Asset-Liability Management 2018

Project

Introduction

The project is designed to be solved in groups of 2-3 students. The technical work is the most important. It should result in a report of not more than 15 pages. A neat presentation counts in your favour. Please place important results, tables and graphs into your report, to make it accessible to a reader who does not want to dive deep into Excel workings.

You may write your report in English, Portuguese, German or Danish.

You may contact me with questions at the address walther.neuhaus@zabler-neuhaus.no.

Please note: This is a new project. I have not done the calculations on those numbers and do not have a model answer yet. I cannot guarantee that the numbers selected will "behave well" in the sense of giving reasonable results. Your research is as good as mine: we're all starting from scratch.

The deadline for delivery of the report and underlying workings is Monday, 29 October 2018.

Have fun!

Data

You have received three sets of data:

YIELD_rates

Yield rates for NOK (Norwegian krone), monthly averages from January 2003 till August 2018. The yield curve is given for each month for the maturities 3-6-9-12 months and 3-5-10 years. The text is partly in Norwegian but should be self-explanatory.

FOREX_rates

Exchange rates of ten currencies against NOK, monthly averages from January 2003 till August 2018. Read the exchange rate figure as "the number of NOK required to buy one AUD, one CAD, and so on".

EIOPA_RFR_20180831_Term_Structures

Term structures of the same ten currencies, plus NOK, for the risk free rate at 31.08.18, published by EIOPA.

1. Term structure modelling

a) Use the YIELD data to produce a graph of the temporal evolution of the empirical NOK yield curves between January 2003 and August 2018, structured similar to the graph you see in the spreadsheet `Examples/[Estimate_CIR_Vasicek_model.xlsx]Chart_CIR_yield_time_series`. Show separate curves for 3-6-9-12 months and 3-5-10 years.

b) Use the regression technique of Schiegl (pp. 78 in the slides) to estimate the parameters of a Vasicek model. As short rate you can use the three month rate given in the data.

c) Compare graphically the yield curve that is given by the estimated Vasicek model for August 2018, against the empirical yield curve at the same date. For an example graph, see slide 82. You may of course also compare them for older months.

d) Use the regression technique of Schiegl (pp. 78 in the slides) to estimate the parameters of a Cox-Ingersoll-Ross model. As short rate you can use the three month rate given in the data.

e) Compare graphically the yield curve that is given by the estimated Cox-Ingersoll-Ross model for August 2018, against the empirical yield curve at the same date. For an example graph, see slide 82. You may of course also compare them for older months.

f) Assess how well the two term structure models replicate the observed yield curves. If the models do not fit reality well, you may attempt to restrict the time frame of the estimation to more recent years. Use your phantasy.

2. Exchange rate modelling and MVA

a) Use the FOREX data to estimate the one-year volatility of the ten currencies against NOK. The volatility should be expressed as a 10x10 covariance matrix:

$$\boldsymbol{\Sigma}_{\text{YEARLY}} = \begin{pmatrix} \text{Var(AUD)} & \cdots & \text{Cov(AUD,USD)} \\ \vdots & \ddots & \vdots \\ \text{Cov(USD,AUD)} & \cdots & \text{Var(USD)} \end{pmatrix}.$$

A simple way of calculating the monthly volatility is to use

$$\boldsymbol{\Sigma}_{\text{MONTHLY}} = \frac{1}{n}\sum_{i=1}^{n} \begin{pmatrix} \Delta_i^{\text{AUD}} \cdot \Delta_i^{\text{AUD}} & \cdots & \Delta_i^{\text{AUD}} \cdot \Delta_i^{\text{USD}} \\ \vdots & \ddots & \vdots \\ \Delta_i^{\text{USD}} \cdot \Delta_i^{\text{AUD}} & \cdots & \Delta_i^{\text{USD}} \cdot \Delta_i^{\text{USD}} \end{pmatrix},$$

where Δ_i^{XXX} is the change in the XXX exchange rate on month number i and n is the number of month-to-month changes observed. The yearly volatility you calculate by

$$\boldsymbol{\Sigma}_{\text{YEARLY}} = 12 \cdot \boldsymbol{\Sigma}_{\text{MONTHLY}}.$$

b) Now assume the following (using the AUD currency as an illustration): The value of one AUD at the end of August 2018 is NOK 6.1008. If we invest that amount in AUD at the end of August 2018, the expected value of our investment at the end of August 2019 is NOK 6.1008 x (1+1.891%) = NOK 6.2162. Why? Because the one-year risk free rate for AUD is 1.891%, and we do not expect the exchange rate to change. In other words we say that the expected return of AUD over one year is its risk free rate, 1.891%. The volatility of the AUD return and its covariance with the other currencies' returns, is given by the matrix you calculated in a).

Task: Write the expected return vector $\boldsymbol{\mu}$ and the covariance matrix $\boldsymbol{\Sigma}$ of the ten currencies. NOK is considered to be a risk-free asset as far as exchange rate fluctuations are concerned.

c) Assume that at the end of August 2018, we have cash of NOK 1,000,000 and a liability of NOK 1,000,000 with a deterministic liability "return" of 2%. The risk-free return of NOK assets is 1,12%. Even if we have enough money to cover the liability today, we cannot earn enough risk-free interest from NOK to fund the growth of the liability over the following year. Some of the other currencies offer higher expected return, but at the price of exchange rate volatility.

Task: Using the ten investable currencies and NOK as the notional risk-free asset, calculate $\boldsymbol{w}_{\text{min}}$ (the minimum asset variance portfolio), $\boldsymbol{w}_{\text{ref}}$ (the reference portfolio of risky assets) and $\boldsymbol{w}_{\tan \mid \mu_0=1.12\%}$ (the tangency portfolio when the risk-free return is 1.12%). Then find the optimal portfolio, including risk-free NOK, that gives an expected asset return of 2.2%.

d) In the previous paragraph we assumed that the liability was deterministic and in NOK. There could be no liability hedge. Now assume, for argument's sake, that the liability is random and strongly correlated with Swedish Krone, or any of the other currencies.

Task: Find the optimal portfolio that includes a liability hedge and risk-free NOK and gives an expected asset return of 2.2%. Negative holdings (borrowing) are allowed in both c) and d).