DRW New-Hire Learning Program

Module: FX, Commodities, and Equities

# Session B.1: FX and Carry

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# Outline

# Notation

$S_t$ denotes the foreign exchange rate, expressed as USD per foreign currencies.

- For notational specificity, we refer to the USD/Euro exchange rate, but the statements apply to any FX rate.
- $R^{f,\$}_{t,t+1}$ denotes the risk-free factor on US dollars (USD).
- $R^{f,€}_{t,t+1}$ denotes the risk-free factor on Euros.

# FX as an asset

Misconception that $\frac{S_{t+1}}{S_t}$ is the return on foreign currency.

- The price of the Euro is $S_t$ dollars.
- In terms of USD, the payoff at time $t+1$ of the Euro riskless asset is $R^{f,€}_{t,t+1} S_{t+1}$.
- That is, we capitalize any FX gains, but we also earn the riskless return accumulated by the foreign currency.

Thus, the USD return on holding Euros is given by,

$$\frac{S_{t+1}}{S_t} R^{f,€}_{t+1}$$

# Forward exchange rate

Let $F_t^s$ denote the forward rate on the one-period FX contract, $S_{t+1}$.

- The forward FX rate, $F_t^s$, is a rate contracted at time $t$ regarding the exchange of currency at some future time, $t + k$.
- Here, we just consider one-period forward rates. In general, we could write the $k$-period forward as $F_t^{s,k}$.
- The superscript $s$ is simply to distinguish this as an FX forward versus an interest rate forward.

# Log notation

Denote log quantities:

- $\mathrm{s} \equiv \ln S$
- $f^s \equiv \ln F^s$

Write the log, one-period interest rate as

- $r^f_{t+1} \equiv \ln R^f_{t,t+1}$
- Then $r^f_{t+1}$ is known at time $t$.

# Covered interest parity

Equation (1) is known as **covered interest parity (CIP)**.

$$f_t^s - \mathtt{s}_t = \mathtt{r}_{t,t+1}^{f,\$} - \mathtt{r}_{t,t+1}^{f,€} \tag{1}$$

Or in levels,

$$\frac{F_t^s}{S_t} R_{t,t+1}^{f,€} = R_{t,t+1}^{f,\$}$$

# CIP and Law of One Price

Consider two ways of moving USD from $t$ to $t+1$.

1. Invest in the USD risk-free rate.
2. Invest in the Euro risk-free rate.
   - Buy Euros, invest in the Euro risk-free rate
   - simultaneously use a forward contract to lock in the time $t+1$ price of selling the Euros back for USD.

The second strategy replicates the first, so CIP follows just from the assumption of the Law of One Price.

# CIP in the data

Given that CIP follows from Law of One Price, it generally holds in the data.

Most deviations from CIP...

- stem from the credit risk of the counterparty on the forward contract
- concern about whether one of the so called risk-free rates is at risk.

