DATA.STAT.610 Financial Mathematics and Statistics

2021 – 2022

Problems on model calibration

Problem 1: Use of optimization algorithms

- Select a loss function with constrains, see `https://en.wikipedia.org/wiki/Test_functions_for_optimization`.
- Give initial parameters (not too close with the optimal ones, but within the constrains).
- Minimize the problem for the given loss function using a selected optimization method, e.g. Nelder Mead (`https://se.mathworks.com/help/matlab/ref/fminsearch.html` for Matlab)
- If the optimization function is unconstrained, then specify the constrains within the loss-function so that the loss-function gets a very high value (say 1E10) if the constrains are not satisfied.
- Try different optimization algorithms with different settings and different loss-functions
- Extra: Calculate the standard errors of parameter estimates

Problem 2: Calibration of Heston Stochastic Volatility Model

- The task is to calibrate the models, i.e. estimate the model parameters $\Psi = \{\kappa, \theta, \eta, \rho, V_0\}$, using a snapshot of volatility surface (empVolatilitySurfaceData.mat)
- The file contains a data structure
  - data.K: 1×42 strike prices
  - data.T: 8×1 maturities
  - data.IVolSurf: 8×41 Implied volatilities (that is, option prices are provided in terms of B-S implied volatilities)
  - data.r: interest rate (0.0466)
  - data.S0: current price of the underlying stock (1.00)

– The loss function is

$$\sum_{i=1}^{42}\sum_{j=1}^{8}\left(\mathrm{IV}_{\mathrm{Market}}(K_i,T_j)-\mathrm{IV}_{\mathrm{Model}}(K_i,T_j;\Psi)\right)^2,$$

which is to be minimized with respect to model parameters Ψ. Here $\mathrm{IV}_{\mathrm{Market}}(K_i,T_j)$ is the implied volatility from the market and $\mathrm{IV}_{\mathrm{Model}}(K_i,T_j;\Psi)$ the implied volatility from the model with the given values of parameters.

– Use the existing codes with FFT-approach to price options with given parameter values and convert the dollar prices to Implied Volatilities.

– You may visualize the market and volatility surfaces in every optimization iteration

– Extra: Calculate the standard errors of parameter estimates