FINM 36700 **Mark Hendricks**
Autumn 2021

Homework #8

Due on Monday, Nov 29, at 6:00pm.

Long-Term Capital Management, L.P. (A) [HBS 9-200-007]

1 Conceptual issues for LTCM

Discuss these questions briefly, based on the info in the case. No need to quantitatively answer these questions.

1. Describe LTCM's investment strategy with regard to the following aspects:
   - Securities traded
   - Trading frequency
   - Skewness (Do they seek many small wins or a few big hits?)
   - Forecasting (What is behind their selection of trades?)
2. What are LTCM's biggest advantages over its competitors?
3. The case discusses four types of funding risk facing LTCM:
   - collateral haircuts
   - repo maturity
   - equity redemption
   - loan access

   The case discusses specific ways in which LTCM manages each of these risks. Briefly discuss them.
4. LTCM is largely in the business of selling liquidity and volatility. Describe how LTCM accounts for liquidity risk in their quantitative measurements.
5. Is leverage risk currently a concern for LTCM?
6. Many strategies of LTCM rely on converging spreads. LTCM feels that these are almost win/win situations because of the fact that if the spread converges, they make money. If it diverges, the trade becomes even more attractive, as convergence is still expected at a future date.

   What is the risk in these convergence trades?

2 LTCM Risk Decomposition

- On Canvas, find the data file, **"ltcm_exhibits_data.xlsx"**. Get the gross and net (total) returns of LTCM from "Exhibit 2".

- Get the returns on SPY as well as the risk-free rate from the file, "gmo_analysis_data".

1. Summary stats.
   (a) For both the gross and net series of LTCM excess returns, report the mean, volatility, and Sharpe ratios. (Annualize them.)
   (b) Report the skewness, kurtosis, and (historic) VaR(.05).
   (c) Comment on how these stats compare to SPY and other assets we have seen. How much do they differ between gross and net?

2. Using the series of **net** LTCM excess returns, denoted $\tilde{r}^{\text{LTCM}}$, estimate the following regression:

$$\tilde{r}_t^{\text{LTCM}} = \alpha + \beta^m \tilde{r}_t^m + \epsilon_t$$

   (a) Report α and β^m. Report the R^2 stat.
   (b) From this regression, does LTCM appear to be a "closet indexer"?
   (c) From the regression, does LTCM appear to deliver excess returns beyond the risk premium we expect from market exposure?

3. Let's check for non-linear market exposure. Run the following regression on LTCM's net excess returns:

$$\tilde{r}_t^{\text{LTCM}} = \alpha + \beta_1 \tilde{r}_t^m + \beta_2 \left(\tilde{r}_t^m\right)^2 + \epsilon_t$$

   (a) Report β_1, β_2, and the R^2 stat.
   (b) Does the quadratic market factor do much to increase the overall LTCM variation explained by the market?
   (c) From the regression evidence, does LTCM's market exposure behave as if it is long market options or short market options?
   (d) Should we describe LTCM as being positively or negatively exposed to market volatility?

4. Let's try to pinpoint the nature of LTCM's nonlinear exposure. Does it come more from exposure to up-markets or down-markets? Run the following regression on LTCM's net excess returns:

$$\tilde{r}_t^{\text{LTCM}} = \alpha + \beta \tilde{r}_t^m + \beta_u \max\left(\tilde{r}_t^m - k_1, 0\right) + \beta_d \max\left(k_2 - \tilde{r}_t^m, 0\right) + \epsilon_t$$

   where $k_1 = .03$ and $k_2 = -.03$. (This is roughly one standard deviation of $\tilde{r}^m$.)

   (a) Report β, β_u, β_d, and the R^2 stat.
   (b) Is LTCM long or short the call-like factor? And the put-like factor?
   (c) Which factor moves LTCM more, the call-like factor, or the put-like factor?
   (d) In the previous problem, you commented on whether LTCM is positively or negatively exposed to market volatility. Using this current regression, does this volatility exposure come more from being long the market's upside? Short the market's downside? Something else?

3 The FX Carry Trade

Find an Excel data file, "fx_carry_data.xlsx". The file has two sets of data:

- Risk-free rates across 5 currencies, as measured by annualized 3-month LIBOR rates.

- Spot FX rates, as direct quotes to the USD. (Note that all currencies are quoted as USD per the foreign currency.)

For use in the homework, note the following:

- For risk-free rate data, $r^{f,i}_{t,t+1}$, the rate is known and reported in the data at time t. **Namely, any given date t in the data file is reporting both S^i_t and $r^{f,i}_{t,t+1}$.**

- The theory says to use log risk-free rates. You have the risk-free rate in levels: use the following equation to convert them:
$$\mathrm{r}^{f,i}_{t,t+1} = \ln(1 + r^{f,i}_{t,t+1})$$

- The theory says to use log spot FX prices. You have the FX prices in levels, so directly take their logarithims:
$$s^i_t = \ln(S^i_t)$$

1. The Static Carry Trade

   Define the log return of holding the foreign currency using log values of the risk-free rate and log values of the FX rates:
$$\mathrm{r}^i_{t+1} \equiv s^i_{t+1} - s^i_t + \mathrm{r}^{f,i}_{t,t+1}$$
   Then the excess log return relative to USD, is expressed as
$$\tilde{\mathrm{r}}^i_{t+1} \equiv s^i_{t+1} - s^i_t + \mathrm{r}^{f,i}_{t,t+1} - \mathrm{r}^{f,\$}_{t,t+1}$$
   For each foreign currency, i, calculate the excess log return series, $\tilde{\mathrm{r}}_{t+1}$. Report the following stats, (based on the excess **log** returns.) Annualize them.

