Futures, forwards and carry

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- Future $>$ spot is *contango*
- Future $<$ spot is *backwardation*

Price of futures 1

When the only cost is the cost of finance

$$F(t, T) = S(t) \times (1 + r)^{(T-t)} \tag{1}$$

or, in continuous time

$$F(t, T) = S(t)e^{r(T-t)} \tag{2}$$

Where t is today, T is the exercise date, r is the interest rate, F is the future price and S is the spot price.

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  - Shipping

Covered interest parity

$$\frac{F_{t,j}}{S_t} \times (1 + i_{t,j}) = (1 + i^*_{t,j})$$

Where, $F_{t,j}$ is the forward rate in terms of foreign currency for domestic at time t for j periods ahead, S_t is the spot rate, $i_{t,j}$ is the nominal interest rate at time t for j periods ahead and i^* is the foreign rate.

Forward rate 1

$$F_{t,j} = S_t \times \frac{(1 + i^*_{t,j})}{(1 + i_{t,j})} \tag{3}$$

Calculate the 1-year forward for USD-JPY with spot at JPY 150; the US 1-year rate at 1.0% and the Japanese 1-year rate at zero.

Forward rate 2

Action	USD	JPY
Borrow USD	1,000,000	
Owe	1,010,000	
Buy JPY		150,000,000
Receive		150,000,000
Sell	$\frac{150{,}000{,}000}{148.5149} = 1,010,000$	

Table: Covered interest parity

Covered interest parity 3

From Equation 3

$$\frac{F_{t,j}}{S_t} = \frac{(1 + i^*_{t,j})}{(1 + i_{t,j})}$$

Taking 1 from each side and re-arranging.

$$\frac{F_{t,j} - S_t}{S_t} = \frac{(i^*_{t,j} - i_{t,j})}{(1 + i_{t,j})} \tag{4}$$

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- If not, there is an arbitrage opportunity

Expectations and forward rate 1

Action	USD	JPY
Borrow USD	1,000,000	
Owe	1,010,000	
Buy JPY		150,000,000
Receive		150,000,000
Sell	$\frac{150{,}000{,}000}{150.00} = 1,000,000$	

Table: Expected rate is above forward: Loss

Expectations and forward rate 2

Action	USD	JPY
Borrow USD	1,000,000	
Owe	1,010,000	
Buy JPY		150,000,000
Receive		150,000,000
Sell	$\frac{150{,}000{,}000}{145.00} = 1,034,483$	

Table: Expected rate is below forward: gain

Uncovered interest parity 2

The expected future rate is equal to the forward rate so,

$$E[s_{t+j}] - s_t = \frac{(i^*_{t,j} - i_{t,j})}{(1 + i_{t,j})} \tag{5}$$

or approximately,

$$E[\Delta s_{t+j}] = i^*_{t,j} - i_{t,j} \tag{6}$$

$$\Delta s_t = i^*_{t,j} - i_{t,j} \tag{7}$$

Where Δs_t is $log(s_t) - log(s_{t-1})$

Testing UIP 1

A usual test of UIP is

$$\Delta s_{t+j} = \beta_0 + \beta_1 f_{t+j} + \varepsilon \tag{8}$$

Where f_{t+j} is the *forward premium* and UIP would mean that $\beta_0 = 0$ and $\beta_1 = 1$

Many tests find that $\beta_1 < 0$

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- See CHF

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- UIP failure: are there market frictions that prevent arbitrage?
- Expectations failure: is there a risk premium that explains the divergence?

Carry returns in calm and crisis