Group Assignment #1 - The Carry Trade

Ben Charoenwong
International Finance and Economics
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Guidelines

This is a group assignment. The assignment write-up **for each part** should be a maximum of 5 pages with Times New Roman font sized 12, 1.15 spacing, and have 1-inch margins. **This limit includes tables and exhibits**. If you find your write-up is considerably longer, you are probably including too much material. Overloading your solutions with extraneous details may make your analysis hard to follow which could make them difficult to grade effectively. There is no need to turn in raw data in any form or programming scripts. However, cite all data sources on plots and tables. Finally, please use Microsoft Word Equation Editor or LaTeX for equations. Assignment write-ups should be in question and answer format, with clear headings to each of the questions to answer. All tables and plots must be labeled clearly.

All homework assignments are open-book and open-internet. However, note that not all material on the internet is correct. Please list the information of all participating team members. Every group member must sign the honor code to receive credit. Hand in assignments based on the class you are registered for. You can turn in assignments early but no late homework will be accepted. This is because in class I may go over some problems on the homework.

Homework must be submitted online, with a cover-page listing the names, student ID, and signed copies of the Honor code. Homework assignments are due at the beginning of class.

Overview

Objective. In this assignment, you will use both some data provided and some data from the World Bank. There are 2 parts to this homework. Part 1 focuses on forming carry trade portfolios, while Part 2 decomposes the carry trade returns into different components. Part 1 is due on Week 3, while Part 2 is due on Week 4.

Data. The provided data file contains interest rate differentials and changes in exchange rates between a country and the US at a monthly frequency. That is, the data is defined from the perspective of a US investor. Interest rate differentials are relative to the U.S., with a positive number meaning that the foreign country has an interest rate higher than that of the United States. The interest rate differential variable is quoted as a monthly return (as opposed to an annualized return) and is defined as $\left(i_{Foreign} - i_{US}\right)$. Exchange rate changes $\%\Delta E_{Foreign/US}$ are the percentage differences in the exchange rates from the perspective of a US investor. The units are

in foreign currency per USD. This is the depreciation of the foreign currency. That is, if you are long that currency relative to the USD, a positive exchange rate change is a loss.

The data are provided in Wide XLSX format. You may do your analysis in Excel, R, or any other statistical software you are comfortable using.

If you are using R, I have provided the transformed CSV for your convenience.

Part 1: Due Week 3

Reminder: Be sure to save both the data output and plots. You will use the constructed carry trade returns for homework part 2 due Week 4.

Question 1. Data Prep & Summary Stats. Download GDP and GDP per capita data measured using PPP exchange rates for countries in the data set. You can do this in one go through the interactive data interface on the World Bank website (or if you are using R, you can download World Bank data directly using the "WDI" library. However, you will need to learn how to use this library and pull data directly based on the World Bank Data Indicator codes.) Merge the macro data with the data provided. Keep track of the available observations.

Hint: In R, you can use the "merge" command, merging by name and year. To do this, you may need to create a clean country name column and a year column in the data provided. In Excel, you can merge by applying a vlookup on both the country name and year.

Create a summary-statistics table of your data. For each country, include:

1. Country name
2. Data availability by year-months. (e.g. August 2004 – December 2016). Use the range where both interest rate differentials and exchange rate returns are available.
3. Number of data points available for that data availability range. Use this as a check that no data is missing.
4. Mean and SD of the interest rate of the annualized interest rate differential.
5. Mean and SD of the annualized changes in exchange rates
6. GDP per capita for 2010 (pull data from the World Bank, note source in write-up)

What countries have the most available data? How many rich countries do you have in the sample? Use the same definition in class for rich and poor countries where rich countries are those with GDP per capita using PPP exchange rates at least 0.67 compared to the US GDP per capita.

Are we concerned about potential data availability issues? That is, given your experience / knowledge about the world, should we be concerned about any of our data coverages? This is a difficult discussion, since it draws upon existing knowledge. You will be graded based on your logic, not just knowledge of facts. If you are not concerned about any data availability issues, explain why.

