NATIONAL UNIVERSITY OF SINGAPORE
Computational Finance Programme

2018/2019 **QF3101 Investment Instruments: Theory and Computation** Semester II

Computing Assignment

This assignment is to be undertaken on an individual-work basis.

I will do a walkthrough of the necessary data collection steps during lecture on 6 Mar.

Part 1 of 2: Eurodollar Futures and Deferred Interest Rate Swaps

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Statement of the problem

A series of prices of Eurodollar futures contracts and their expiry dates are collected on a chosen day and used in the construction of forward LIBOR term structures (with respect to various future dates). The forward LIBOR term structures are then used to obtain the swap rates for deferred (forward) K-year interest rate swaps on half-yearly exchanges.

Scope of the assignment

This part of the assignment should be undertaken in four consecutive stages. All collected data, computed values, graphs for this part should be contained in a worksheet named "**Part 1**" in your submitted Excel file.

Stage 1: Data collection and preparation.

Eurodollar (ED) futures contracts are traded on the Chicago Mercantile Exchange (CME) with delivery months of March, June, September, and December up to ten years into the future (details of these contracts can be found at
`http://www.cmegroup.com/trading/interest-rates/stir/eurodollar_contract_specifications.html`).
The variable underpinning each contract is the 3-month LIBOR (for Eurodollar) applicable for the 3-month period starting from the expiry date of the contract.

For a given ED futures, if the futures price is P, then the corresponding 3-month LIBOR is given by $(100 - P)\%$. These 3-month LIBORs corresponding to various ED futures are forward rates for respective 3-month periods in the future.

1. Choose a business day, say day X, from within the 12-day period: **4 March 2019** to **15 March 2019** (indicate your choice of day X clearly in your spreadsheet). For day X, collect settlement prices of ED futures contracts which expire in March 2019, June 2019, September 2019, December 2018, March 2020, ..., up to December 2028 (ie. 10 years into the future). (You can obtain these prices at this page:
`http://www.cmegroup.com/trading/interest-rates/stir/eurodollar_quotes_settlements_futures.html`, use values in the column titled "Settle").
2. Obtain the corresponding expiry/settlement dates of the ED futures mentioned in item 1. (See `http://www.cmegroup.com/trading/interest-rates/stir/eurodollar_product_calendar_futures.html`, under the "Settlement" column.)

3. Enter these collected values in your spreadsheet.

Stage 2: Implied Forward LIBOR term structure.

Write an VBA **cell-array** function which computes and returns a forward LIBOR term structure implied by `FwdLIBOR` which is a given vector of forward 3-month LIBORs (obtained from a series of consecutive Eurodollar futures prices), and `EDFDays` which is a vector containing actual number of days for the corresponding 3-month periods for the Eurodollar futures. All input and output ranges are assumed to be "column" ranges. The function must have the following heading:

```
Function GetTermStructure(FwdLIBOR As Range, EDFDays As Range) As Double()
```

Your spreadsheet should provide illustrative uses of this function. As a minimum requirement, the function should be used five times to obtain the implied forward LIBOR term structures for the reference dates of 18 March 2019, 17 June 2019, 16 September 2019, 16 December 2019 and 16 March 2020.

Graph and comment on the term structures obtained.

Note: the actual number of days for a given 3-month period can be computed from the expiry date of the ED futures contract for the given 3-month period (which expires at the start of the 3-month period), and the expiry date of the ED futures contract for the next 3-month period.

Stage 3: Swap Rate for Deferred Interest Rate Swap.

Suppose two companies are to negotiate a deferred K-year interest rate swap with them swapping payments tied to a fixed rate (actual/360) for floating payments based on 6-month LIBOR at **half-yearly** intervals. The start of the swap is deferred to a given date in the future.

1. Write a VBA user-defined function to compute and return the swap rate (actual/360) of a deferred `K`-year interest rate swap on half-yearly exchanges. This function accepts as inputs the value of `K`, the relevant term structure `FowardLIBORTerm` (as computed by the function written in stage 2 for the desired deferred start-date) and the vector `DaysInTerm` which contains the number of days (maturities) for rates in the term structure.

