \Psi\tau}{\sigma\sqrt{\tau}}\right].$$

b) Deduza a função densidade de probabilidade do supremo registado durante o intervalo de tempo $[t,T]$ pelo preço "S" de um activo que segue um *geometric Brownian motion.*

We start by finding the pdf for the infimum of the rate of return $y_u := \ln\left(\frac{S_u}{S_t}\right)$. Using, for instance, equations (148) and (152) of the handouts, we know that

$$Q\left(\sup_{t<u\leq T}(y_u) < \ln\left(\frac{U}{S_t}\right)\middle| F_t\right) = \Phi\left[-\frac{\ln\left(\frac{S_t}{U}\right)+\mu\tau}{\sigma\sqrt{\tau}}\right] - \left(\frac{U}{S_t}\right)^{\frac{2\mu}{\sigma^2}} \Phi\left[-\frac{\ln\left(\frac{U}{S_t}\right)+\mu\tau}{\sigma\sqrt{\tau}}\right],$$

i.e.

$$Q\left(\sup_{t<u\leq T}(y_u) < y\middle| F_t\right) = \Phi\left[-\frac{-y+\mu\tau}{\sigma\sqrt{\tau}}\right] - \left(e^y\right)^{\frac{2\mu}{\sigma^2}} \Phi\left[-\frac{y+\mu\tau}{\sigma\sqrt{\tau}}\right],$$

for $y = \ln\left(\frac{U}{S_t}\right)$.

Therefore,

$$Q\left(\sup_{t<u\leq T}(y_u) \in dy\middle| F_t\right) = \frac{d}{dy} Q\left(\sup_{t<u\leq T}(y_u) < y\middle| F_t\right)$$

$$= \left\{\phi\left(y;\mu\tau,\sigma\sqrt{\tau}\right) - \frac{2\mu}{\sigma^2} e^{\frac{2\mu y}{\sigma^2}} \Phi\left[-\frac{y+\mu\tau}{\sigma\sqrt{\tau}}\right] + e^{\frac{2\mu y}{\sigma^2}} \phi\left(y;-\mu\tau,\sigma\sqrt{\tau}\right)\right\} dy.$$

Finally, and since

$$\sup_{t<u\leq T}(S_u) = S_t \exp\left(\sup_{t<u\leq T}(y_u)\right),$$

or

$$\sup_{t<u\leq T}(y_u) = \ln\left(\frac{\sup_{t<u\leq T}(S_u)}{S_t}\right),$$

then

$$Q\left(\sup_{t<u\leq T}(S_u)\in dS \middle| F_t\right)$$

$$= Q\left(\sup_{t<u\leq T}(y_u)\in dy \middle| F_t\right)\times\left|\frac{d\sup_{t<u\leq T}(y_u)}{d\sup_{t<u\leq T}(S_u)}\right|$$

$$=\left\{\phi\left(\ln\left(\frac{S}{S_t}\right);\mu\tau,\sigma\sqrt{\tau}\right)-\frac{2\mu}{\sigma^2}\left(\frac{S}{S_t}\right)^{\frac{2\mu}{\sigma^2}}\Phi\left[-\frac{\ln\left(\frac{S}{S_t}\right)+\mu\tau}{\sigma\sqrt{\tau}}\right]+\left(\frac{S}{S_t}\right)^{\frac{2\mu}{\sigma^2}}\phi\left(\ln\left(\frac{S}{S_t}\right);-\mu\tau,\sigma\sqrt{\tau}\right)\right\}\frac{1}{S}dS.$$

c) Deduza uma relação de paridade *put-call* para *cash-or-nothing options*.