Question 2. Carry Trade Strategy. Create the carry trade strategy for all available countries and time periods, rebalanced every month. For example, if the interest rate differential between Singapore and US is 0.002 in August 2015, I will borrow in the United States and invest in Singapore. (If the interest differential is negative, borrow in the foreign country and invest in US.) If the interest rate differential is zero, impute zero for the return (i.e. no trade is implemented).

Recall that the data is defined as the foreign currency relative to USD. If you are long JPY and short the USD in the carry trade, the realized return will be

$$r_{US,t} = \left(i_{JPY,t} - i_{US,t}\right) - \%\Delta \mathrm{E}_{\mathrm{JPY/USD}}$$

where $\mathrm{E}_{\mathrm{JPY/USD}}$ is defined as the price of 1 USD in terms of Yen. That is, how many Yen you get for 1 USD. Therefore, $\%\Delta \mathrm{E}_{\mathrm{JPY/USD}} < 0$ means that the Japanese yen appreciated. This is beneficial if you are long Yen. $\%\Delta \mathrm{E}_{\mathrm{JPY/USD}} > 0$ means that the Japanese yen depreciated. This is a loss if you are long Yen. The opposite is true for a short position.

Make a time series plot with one line for each country carry trade return with respect to the U.S. Do they show any discernible patterns?

Construct a table titled "Country Carry Trade Returns" which reports summary statistics of the carry trade returns. For returns, always report annualized numbers either in percentage form (i.e. 2.42%. To convert from a monthly rate to annualized rate, multiply by 12). Include:

1. Country Name
2. Sample time period (should be the same as Column 2 from Question 1.)
3. Mean
4. Standard deviation
5. Skewness
6. Kurtosis
7. Sharpe Ratio (note that Sharpe Ratios should be annualized)
8. Maximum Drawdown[1]
9. Maximum Drawdown time period

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[1] Recall the definition of drawdown. In R, you can calculate the maximum drawdown for each country strategy by using the "maxDrawdown" function in the Performance Analytics package (this is a package designed specifically for portfolio analysis.). In Excel, you can calculate the maximum drawdown by hand using condition checks by cell. See here.

Discuss the following with up to one paragraph each:

1. Which countries had the highest average carry trade returns, annualized? Did the countries with the highest returns also have the highest in terms of volatility? Which countries had the highest Sharpe Ratios?
2. Are the carry trade returns skewed or exhibit fat tails? What do the summary statistics tell you about assuming a normal return distribution for carry trade returns?

Sort the data by country names and construct a table titled "Country Carry Trade Correlations" which reports the correlation of all pair-wise carry trade returns. (Since the correlation matrix is symmetric, you can report either just the upper-triangular or lower-triangular portion of the matrix). Are the carry trade returns correlated? Do you notice any patterns?

Question 3. Carry Trade Portfolios. Construct carry trade portfolios using the following weighting schemes (pull the relevant data from the World Bank):

1. Equal weight all countries
2. Weighted by total GDP measured using PPP exchange rates
3. Weighted by GDP per capita measured using PPP exchange rates.
4. Create two portfolios of carry trade returns, one for rich countries and one for poor countries. Use the same definition as before, with rich countries being those whose GDP per capita using PPP exchange rates is greater than or equal to 0.67 that of the United States. Label them "Poor" and "Rich". Within each portfolio, equal weight across countries.

Plot the cumulative time series return index for the 5 portfolios. For January 2000 onwards, recall that the cumulative return is $CR_{1\to t} = \prod_{\tau=1}^{t}(1 + r_{i\tau})$, and the index will be the cumulative return $CR_{1\to t} \times 100$. This simulates the idea of putting \$100 into the strategy in December 1999 and reaping the returns from January 2000 onwards. Optional: To improve the plot, you may include 100 as the December 1999 value for all portfolios. Then, all portfolios will start with at the same point on the time series plot.

For portfolios 2 and 3, those weighted by GDP, apply the GDP number for the entire year (e.g. use the 2016 value for all carry trade returns in 2016.). Discuss whether these GDP-related portfolios would be implementable in real time. Why or why not? If not, how would you suggest adjusting the portfolio weights?