   (a) mean
   (b) volatility
   (c) Sharpe ratio

   What differences do you see across currencies?

2. Implications for UIP:

   (a) Do any of these stats contradict the (log version) of Uncovered Interest Parity (UIP)?
   (b) A long position in which foreign currency offered the best Sharpe ratio over the sample?

(c) Are there any foreign currencies for which a long position earned a negative excess return (in USD) over the sample?

3. Predicting FX

For each foreign currency, test whether interest-rate differentials can predict growth in the foreign-exchange rate.[1] Do this by estimating the following forecasting regression::

$$s^i_{t+1} - s^i_t = \alpha^i + \beta^i \left(\mathrm{r}^{f,\$}_{t,t+1} - \mathrm{r}^{f,i}_{t,t+1}\right) + \epsilon^i_{t+1}$$

where $\mathrm{r}^{f,i}$ denotes the risk-free rate of currency i, and s^i denotes the FX rate for currency i. Again, note that both $\mathrm{r}^{f,\$}_{t,t+1}$ and s_t are determined at time t.

(a) Make a table with columns corresponding to a different currency regression. Report the regression estimates α^i and β^i in the first two rows. Report the R^2 stat in the third row.

(b) Suppose the foreign risk-free rate increases relative to the US rate.

i. For which foreign currencies would we predict a relative strengthening of the USD in the following period?

ii. For which currencies would we predict relative weakening of the USD in the following period?

iii. This FX predictability is strongest in the case of which foreign currency?

4. The Dynamic Carry Trade

Use this to write $\mathbb{E}_t\left[\tilde{\mathrm{r}}^i_{t+1}\right]$ as a function of the interest-rate differential as well as α and β from this FX regression.

$$\mathbb{E}_t\left[s_{t+1} - s_t\right] = \alpha + \beta\left(\mathrm{r}^{f,\$}_{t,t+1} - \mathrm{r}^{f,i}_{t,t+1}\right)$$

Then use the definition of excess (log) returns on FX:

$$\tilde{\mathrm{r}}^i_{t+1} = s_{t+1} - s_t - \left(\mathrm{r}^{f,\$}_{t,t+1} - \mathrm{r}^{f,i}_{t,t+1}\right)$$

Rearranging, this implies the following forecast for excess log returns:

$$\mathbb{E}_t\left[\tilde{\mathrm{r}}^i_{t+1}\right] = \alpha + (\beta - 1)\left(\mathrm{r}^{f,\$}_{t,t+1} - \mathrm{r}^{f,i}_{t,t+1}\right)$$

(a) Use your regression estimates from Problem 3 along with the formula above to calculate the fraction of months for which the estimated FX risk premium positive. That is, for each i, calculate how often in the time-series we have

$$\mathbb{E}_t\left[\tilde{\mathrm{r}}^i_{t+1}\right] > 0$$

(b) Which currencies most consistently have a positive FX risk premium? And for which currencies does the FX risk premium most often go negative?

(c) Explain how we could use these conditional risk premia to improve the static carry trade returns calculated in Problem 1.

[1]Note that $s_{t+1} - s_t$ is a log-growth rate in the USD per foreign currency, which indicates USD depreciation.

4 Interest Rates and the Expectations Hypothesis

This section is not graded, and you do not need to submit your answers. We may discuss some of these extensions.

- Use the data file, **"treasury_data.xlsx."** We will **only** use the "prices" tab. (Though yields are provided, we will calculate log yields below.)

- Remember that this is monthly data, so the notation below measures t in ***months***.

- But the maturities are years, so the notation below measures n in ***years***.

1. Log yields
   (a) Use the price data, $P_t^{(n)}$, $(n = 1, 2, 3, 4, 5)$ to calculate the time series of log yields denoted $y_t^{(n)}$ for $n = 1, 2, 3, 4, 5$.
   (b) Report the mean and volatility of (log) yields for each maturity.
   (c) Plot all five time series of yields together on one graph.

2. Log forward rates
   (a) Calculate the time-series of log forward rates: $f_t^{(n \to n+1)}$ for $n = 1, 2, 3, 4$.)
   (b) Report the mean and volatility of (log) forwards for each maturity.
   (c) Plot the time series of forward rates together on one graph

3. Log returns
   (a) Calculate the time series of excess (log) one-year returns for the bonds of each maturity. Note that the returns of maturity 1 are the risk-free rate, so you are calculating returns for $n = 2, 3, 4, 5$ in excess of this, by subtracting the returns for $n = 1$.
   Be careful to use the formula from the lecture![2]
   (b) For each series of excess log returns, report the following (annualized) statistics:
      - mean volatility Sharpe ratio
   (c) Report the correlation matrix of the 4 excess bond returns.

4. Are any of the basic statistics above evidence for or against the strict version of the Expectations Hypothesis?

5. Test the Expectations Hypothesis with the regression test explained in the Lecture Note. Using your calculations from above, run the regressions
$$r_{t+1}^{(n)} - y_t^{(1)} = \alpha + \beta \left(f_t^{((n-1) \to n)} - y_t^{(}1) \right) + \epsilon_{t+1}$$
   Do this for $n = 2, 3, 4$.
   (a) For each maturity, report
      - α β R-squared
   (b) What do your point estimates imply about the 3 statements of the Expectations Hypothesis?

[2] You must keep track of the fact that the bond ages: thus the one-year return on a 5-year bond involves the price of the 5-year bond and the price of the 4-year bond. This is why we must calculate one-year returns rather than monthly returns.