Starting with the terminal payoffs of both cash-or-nothing call and put options,

$$D(1)_T(S,X,T;M)+D(-1)_T(S,X,T;M)=M\times 1_{\{S_T>X\}}+M\times 1_{\{S_T<X\}}$$

$$=M.$$

Therefore,

$$D(1)_t(S,X,T;M)+D(-1)_t(S,X,T;M)=Me^{-r(T-t)}.$$

CASO 2

a)

$$r:\quad e^{r\times 0.25}=1+1.426\%\times {}^{3}\!/_{12}\Rightarrow r=4\ln\left(1+1.426\%\times {}^{3}\!/_{12}\right)\cong 1.4235\%.$$

.1º valor:

$$S_{2,10} = 21{,}055.59 \times \exp\left\{\left[1.4235\% - 1\% - \frac{(0.25)^2}{2}\right] \times \frac{0.25}{6} + 0.6036 \times 0.25 \times \sqrt{\frac{0.25}{6}}\right\}$$

$$S_{2,10} \cong 21{,}689.83.$$

.2º valor:

$$\begin{aligned} V_{6,2} &= \max(20{,}940.51 - 21{,}010.54;0) \times 1_{\{S\min \leq 20{,}800\}} \\ &= 0 \times 1_{\{21{,}010.54 \leq 20{,}800\}} \\ &= 0 \times 0 \\ &= 0. \end{aligned}$$

.3º valor:

$$\begin{aligned} V_{6,8} &= \max(20{,}940.51 - 19{,}712.43;0) \times 1_{\{S\min \leq 20{,}800\}} \\ &= (20{,}940.51 - 19{,}712.43) \times 1_{\{19{,}712.43 \leq 20{,}800\}} \\ &= 20{,}940.51 - 19{,}712.43 \\ &= 1{,}228.08. \end{aligned}$$

b)

$$\hat{V}_0 = e^{-1.4235 \times 0.25} \times \frac{8{,}632.31}{10} \cong 860.16.$$

$$\sigma\left(\hat{V}_0\right) = \frac{e^{-1.4235 \times 0.25}}{\sqrt{10}} \times \sqrt{\frac{16{,}772{,}151.93 - (8{,}632.31)^2 / 10}{10 - 1}} \cong 320.67.$$

c)

Existem apenas duas simulações (#2 e #4) em que não há o evento de knock-in (na medida em que a cotação mínima é superior à barreira definida).

Nestas duas simulações o payoff final será não de zero (conforme estabelecido na tabela do enunciado) mas sim de 100 pontos de índice para cada simulação. Assim sendo, o somatório dos 10 payoffs finais passará a ser igual a

$$8{,}632.31 + 2 \text{ x}100 = 8{,}832.31.$$

Consequentemente,

$$\hat{V}_0 = e^{-1.4235 \times 0.25} \times \frac{8{,}832.31}{10} \cong 880.09\,.$$

CASO 3

a) Formulate a trading decision for a (USD denominated) bank deposit with expiry date after 6 months, and with a variable return equal to 5% if the Dow Jones index increases (after 6 months) above 22,000 index points.

$$r: \quad e^{r\times 6/12} = 1 + 1.426\% \times 6/12 \Rightarrow r = 2\times \ln\left(1 + 1.426\%/2\right) \cong 1.4209\%.$$

Concerning the variable return component, and denoting the Dow Jones index price by "S", then

$$VR_{6M} = \begin{cases} 5\% \Leftarrow S_{6M} > 22{,}000 \\ 0\% \Leftarrow ELSE \end{cases}$$

$$= 5\% \times c^{d}_{6M}\left(S; X = 22{,}000; T = 6M; M = 1\right).$$

Therefore,

$$B_0 = 100\% \times e^{-1.4209\%\times 0.5} + VR_0,$$

and

$$VR_0 = 5\% \times c^{d}_{0}\left(S; X = 22{,}000; T = 6M; M = 1\right)$$

$$= 5\% \times e^{-1.4209\%\times 0.5} \times N\left[d_2^M\left(20{,}940.51; 22{,}000\right)\right].$$

$$N\left[d_2^M\left(20{,}940.51;22{,}000\right)\right] = N\left[\frac{\ln\left(20{,}940.51/22{,}000\right) + \left(1.4209\% - 1\% - (0.25)^2/2\right)\times 0.5}{0.25\times\sqrt{0.5}}\right]$$

$$\begin{aligned} &= N(-0.3557) \\ &= 1 - N(0.3557) \\ &\cong 1 - N(0.36) \\ &= 1 - 0.6406 \\ &= 0.3594. \end{aligned}$$