Note: You may also convert things to log returns. If so, note it clearly in your plots.

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Then, construct a table titled "Carry Trade Portfolio Returns" which reports summary statistics of the carry trade returns by portfolio. Include:

1. Portfolio weighting (i.e. the 5 portfolios from above)
2. Sample time period (should be the same as Column 2 from Question 1.)
3. Mean
4. Standard deviation
5. Skewness
6. Kurtosis
7. Sharpe Ratio
8. Maximum Drawdown
9. Maximum Drawdown time period

If there is space, append these columns/rows to the table from the previous question. Note that these summary statistics should be based on the 5 (=1+1+1+2) different portfolios, and should no longer be country-specific.

If country size were a factor affect the carry trade risk premium, what would we expect? How does each weighting scheme affect the overall portfolio return? Which portfolio generated the highest Sharpe Ratio? Intuitively, we may think that emerging markets will command a higher premium. Does this seem to be true in the data?

Part 2: Due Week 4

Use the carry trade returns that you constructed for Part 1. This part of the group assignment revisits the carry trade return and focuses on the potential drivers of these expected returns (or lack thereof). There are two questions in this part.

Question 4. Country Richness & Size. In this part, you may exclude countries with missing 2010 GDP and GDP per capita data. You will create three plots and two regressions.

Create a scatter plot of the annualized expected returns by country on the y-axis and standard deviation of annualized returns on the x-axis. Is there any clear pattern of a risk-return trade-off based on the volatility of returns?

Richness. Create another plot where the x-axis is GDP per capita using PPP exchange rates for 2010. Are there any discernible patterns? Report regression results of expected returns on GDP per capita using PPP exchange rates. Interpret the regression results.

Size. Create another plot where the x-axis is log total GDP using PPP exchange rates. Are there any discernible patterns? Report regression results of average carry trade return on log PPP GDP. Interpret the regression results. Referring to the point estimates in both regressions for Richness and Size, which captures more of the variation in the expected returns?

Note that interpreting regression results involve using the point estimate in a sentence, discussing its statistical significant, and discussing its economic significance. The latter involves putting the point estimate in context. For example, when looking at an expected return of 25%, we can get a sense of the economic significance by saying: “The 25% expected return is almost 3 times that of the annual U.S. stock return.”

Question 5. Carry Trade Decomposition. For each country's carry trade return, decompose the carry trade return into the portion coming from the interest rate differential and the portion from exchange rates.

Recall the return definition for a long carry-trade strategy that is long JPY is

$$r_t = \left(i_{JPY,t} - i_{US,t}\right) - \%\Delta \mathrm{E}_{\mathrm{JPY/USD}}$$

Note that the short carry trade is simply minus the long strategy. Use the appropriate long and short positions based on the interest rate differential.

Expected Return Decomposition. Taking the expected returns, we get that $E(r_t) = E\left(i_{JPY,t} - i_{US,t}\right) - E(\%\Delta \mathrm{E}_{\mathrm{JPY/USD}})$. Alternatively,

$$1 = \frac{E\left(i_{JPY,t} - i_{US,t}\right)}{E(r_t)} + \frac{-E\left(\%\Delta \mathrm{E}_{\mathrm{JPY/USD}}\right)}{E(r_t)}$$

Variance Decomposition. Therefore, generally for some foreign currency "FC", we have that $var(r_t) = var(\Delta i_t) + var\left(\%\Delta E_{FC/USD}\right) - 2cov\left(\Delta i_t, \%\Delta E_{FC/USD}\right)$, or alternatively,

$$1 = \frac{var(\Delta i_t)}{var(r_t)} + \frac{var\left(\%\Delta E_{FC/USD}\right)}{var(r_t)} - \frac{2cov\left(\Delta i_t, \%\Delta E_{FC/USD}\right)}{var(r_t)}$$

for some foreign currency F.

Construct the expected return and variance decomposition for every country in the dataset in the sample. Which component of expected returns is highest?

How much of the variation is due to the interest rate differential, and how much is due to the exchange rate fluctuations?

Is the driver of expected returns also the driver of the variance in the carry trade returns? What did we learn from this exercise?