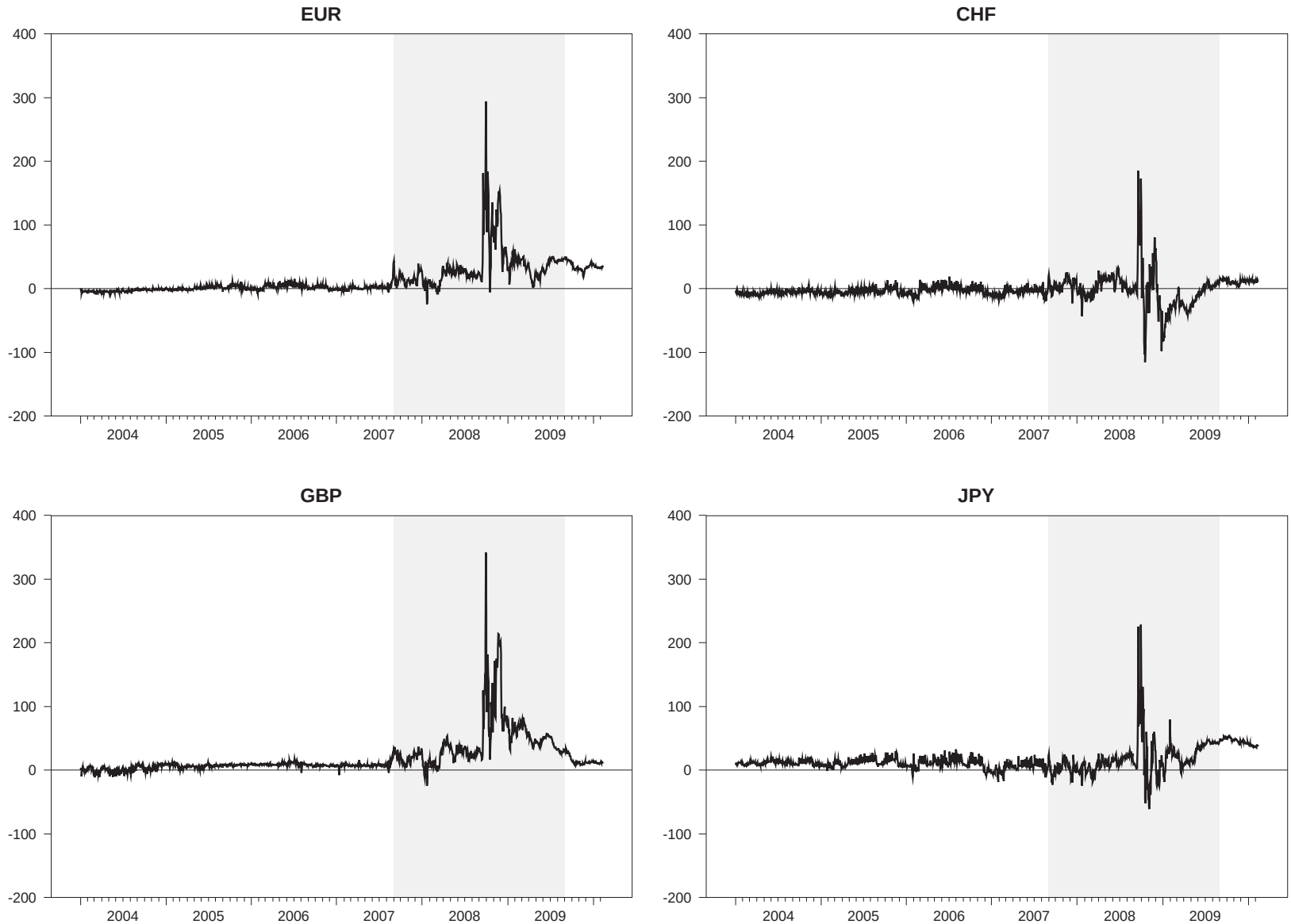


Figure: Source: Chen (2012).

# Forward premium

The (log) **forward premium** on Euros refers to

$$f_t^s - \mathtt{s}_t$$

Because CIP is so accurate, the forward premium is often used to measure the difference in interest rates across countries,

$$f_t^s - \mathtt{s}_t = \mathtt{r}_{t+1}^{f,\$} - \mathtt{r}_{t+1}^{f,€}$$

# Outline

# Uncovered interest parity

**Uncovered interest parity (UIP)** is a popular model for FX.

$$\mathbb{E}_t\left[\frac{S_{t+1}}{S_t}\right] = \frac{R^{f,\$}_{t+1}}{R^{f,€}_{t+1}}$$

- Similar to CIP, but replace the FX-forward rate with the time $t+1$ FX spot rate, $S_{t+1}$.
- CIP is a no-arbitrage condition, while UIP is a theory.
- In logs,

$$\ln \mathbb{E}_t\left[S_{t+1}\right] - \mathtt{s}_t = \mathtt{r}^{f,\$}_{t+1} - \mathtt{r}^{f,€}_{t+1} \tag{2}$$

# Uncovered FX trading

Consider two ways of moving USD from $t$ to $t+1$.

1. At time $t$, one could simply invest in the USD risk-free rate.
2. Invest in the Euro risk-free rate:
   - At time $t$, one could buy Euros to invest in the Euro risk-free rate.
   - Then at time $t+1$ convert the payoff back to dollars.

- The first investment is riskless while the second involves uncertainty about the future exchange rate.
- UIP claims the expected depreciation of the USD will exactly offset any interest rate premium over the Euro.

# UIP and FX risk

UIP assumes that FX risk is not priced, and generates no risk premium.