Hence,

$$VR_0 = 5\% \times e^{-1.4209\%\times 0.5} \times 0.3594 \cong 1.79\%,$$

and

$$B_0 = 99.29\% + 1.79\% \cong 101.08\% > 100\% \Rightarrow \text{ Invest.}$$

b) Formulate a trading decision for a (USD denominated) bank deposit with expiry date after 6 months, and with a variable return equal to 2.5% (after 6 months) if the Dow Jones index never increases above 22,000 index points at any moment during the next 6 months.

$$B_0 = 100\% \times e^{-1.4209\% \times 0.5} + VR_0,$$

$$VR_{6M} = \begin{cases} 2.5\% \Leftarrow \sup\limits_{0<u<6M} (S_u) < 22{,}000 \\ 0\% \Leftarrow ELSE \end{cases}$$

$$= 2.5\% \times 1_{\left\{ \sup\limits_{0<u<6M} (S_u) < 22{,}000 \right\}}.$$

Hence,

$$VR_0 = 2.5\% \times e^{-1.4209\% \times 0.5} \times Q\left[\sup_{0<u<6M} (S_u) < 22{,}000 \middle| F_0 \right].$$

Since the variable return value corresponds to the present value of a knock-in rebate equal to 3% and associated to an up barrier of 22,000 index points, we can use Proposition 52 of the handouts (with $\eta = 1$) to compute the following probability:

$$Q\left[\sup_{0<u<6M} (S_u) < 22{,}000 \middle| F_0 \right]$$

$$= N\left[-d_2^M (20{,}940.51; 22{,}000) \right] - \left(\frac{22{,}000}{20{,}940.51} \right)^{\frac{2\mu}{0.25^2}} N\left[-d_2^M (22{,}000; 20{,}940.51) \right],$$

where

$$\mu = r - q - \sigma^2/2 = 1.4209\% - 1\% - (0.25)^2/2 = \text{-0.02704}.$$

Using the results from the answer to the previous question, then

$$N\left[-d_2^M(20{,}940.51;22{,}000)\right]=1-N\left[d_2^M(20{,}940.51;22{,}000)\right]$$
$$=1-0.3594$$
$$=0.6406.$$

Auxiliary calculus:

$$N\left[-d_2^M(22{,}000;20{,}940.51)\right]=N\left[-\frac{\ln\left(22{,}000 / 20{,}940.51\right)+\left(1.4209\%-1\%-(0.25)^2 / 2\right)\times 0.5}{0.25\times\sqrt{0.5}}\right]$$
$$=N(-0.2027)$$
$$=1-N(0.2027)$$
$$\cong 1-N(0.20)$$
$$=1-0.5793$$
$$=0.4207.$$

Therefore,

$$Q\left[\sup_{0<u<6M}(S_u)<22{,}000\middle|F_0\right]=0.6406-\left(\frac{22{,}000}{20{,}940.51}\right)^{\frac{2\times(-0.02704)}{0.25^2}}\times 0.4207\cong 0.236832905,$$

$$VR_0=2.5\%\times e^{-1.4209\%\times 0.5}\times 0.236832905\cong 0.588\%,$$

and

$$B_0=99.29\%+0.588\%\cong 99.88\%<100\%\Rightarrow \text{ Do not invest.}$$

c) Formulate a trading decision for a bond issued at the par value of US$100,000,000, with bullet redemption (at par value) after 6 months, and with a variable return (to be paid after 6 months) equal to 60% of the devaluation rate of the Dow Jones index, if this index never increases above 22,000 index points during the next 6 months.

$$B_0=100\%\times e^{-1.4209\%\times 0.5}+VR_0.$$

Concerning the variable return component,

$$VR_{6M} = \begin{cases} 60\% \times \max\left(0\%; \dfrac{S_0 - S_{6M}}{S_0}\right) \Leftarrow \sup\limits_{0<u\leq 0.5} (S_u) < 22{,}000 \\ 0\% \Leftarrow \sup\limits_{0<u\leq 0.5} (S_u) \geq 22{,}000 \end{cases}$$

$$= \frac{60\%}{S_0} \times \begin{cases} \max(0; S_0 - S_{6M}) \Leftarrow \sup\limits_{0<u\leq 0.5} (S_u) < 22{,}000 \\ 0 \Leftarrow \sup\limits_{0<u\leq 0.5} (S_u) \geq 22{,}000 \end{cases}$$

$$= \frac{60\%}{S_0} \times p_{6M}^{uo}(S_{6M}; X = S_0; H = 22{,}000; R = 0; T = 0.5y).$$

