Large Project 2012

This year's Large Project will be a joint project for all students participating in the course. In this project we shall extend an existing package for evaluating contingent claims on the equity and fixed income markets. This software has to be written for an end-user who uses financial instruments in its everyday operations and is not an expert in numerical analysis and computational finance. The project will be the continuation of the project from the last year. The project is a library of functions performing different tasks. A number of functions is already available. We shall only modify some of existing functions and write few new functions.

The main task of the project is to extend the main module (main programme) which manages all functions, supplies data to them, provides the communication between the functions and solves the problem of communication with an end-user interface. A part of this module is ready but it needs suitable extentions.

The main module is split into two separate sub-modules: one which uses individual users accounts and performs complicated calculations with market data provided by the user as separate files, and the second one (a simple calculator) which is accessible on-line by everybody and calculate prices of simple instruments (that which possess analytic formulas for prices) after entering necessary data from keyboard. The simple calculator is already in its final version. We shall extend however the real data calculator which is written only for FX market.

The main goal of the project is to produce a working web-page calculator for Fixed Income Market and Equity Market. This goal should be complemented with some modifications of existing functions and writing few specific functions.

In the course of the project the following tasks are essential:

1. Extension of the existing main module to fixed income instruments. The module should be written in "python-django". This task consists of several steps: the input and processing of data (together with some verification procedure), construction of a structure in which new instruments can be easily added, and then add those instruments for which relevant octave functions are already prepared.

2. Extension of the existing main module to stock options. The web part of the module should be written in "python-django". The goal is to write a Monte Carlo module for evaluation of European and American options. Essential steps are: the input and processing of data, in particular volatility data for options, writing Octave functions for MC calculations for European and American options, writing in "python-django" a communication structure in which new instruments can be easily added, and then add instruments priced by MC algorithm.

3. Processing input data – term structure of interest rates. Recovering the term structure of interest rates from the prices of traded instruments (LIBOR rates, FRA rates and swap rates) is complicated because it requires full use of the calendar. The existing functions are based on a term structure of discount factors. These discount factors are calculated from real market quotations. But there are markets on which FRA's are not liquid instruments. On such markets the term structure of interest rates is recovered from deposit rates, LIBOR future rates and swap rates. Incorporating futures instead of FRA's requires some care as futures are exchange traded instruments and some of their characteristics (contract size, issue and expiration dates) are standarized.

Documentation. It is absolutely essential to describe carefully the theoretical background of every function. But also the documentation of the computer code has to be provided. A particular attention

should be put on the structure of the programme (block scheme), the format of input and output data, signaling choices, etc.

The project will consist of the following tasks:

1. Extend communication module for logged users to fixed income instruments.
2. Extend communication module for logged users to stock options and prepare Octave functions form MC calculations of American options.
3. Processing input data — processing new raw data for discount factors.

Literature comments

- Preparing discount factors table — knowledge for financial engineering, and numerical mathematics, but you can also consult the course coordinators.
- Construction of implied volatility surface — general idea is in the book by Gatheral, but the volatility surface for stock options should be based on general knowledge from financial engineering.
- Pricing fixed income instruments from the Black-Scholes formula — knowledge from financial engineering. Octave code and documentation will be provided by the course coordinators.
- MC pricing of American options – the paper by Longstaff and Schwartz is essential.

References

1. Jim Gatheral – *The Volatility Surface*, J. Wiley 2006.
2. Justin London – *Modeling Derivatives in C++*, Wiley 2005. (Library)
3. Patrick S. Hagan and Graeme West – Interpolation methods for curve construction, *Applied Mathematical Finance*, **13** (2006), 89–129.
4. Francis A. Longstaff and Eduardo S. Schwartz – Valuing American Options by Simulation: A Simple Least-Squares Approach, *The Review of Financial Studies*, **14** (2001), 113–147.
5. Andrew Lesniewski – Interest rates and FX models: LIBOR and OIS. (pdf)