- The UIP equation holds if on average, investors do not require compensation for FX volatility exposure.
- Notice the words, "on average". Even UIP is consistent with the idea that some investors dislike FX volatility and want to hedge.
- It simply states that FX hedging is idiosyncratic.
- The overall market does not demand a premium to hedge it, as most investors are not sensitive to this risk.

# UIP for forward premium

UIP relates expected FX growth to interest rate differential:

$$\ln \mathbb{E}_t \left[ S_{t+1} \right] - \mathtt{s}_t = \mathtt{r}_{t+1}^{f,\$} - \mathtt{r}_{t+1}^{f,€}$$

Rewrite the UIP condition, using CIP to sub out the interest rate differential for the forward premium.

$$\ln \mathbb{E}_t \left[ S_{t+1} \right] - \mathtt{s}_t = f_t^s - \mathtt{s}_t$$

Conceptually, UIP says that the forward rate is the best predictor of the future spot rate.

$$\ln \mathbb{E}_t \left[ S_{t+1} \right] = f_t^s$$

# Testing the UIP in logs

Standard to test $\mathbb{E}_t[s_{t+1}]$ as an approximation of $\ln \mathbb{E}_t[S_{t+1}]$.

- Theory on previous slide is in levels, so there is a difference of a Jensen's inequality term.
- But this term tends to be very small, unimportant.

# UIP regression tests

Consider the regression tests for these two UIP statements.

1. Using the interest rate differential,

$$\mathtt{s}_{t+1} - \mathtt{s}_t = \alpha + \beta \left( \mathtt{r}^{f,\$}_{t+1} - \mathtt{r}^{f,€}_{t+1} \right) + \epsilon_{t+1} \tag{3}$$

   (Noting yet again that $r^f_{t+1}$ is known at time $t$.)

2. Alternatively, using the forward premium,

$$\mathtt{s}_{t+1} - \mathtt{s}_t = \alpha + \beta \ (f^s_t - \mathtt{s}_t) + \epsilon_{t+1} \tag{4}$$

In either test, UIP implies that $\beta = 1$ and $\alpha = 0$.

# The carry trade

The **carry trade** refers to trading on uncovered foreign riskless assets.

- Go long in a currency with a high risk-free rate relative to the U.S.
- UIP says that after exchange rate transactions, there will be no excess return.
- Empirically, what happens?