Therefore, the variable return is given by an up-and-out zero rebate put, i.e.

$$VR_0 = \frac{60\%}{S_0} \times p_0^{uo}(S_0; X = S_0; H = 22{,}000; R = 0; T = 0.5y).$$

The up-and-out put without rebate is priced through the following expression:

$$p_t^{uo}(S; X; H; T)$$

$$= p_t(S_t; \min(H; X); T) - \left(\frac{H}{S_t}\right)^{\frac{2\mu}{\sigma^2}} p_t\left(\frac{H^2}{S_t}; \min(H; X); T\right)$$

$$+ [X - \min(H; X)] e^{-r\tau} \left\{ N\left[-d_2^M(S_t, H)\right] - \left(\frac{H}{S_t}\right)^{\frac{2\mu}{\sigma^2}} N\left[-d_2^M(H, S_t)\right] \right\}$$

Since X = 20,940.51 < H = 22,000, then the previeus expression can be rewritten as:

$$p_t^{uo}(S; X; H > X; T) = p_t(S_t; \min(H; X); T) - \left(\frac{H}{S_t}\right)^{\frac{2\mu}{\sigma^2}} p_t\left(\frac{H^2}{S_t}; \min(H; X); T\right).$$

Considering the data given, then

$$p_0^{uo}(S_0; X = 20{,}940.51; H = 22{,}000; R = 0; T = 0.5y)$$

$$= p_0(S_0 = 20{,}940.51; X = 20{,}940.51; T = 0.5y)$$
$$- \left(\frac{22{,}000}{20{,}940.51}\right)^{\frac{2\mu}{\sigma^2}} p_t\left(\frac{22{,}000^2}{20{,}940.51}; X = 20{,}940.51; T = 0.5y\right).$$

Since the value of a standard put option is an homogeneous function of degree one of the spot and the strike, then

$$p_0^{uo}\left(S_0; X = 20{,}940.51; H = 22{,}000; R = 0; T = 0.5y\right)$$

$$= p_0\left(S_0 = 20{,}940.51; X = 20{,}940.51; T = 0.5y\right)$$

$$-\left(\frac{22{,}000}{20{,}940.51}\right)^{\frac{2\mu}{\sigma^2}} \times \frac{(22{,}000)^2}{(20{,}940.51)^2} \times p_0\left(20{,}940.51; 20{,}940.51 \times \frac{(20{,}940.51)^2}{(22{,}000)^2} \cong 18{,}972.14; T = 0.5y\right).$$

Since

$$\mu = r - q - \sigma^2/2 = 1.4209\% - 1\% - (0.25)^2/2 = \text{-}0.02704,$$

and using the data from the from the exam sheet, then

$$p_0^{uo}\left(S_0; X = 20{,}940.51; H = 22{,}000; R = 0; T = 0.5y\right)$$

$$= 1{,}444{,}18 - \left(\frac{22{,}000}{20{,}940.51}\right)^{\frac{2\times(-0.02704)}{(0.25)^2}} \times \frac{(22{,}000)^2}{(20{,}940.51)^2} \times 618.48$$

$$\cong 790.07.$$

In summary,

$$VR_0 = \frac{60\%}{20{,}940.51} \times 790.07 \cong 2.264\%,$$

and

$$B_0 = 99.29\% + 2.264\% \cong 101.56\% > 100\% \Rightarrow \text{ Invest.}$$

d) Compute the fair value of European-style put on the Dow Jones index, with a strike equal to 90% of the index value after 3 months and with a time-to-maturity of 6 month. For this purpose, assume that the FRA 6x12 is now quoted at 1.426%.