   The function must have the following heading:

   ```
   Function GetSwapRate(K As Integer, ForwardLIBORTerm As Range, DaysInTerm As Range) As Double
   ```

2. Your spreadsheet should contain illustrative uses of the above VBA function for `K`$= 1, 2, \ldots, 8$ and for the deferred start-dates of 18 March 2019, 17 June 2019, 16 September 2019, 16 December 2019 and 16 March 2020.
3. Tabulate the swap rates obtained and comment accordingly.

Part 2 of 2: Efficient Equity Portfolios

Statement of the problem

Seven stocks of your choice, belonging to **different industrial/commerical sectors** in the same country/market, are to be selected for construction of efficient portfolios of these stocks.

Scope of the assignment

This part of assignment should be undertaken in four consecutive stages. All collected data, computed values, graphs for this part should be contained in a worksheet named "**Part 2**" in your submitted Excel file.

Stage 1: Data collection and preparation.
Choose a 5-year period starting in any trading week after December 2013. Next choose 7 stocks belonging to different industrial/commerical sectors and trading in the same country/market. For each stock, collect the weekly closing prices in the chosen time period. Such historical data can be obtained from the web site

http : //finance.yahoo.com

Compute the weekly returns as follows: If v_{i-1} and v_i are the weekly (adjusted price, adjusted for dividend/split etc) closing prices for week $i-1$ and i, then the rate of return is given by

$$r_i = \frac{v_i - v_{i-1}}{v_{i-1}}.$$

Once the sets of rates of return are obtained, proceed to compute the relevant means and covariances (using Excel's cell formulae and worksheet functions).

Stage 2: Minimum Variance Point Portfolio And An Efficient Portfolio.
Write a VBA **cell-array** function to determine the minimum variance point portfolio of a portfolio of `N` assets with the covariance matrix `AssetCov` (of their rates of return). This VBA function must have the following heading:

```
Function GetMinVarPortfolio(AssetCov As Range) As Double()
```

This function returns the weight vector of the minimum variance point portfolio. (Hint: Recall Tut 1 Question 5).

Write another VBA cell-array function to obtain an efficient portfolio of a portfolio of `N` assets with the covariance matrix `AssetCov`. (Hint: One can be obtained by solving the same linear system as above, but with the right hand side vector changed to the vector of expected rates of return `AssetReturn` of the `N` assets). This VBA function must have the following heading:

```
Function GetAnEfficientPortfolio(AssetCov As Range, AssetReturn As Range) As Double()
```

This function returns the weight vector of an efficient portfolio.

Stage 3: Efficient Portfolios.
Perform the following tasks in your worksheet.

- For your chosen set of stocks and computed values in stage 1, use the two VBA functions from stage 2 to obtain the minimum variance point portfolio and an efficient portfolio of the 7 stocks. Also compute the rates of return for both portfolios.
- Hence, apply the Two-Fund Theorem (See page 162 of Luenberger's text on Investment Science) to obtain a series of 30 efficient portfolios with rate of returns more than of the minimum variance point portfolio.
- Graphically present these efficient portfolios in a σ-$\overline{r}$ diagram.

Stage 4: Analyze, compare and comment on the results obtained in Stages 1-3.

Due date, requirement, guidelines and regulations

(i) The due date/time for the project report is **2359hr on 31 March, 2019**. No late submission will be accepted.

(ii) Start working on the assignment problem right away as the data collection and preparation phase can be time consuming and time sensitive. Note too that March 2018 Eurodollar futures contract is expiring soon, and once missed, the price data cannot be found "freely" as historical prices on the cmegroup website.

(iii) Use **Microsoft Excel** for all stages.
Please note that all data collected, computation and programming work for both parts should be contained within a single Excel spreadsheet file. Data and results should be properly labelled, and where appropriate graphs should be used to illustrate your results and your analysis. You **must** use VBA functions to automate the computation involved where the specifications above explicitly mention so.

(iv) Prepare a report in Windows Word format or PDF format with a description of your work done plus supporting figures and tables etc, as well as all necessary analysis and comments.

(v) What you must submit:

- One Excel file containing all data, computation/graph/VBA codes.
- One Word or PDF file containing your report.

Both files must be archived in a single WinZip/Rar file. Name your .zip/.rar file with your name, and submit it online to the IVLE workbin set up for this purpose.

