Exercise 1

Goal of this exercise is to perform and a test a calibration of the covariance structure of a LIBOR Market Model, based on the price of swaptions for different strikes and with the help of the Finmath library implementation. In particular, do the following:

(a) Write a class `CalibrationWithSwaptions` where:

- You give (either in the constructor or in the methods you write: this is your choice) an object `trueLIBORMarketModel` of type `LIBORMonteCarloSimulationFromLIBORModel` which provides the tenure structure of the swaptions based on which you calibrate, the LIBOR Market Model simulation that you use to compute the target prices (see next point) and the simulation time discretization, the tenure structure, the forward curve and the discount curve of the LIBOR Market Model whose covariance you have to calibrate: in the end, we want to see how much the calibrated model differs from `trueLIBORMarketModel`.
- You construct an array of objects of type

  `net.finmath.montecarlo.interestrate.CalibrationProduct`,

  specifying that you want to calibrate based on Swaptions with tenure structure given by `trueLIBORMarketModel`, exercise date of your choice and strike which varies in the for loop identifying the entries of the array. For example, you can compute the initial value S_0 of the par swap rate and let the strike run from $\frac{1}{\alpha}S_0$ to αS_0, $\alpha > 1$: the swaption of the i-th element of your array of `CalibrationProduct`s has strike K_i. The target values of your calibration products (i.e., the prices we are pretending to see in the market) are the Monte-Carlo prices of such swaptions when the LIBOR Market Model simulation is represented by `trueLIBORMarketModel`, maybe plus some random noise if you like.
- You then calibrate based on the array you construct at the point above: in order to do that, you can construct an object of type `LIBORMarketModelFromCovarianceModel`, whose `CalibrationProduct[]` field is given by such an array and whose simulation time discretization, tenure structure, forward curve and discount curve are taken from `trueLIBORMarketModel`.

(b) Write a test where you construct a LIBOR Market Model simulation `hiddenLIBORMarketModel` with a covariance structure of your choice: this is the object you give to the class constructed above, in order to let it play the role of `trueLIBORMarketModel`. Perform then the calibration calling the appropriate methods you wrote for point (a). If the calibration works well, you are supposed to get a model which is quite close to `hiddenLIBORMarketModel`: in order to check this, do the following tests:

- compare the calibrated parameters to the ones of `hiddenLIBORMarketModel`;
- compare the prices you get for the swaptions (for the same strikes you used to calibrate or others) with `hiddenLIBORMarketModel` and with the calibrated model;
- if you like, other tests at your choice (maybe prices based of other products?)