**Marco Bianchetti and Marcello Terraneo**

The market data to complete the problems are available in the associated file MarketData31Oct2019.xls. Each market data is described in the course slides and was discussed during the course. The market data refer to a specific date, 31 October 2019, which is also the valuation date to be used for the exercises.

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| **#** | **Problem** | **Instruments** | **Deliverable** |
|  | **Bond pricing**: using the yield curves provided in the market data sheets,  a) price an EUR fixed rate bond (FiRB) with residual maturity 5 years and 4 months, annual coupon rate 3%, semi-annual coupons, issuer’s credit z-spread 200 bps on EURIBOR6M;  b) price an EUR floating rate bond (FRB) with the same characteristics above but indexed to EURIBOR6M + 50 bps (coupon margin);  c) For the FiRB and FRB above, find the coupon margin of the FRB such that FiRB price = FRB price.  d) Repeat the three steps above using EUR OIS yield curve instead of EURIBOR6M.  For each case compute both clean and dirty prices.  Hint: assume standard market conventions. For FRB use cap/floor term volatility derived from market quotations. | Spreadsheet, market data sheets. | Spreadsheet with relevant data, calculations and charts, written relation with explanations and comments. |
|  | **Cap/Floor term volatility**: using the relevant yield curves and Caps/Floors market prices provided in the market data sheets, build the corresponding normal (Bachelier) and shifted-lognormal (Black) implied term volatility surfaces, and compare them for different values of the lognormal shift. Discuss possible cases where the numerical inversion of the Bachelier or Black formulas is problematic. | Spreadsheet/VBA, market data sheets. | Spreadsheet/VBA with relevant data, calculations and charts, written relation with explanations and comments. |
|  | **Cap/Floor forward volatility**: using the relevant yield curves and Caps/Floors market prices provided in the market data sheets, build the corresponding normal (Bachelier) and shifted-lognormal (Black) implied forward volatility surfaces, and compare them for different values of the lognormal shift. Discuss possible cases where the numerical inversion of the Bachelier or Black formulas is problematic. Compare the results with the approximated transformation formula of Choi et al (2021). | Spreadsheet/VBA, market data sheets. | Spreadsheet/VBA with relevant data, calculations and charts, written relation with explanations and comments. |
|  | **SABR**:  a) implement the shifted SABR model (Hagan 2002, or Hagan 2016) for Swaptions and calibrate its parameters to the market physical Swaption volatility cube;  b) test the calibration precision with respect to different objective functions (i.e. relative price differences, RMSE volatility, vega-weighted RMSE volatility)  c) test different optimization methods in terms of calibration precision and performance  d) test SABR parameter redundancy. | Spreadsheet/VBA/ Matlab/Phyton, market data sheets | Spreadsheet/code with relevant data, calculations and charts, written relation with explanations and comments. |
|  | **Short rate models**: consider a Vasicek model with parameters r(0) = 0.015, k = 0.25, theta = 0.02, sigma = 0.1. Price a caplet with fixing date = 2Y, payment date = 2.5Y, and strike = 0.5%. Use both the analytical formula and Monte Carlo simulation. Choose between risk neutral and forward measure. The idea of the exercise is not a perfect simulation but to present the correct steps. | Spreadsheet/VBA/ Matlab/Phyton | Spreadsheet/code with comments + written relation with results, charts and comments. |