# Evidence: Carry-trade returns

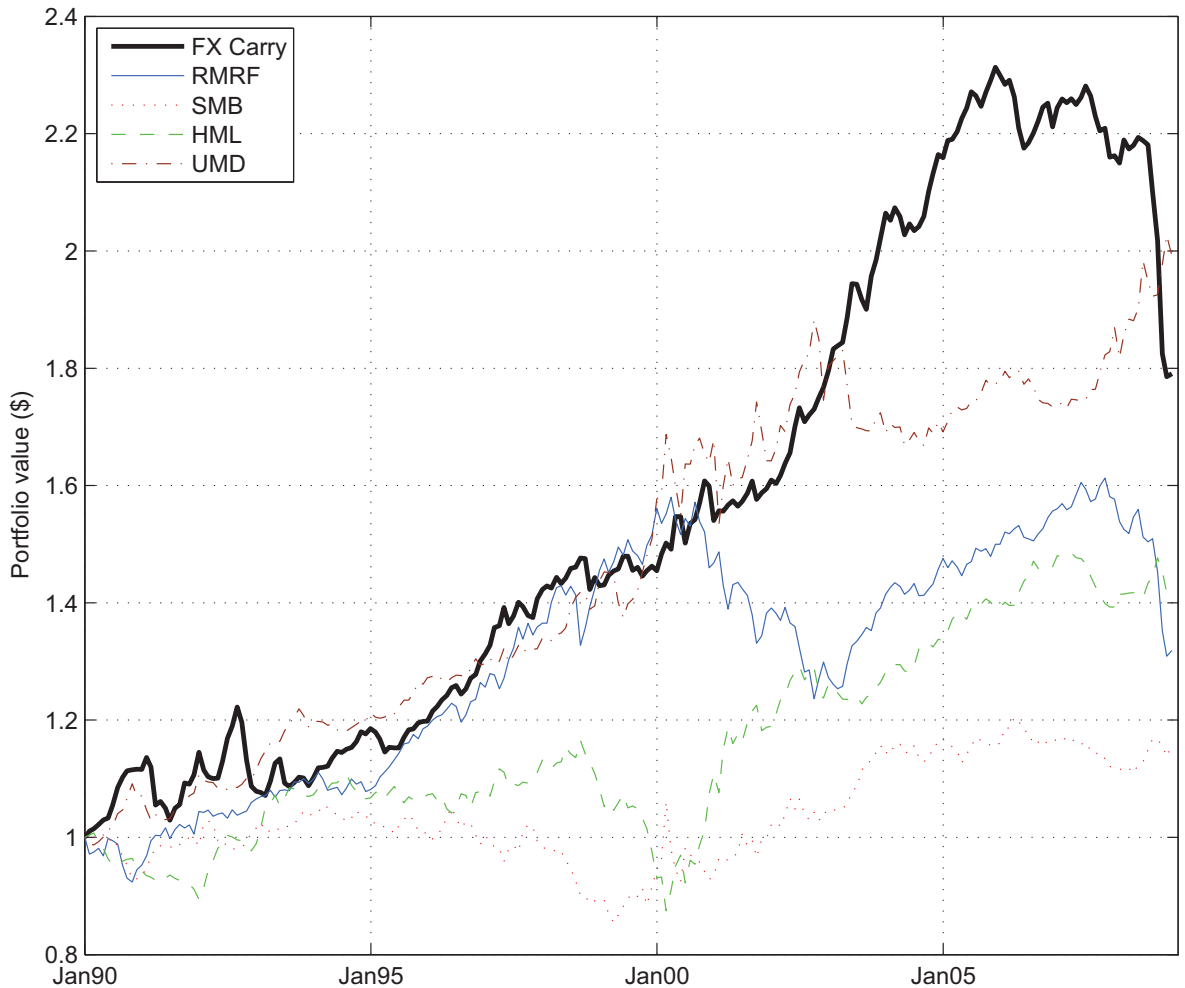


Figure: Carry-trade (black) versus excess market return (solid blue). Source: Jurek (2009).

# Carry trade premium

Historically, the excess return on the carry trade has been significant.

- A widely-used trading strategy.
- At times presented like an arbitrage, it is not.
- If there is systematic risk in FX volatility, then it is a premium for this exposure.

Even so, potentially attractive in that the risk premium is not explained by obvious factors like market beta.

# Peso problems

As is seen in the picture, the carry trade is subject to large crashes. Referred to as a "peso problem".

- In the 1970's, Mexico had pegged their FX rate to the USD for over a decade.
- Yet, a significant interest rate differential persisted.
- Seemingly a lucrative trade: higher interest rate, no FX volatility.
- But what about risk of infrequent, sudden, and large depreciation?

In fact, there eventually was a large depreciation of the peso.

# Evidence: Carry-trade returns

Historical returns:

- Before (USD/G10; monthly, 1990:1-2007:03)

| | RMRF | SMB | HML | UMD | FX Carry |
|---|---|---|---|---|---|
| Mean | 0.0730 | 0.0227 | 0.0477 | 0.0985 | 0.0478 |
| t-stat | 2.13 | 0.75 | 1.72 | 2.51 | 3.91 |
| St. dev. | 0.1422 | 0.1261 | 0.1153 | 0.1630 | 0.0507 |
| Skewness | -0.68 | 0.81 | 0.11 | -0.66 | -0.95 |
| SR | 0.51 | 0.18 | 0.41 | 0.60 | 0.94 |

- After (USD/G10; monthly, 1990:1-2008:10)

| | RMRF | SMB | HML | UMD | FX Carry |
|---|---|---|---|---|---|
| Mean | 0.0477 | 0.0191 | 0.0392 | 0.1060 | 0.0331 |
| t-stat | 1.39 | 0.68 | 1.50 | 2.83 | 2.55 |
| St. dev. | 0.1485 | 0.1223 | 0.1136 | 0.1628 | 0.0563 |
| Skewness | -0.84 | 0.83 | 0.11 | -0.60 | -1.63 |
| SR | 0.32 | 0.16 | 0.35 | 0.65 | 0.59 |

Figure: Source: Jurek (2009).

# Currency trade and options

Given that exchange rates are subject to large sudden movements,

- Carry trade premium is similar to writing far out of the money puts.
- Make a consistent, small premium, but subject to big losses in a catastrophe.
- But some research shows that even after hedging extreme movements with options, the carry trade has excess returns.

What economic factors explain this premium?