# Option Pricing Models

# 1 Black-Scholes Model

## 2 Barone-Adesi-Whaley Model

## 3 Longstaff-Scharwtz Model

# 4 Vanna-Volga Model

Vanna-Volga method is a technique for pricing first-generatation exotic options in foreign exchange (FX) market.

- First-generatation exotics: touch-like options and vanillas with barriers
- Second-generatation exotics: options with a fixing-date structure or options with no available closed form value
- Third-generatation exotics: hybrid products between different assets

The Vanna and Volga are the sensitivity of the Vega with respect to a change in the spot FX rate and the implied volatility, respectively.

$$\text{Vanna} = \frac{\partial \mathcal{V}}{\partial S}, \quad \text{Volga} = \frac{\partial \mathcal{V}}{\partial \sigma}. \tag{1}$$

The Vanna-Volga method uses a small number of market quotes for liquid instruments (typically At-The-Money options, Risk Reversal and Butterfly strategies) and constructs an hedging portfolio which zeros out the Black-Scholes Vega, Vanna and Volga of the option.

$$\begin{aligned} \text{ATM}(K_0) &= \frac{1}{2}(\text{Call}(K_0, \sigma_0) + \text{Put}(K_0, \sigma_0)) \\ \text{RR}(K_c, K_p) &= \text{Call}(K_c, \sigma(K_c)) - \text{Put}(K_p, \sigma(K_p)) \\ \text{BF}(K_c, K_p) &= \frac{1}{2}(\text{Call}(K_c, \sigma(K_c)) + \text{Put}(K_p, \sigma(K_p))) - \text{ATM}(K_0) \end{aligned} \tag{2}$$