We must price the following European-style forward-start put:

$$p_0^f\left(S_0 = 20{,}940.51; X = 0.9\times S_{3M}; T_2 = 6M\right)$$

$$= 20{,}940.51\times e^{-1\%\times 0.25}\times p_{3M}\left(1;0.9;6M\right).$$

Concerning the standard put price $p_{3M}\left(1;0.9;6M\right)$, we can either use the BSM formula or, more easily, use the market option prices provided.

Since the value of a standard put option is an homogeneous function of degree one of the spot and the strike, and because the the FRA 6x12 is quoted at the current 3-month Libor rate, then

$$\begin{aligned}20{,}940.51\times p_{3M}\left(1;0.9;6M\right) &= p_{3M}\left(20{,}940.51;0.9\times 20{,}940.51;6M\right)\\ &= p_0\left(20{,}940.51;18{,}846{,}46;3M\right)\\ &= 271.30\end{aligned}$$

Therefore,

$$p_0^f\left(S_0 = 20{,}940.51; X = 0.9\times S_{3M}; T_2 = 6M\right)$$

$$= 271.30\times e^{-1\%\times 0.25}$$

$$= 270.63.$$

e) Formule uma estratégia de *static hedging* para uma posição curta sobre uma *as-you-like-it option* simples sobre o índice Dow Jones, com vencimento a 6 meses, com *strike* igual a 20,940.51 pontos de índice e data de determinação (do tipo de opção) daqui a 3 meses.

The fair value of the AYLI option can be given by

$$AYLIS_0 = c_0\left(S_0; X; T_2\right) + e^{-q(T_2-T_1)}p_0\left(S_0; Xe^{-(r-q)(T_2-T_1)}; T_1\right)$$

or by

$$AYLIS_0 = p_0\left(S_0; X; T_2\right) + e^{-q(T_2-T_1)}c_0\left(S_0; Xe^{-(r-q)(T_2-T_1)}; T_1\right).$$

In the first case, the value of the AYLIS is equal to

$$\begin{aligned}AYLIS_0 &= c_0\left(S_0;20{,}940.51;6M\right)\\ &\quad + e^{-1\%(0.5-0.25)}p_0\left(S_0;20{,}940.51\times e^{-(1.4209\%-1\%)(0.5-0.25)}\cong 20{,}918.49;3M\right).\end{aligned}$$

Hence, the hedging strategy would be:

.Buy 1 standard call on the Dow Jones index, with a time to maturity of 6 months, and a strike equal to 20,940.51 index points; and

. Buy $e^{-1\%(0.5-0.25)}$ standard puts on the Dow Jones index, with a time to maturity of 3 months, and a strike equal to 20,918.49 index points.

Since the standard puts on the Dow Jones index, with a time to maturity of 3 months, and a strike equal to 20,918.49 index points are not available in the market, we have to implement the alternative hedging strategy:

.Buy 1 standard put on the Dow Jones index, with a time to maturity of 6 months, and a strike equal to 20,940.51 index points; and

. Buy $e^{-1\%(0.5-0.25)}$ standard calls on the Dow Jones index, with a time to maturity of 3 months, and a strike equal to 20,918.49 index points.

SIMPLE AS YOU LIKE IT OPTIONS (EUROPEAN)

MATRIZ DE INPUTS

COTAÇÃO SPOT (S)	20940.5
PREÇO EXERCÍCIO (X)	20940.5
DIVIDEND YIELD (q)	1.00%
TAXA JURO SEM RISCO (r)	1.4209%
TEMPO PARA ESCOLHA (T1)*	0.25
TEMPO P/ VENCIMENTO OPÇÃO (T2)*	0.5
VOLATILIDADE	25.00%

*em anos

	PRÉMIO
CALL (T2)	1,487.9883
PUT (T1)	1,018.0681
PRÉMIO	2,503.5144

	PRÉMIO
PUT (T2)	1,444.1849
CALL (T1)	1,061.9811
PRÉMIO	2,503.5144

d1	0.0789	d2	-0.0461	T1
N(-d1)	0.4685	N(-d2)	0.5184	

d1	0.1003	d2	-0.0765	T2
N(d1)	0.5399	N(d2)	0.4695	

Adjusted X 20918.49