Application of Matlab for Finance: Group Coursework

This coursework is designed to test your ability to apply MATLAB to a real world financial application: the dynamics of exchange rates and exchange rate excess returns, the carry trade, and exchange rate second moments. Provided on the HUB is some background reading regarding currency markets, currency excess returns and the carry trade.[1] Also provided is an excel file with daily spot exchange rates and forward exchange rates for the currency pairs

$$\{USD/AUD\ ,\ USD/JPY\ ,\ USD/NZD\ ,\ USD/CHF\}$$

Note: these are daily quotes in units of foreign currency period unit USD. To complete the problem sheet successful you will need to be comfortable with: importing data from excel sheets, manipulating time series using the financial time series toolbox, indexing and using in-built functions, using for-loops, plotting, and displaying outputs in tables. The output of this coursework should be a 2-3 page report (including figures and tables) with a *brief* discussion of the results. Include your (commented) matlab code in an appendix at the end of the document.

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Hard copies submitted to the finance team office and soft copy uploaded to the Hub by the given deadline.

1. **Exchange Rate Changes and Excess Returns using Forward Contracts.**

   In this exercise, we use currency spot and one-month forward rates to calculate currency excess returns following Lustig, Roussanov and Verdelhan (2012)[2]

   We use s to denote the log of the nominal spot exchange rate in units of foreign currency per USD, and f for the log of the forward exchange rate, also in units of foreign currency per USD. An increase in s means an appreciation of the home currency (USD). The log excess return rx on buying a foreign currency in the forward market and then selling it in the spot market after one month is simply $rx_{t+1} = f_t - s_{t+1}$. This excess return can also be stated as the log forward discount minus the change in the spot rate: $rx_{t+1} = f_t - s_t - \Delta s_{t+1}$. In normal conditions, forward rates satisfy the covered interest rate parity condition; the forward discount is equal to the interest rate differential: $f_t - s_t \sim i_t^\star - i_t$, where $i^\star$ and i denote the foreign and domestic nominal risk-free rates over the maturity of the contract. Hence, the log currency excess return equals the interest rate differential less the rate of depreciation: $rx_{t+1} = i_t^\star - i_t - \Delta s_{t+1}$.

[1] You do *not* need to understand the papers provided. They are for background reading only. Concentrate on the introductions.

[2] H. Lustig, N. Roussanov, and A. Verdelhan (2012): Countercyclical Currency Risk Premia. Available at SSRN: http://ssrn.com/abstract=1571714.

(a) Given this information create monthly time series for the four currency pairs as follows. Calculate MONTHLY currency excess returns by first sampling the data at the monthly frequency (the first day of the month) then construct excess currency returns as per the instructions above. Produce a time-series plot and table of summary statistics for each currency pair (USD as the home currency).

2. **The Carry Trade**.

The carry trade is set up by borrowing from the low interest rate country, convert to the foreign currency at the spot, invest in the risk-free asset in the investment country, and convert back to the funding currency to repay the initial borrowing when the trade is unwound. Using the definition of excess return $rx_{t+1} = f_t - s_{t+1}$, the (monthly) total JPY/NZD carry return at time $t+1$ is given by $rx_{t+1}^{NZD} - rx_{t+1}^{JPY}$ which, assuming that covered interest rate parity holds, can be further decomposed into two parts:

$$rx_{t+1}^{NZD} - rx_{t+1}^{JPY} \approx (i_t^{NZD} - i_t^{JPY}) + (\Delta s_{t+1}^{JPY} - \Delta s_{t+1}^{NZD})$$

that is, the return from interest rate differentials and the return from the depreciation of the funding currency (relative to the investment currency).

Using the covered interest rate parity, i.e. $f_t - s_t \simeq i_t^* - i_t$, the carry return from interest rate differentials can be found by

$$\begin{aligned} i_t^{NZD} - i_t^{JPY} &= (i_t^{NZD} - i_t^{USD}) - (i_t^{JPY} - i_t^{USD}) \\ &\approx (f_t^{NZD} - s_t^{NZD}) - (f_t^{JPY} - s_t^{JPY}) \end{aligned}$$

Finally, the carry return from depreciation $(\Delta s_{t+1}^{JPY} - \Delta s_{t+1}^{NZD})$ can be calculated directly. Again working with MONTHLY sampled data:

(a) set up a carry trade with the JPY and the NZD at the beginning of 1995. Track the returns to your carry trade portfolio. Calculate the cumulative returns. Split the overall returns into the contribution due to the interest rate differential and the depreciation/appreciation. Plot cumulative returns and the decomposition.

(b) Now you build a carry trade portfolio that you rebalance every month as follows: You invest in the two high interest rate currencies and you short the low interest rate currencies. Track the returns of your carry trade portfolio and plot to cumulative returns.

3. **Volatility and Correlation of Exchange Rate Changes.**

Now you will need to return to the daily time series of log exchange rate changes in order to estimate their conditional volatility σ_t and conditional correlations ρ_t.

(a) Calculate the DAILY log exchange rate changes (rate of depreciation) Δs_t by taking the daily differences of the log nominal spot exchange rates. Produce a time-series plot and table of summary statistics for each currency pair (USD as the home currency).

(b) Using a 5 week window (25 data points) estimate the conditional volatility of currency pair x (σ_t^x) assume the following model:

$$v_t^{x,25} = \frac{1}{25} \sum_{s=t-25}^{t-1} (\Delta s_t^x)^2$$

Annualise the previous conditional variance and calculate the conditional standard deviation (volatility) σ_t by applying:

$$\sigma_t^{x,25} = \sqrt{252 \times v_t^{x,25}}$$

Plot the results and comment on the results.

(c) Now estimate their conditional correlations between currency pair x and y ($\rho x, y_t$) assuming the following model for the (annualised) conditional correlation:

$$\rho_t^{x,y,100} = \frac{\frac{252}{100} \sum_{s=t-100}^{t-1} (\Delta s_t^x)(\Delta s_t^y)}{\sigma_t^{x,100} \times \sigma_t^{y,100}}$$

noting that you are using a 100-day window for the numerator (a covariance) and the denominator (the standard deviations).[3] Plot the results and comment on the results.

[3] See: www.en.wikipedia.org/wiki/Correlation_and_dependence for a definition of correlation.