cf_cir1d_zbputeuro

Output parameters:

- Price

The stochastic differential equation representing the the short rate is given by

$$dr_t = k(\theta - r_t)dt + \sigma\sqrt{r_t}dW(t)$$

The price of the zero-coupon bond is given by

$$P(t,T) = A(t,T)e^{-B(t,T)\,r(t)}.$$

where

$$h = \sqrt{k^2 + 2\sigma^2}$$

$$A(t,T) = \left(\frac{2he^{(k+h)(T-t)/2}}{2h + (k+h)(e^{h(T-t)} - 1)}\right)^{\frac{2k\theta}{\sigma^2}}$$

and

$$B(t,T) = \frac{2(e^{h(T-t)} - 1)}{2h + (k+h)(e^{h(T-t)} - 1)}$$

The price of the European Call with maturity T on Zero-Coupon Bond with maturity (S>T)is given by

$$P(t,S)Chi2(2\bar{r}(\rho+\psi+B(T,S)), \frac{4k\theta}{\sigma^2}, \frac{2\rho^2 r_t e^{ht}}{\rho+\psi+B(T,S)}) - KP(t,T)Chi2(2\bar{r}(\rho+\psi), \frac{4k\theta}{\sigma^2}, \frac{2\rho^2 r_t e^{ht}}{\rho+\psi})$$

where $Chi2$ is the cumulative function of the chi2 law and

$$\bar{r} = \frac{ln(A(T,S)K)}{B(T,S)}$$

$$\rho = \frac{2h}{\sigma^2(e^{h(T-t)} - 1)}$$

$$\psi = \frac{k+h}{\sigma^2}$$

The price of the European Put is obtained via Parity relationship

$$Put = Call - P(t,S) + KP(t,T)$$