(vi) Marks allocation: 30% for worksheet (presentation, correctness), 40% for VBA codes (correctness, adequacy of comments) and 30% for report (presentation, correctness and adequacy of comments/analysis).

(vii) This assignment counts 20% towards the final assessment score of this module.

(viii) Plagiarism (copying work from fellow students, groups or others) **would not be tolerated and all parties involved would be penalized severely**.
Please refer to `http://emodule.nus.edu.sg/ac/` for more information on NUS's disciplinary process on plagiarism.

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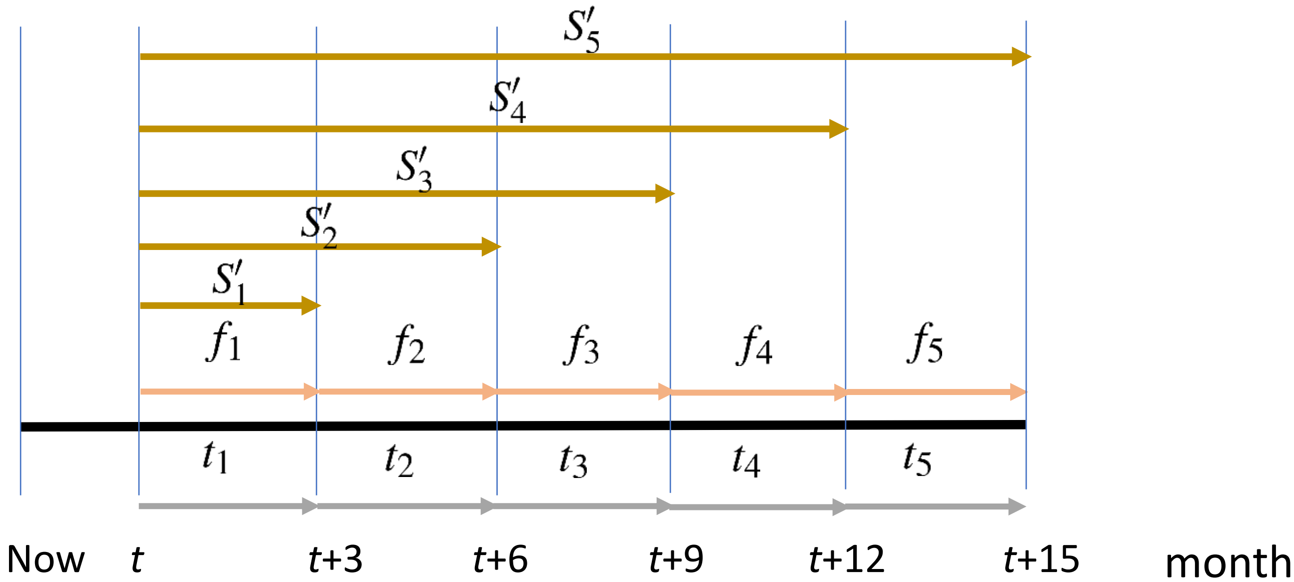
Appendix

We illustrate the function calls in part 1 when there are only 5 futures contracts involved, with the first contract expiring at time *t*.



f_i : forward 3-month LIBOR, $i = 1, 2, 3, 4, 5$.

t_i : actual number of days in 3-month period, $i = 1, 2, 3, 4, 5$.

forward LIBOR term structure: $\{S'_1, S'_2, S'_3, S'_4, S'_5\}$.

- In stage 2, if we use the function GetTermStructure to obtain the forward term structure with respect to time *t*, then we have

  FwdLIBOR = $(f_1, f_2, f_3, f_4, f_5)$ and EDFDays = $(t_1, t_2, t_3, t_4, t_5)$.

  The function will evaluate and return the term structure $(S'_1, S'_2, S'_3, S'_4, S'_5)$.

- In stage 3, if $(S'_1, S'_2, S'_3, S'_4, S'_5)$ is used as the ForwardLIBORTerm in the call to the function GetSwapRate, then K can only be 1 and the deferred start date for this one-year swap is time *t*. In this case, the vector DaysInTerm should be

$$(t_1, t_1 + t_2, t_1 + t_2 + t_3, t_1 + t_2 + t_3 + t_4, t_1 + t_2 + t_3 + t_4 + t_5).$$