Chapter 7

Speculation and Risk in the Foreign Exchange Market
7.1 Speculating in the Foreign Exchange Market

• Uncovered foreign money market investments
  • Kevin Anthony, a portfolio manager, is considering several ways to invest $10M for 1 year
  • The data are as follows:
    • USD interest rate: 8.0% p.a.; GBP interest rate: 12.0% p.a.; Spot: $1.60/£
  • Remember that if Kevin invests in the USD-denominated asset at 8%, after 1 year he will have $10M \times 1.08 = $10.8M
  • What if Kevin invests his $10M in the pound money market, but decides not to hedge the foreign exchange risk?
7.1 Speculating in the Foreign Exchange Market

• As before, we can calculate his dollar return in three steps:
  • Convert dollars into pounds in the spot market
    • The $10M will buy $10M/(\$1.60/\£) = £6.25M at the current spot exchange rate
      • This is Kevin’s pound principal.
    • Calculate pound-denominated interest plus principal
      • Kevin can invest his pound principal at 12% yielding a return in 1 year of £6.25M \times 1.12 = £7M
    • Sell the pound principal plus interest at the spot exchange rate in 1 year
      • Dollar proceeds in 1 year = £7M \times S(t + 1, \$/\£)
      • Excess return $t + 1) = S(t + 1) \times (£7M/$10M) - (1 + 0.08)$
Return and Excess Return in Foreign Market

• We can use the previous calculation to deduce a formula for calculating the return in the foreign market,

\[ r(t + 1) = \frac{1}{S(t)} \times (1 + i(t, \£)) \times S(t + 1) \]

• The return on the British investment is uncertain because of exchange rate uncertainty.

• The excess return is the difference between the risky investment and the riskless investment in dollar deposits:

\[ extr(t + 1) = \frac{S(t + 1)}{S(t)} \times (1 + i(t, \£)) - (1 + i(t, \$)) \]
7.1 Speculating in the Foreign Exchange Market

- Speculating with forward contracts
  - Break-even spot rate: \( S^{BE} = S(t) \times \frac{[1+i(\$)]}{[1+i(£)]} \). The excess return is zero if \( S(t+1) = S^{BE} \)
  - Kevin’s breakeven rate would be:
    \( SBE = $1.60/£ \times (1 + 0.08)/(1 + 0.12) = $1.5429/£ \)
  - If future exchange rate < forward: negative excess return
  - If future exchange rate > forward: positive excess return

- Comparing forward market and foreign money market investments
  - Forward Market return (per $) = \( fmr(t+1) = [S(t+1) - F(t)]/S(t) \)
  - \( fmr(t+1) \times [1 + i(£)] = [S(t+1)/S(t)] \times [1 + i(£)] - [1 + i(\$)] \)
  - That is, the forward market return is simply the excess return when interest parity holds
7.1 Speculating in the Foreign Exchange Market

• Currency speculation and profits and losses
  • Quantifying expected losses and profits
    • Use the conditional expectation of the future exchange rate
    • Kevin expects the £ to depreciate against the $ by 3.57% over next year
      • $1.60/E × (1 − 0.0357) = $1.5429/E
      • £7M × $1.5429/E = $10.8003M
    • At what forex rate will Kevin just get his $10M back?
      • £7M × $ = $10M \rightarrow S = $1.4286/E
    • Probability that he will lose with 10% standard deviation of appreciation of £ would be \[ S(t + 1, $/£) − $1.5429/E]/($0.16/E) \]
      • Test statistic = \[($1.4286/E − $1.5429/E)/($0.16/E) = −0.7144 \]
      • This works out to 23.75% probability that \[ S(t + 1/$/£) < $1.4286/E \]
Probability Kevin is a Loser

- Kevin finds the standard deviation of the change in the exchange rate is 10%. The current spot rate is $1.60, so one standard deviation is $0.16.

- Since the exchange rate change has a normal distribution, if we divide the change by the standard deviation, we have a “standard Normal”, \( \text{N}(0,1) \) distribution.

- Here we want the probability that \( \frac{[$1.4286/£ - $1.5429/£]}{($0.16/£)} \) will occur, or worse.
  - Test statistic = \( \frac{[$1.4286/£ - $1.5429/£]}{($0.16/£)} = -0.7144 \)
  - This works out to 23.75% probability that \( S(t + 1/$/£) < $1.4286/£ \)
Exhibit 7.2 Standard Normal Distribution
7.2 Uncovered Interest Rate Parity and the Unbiasedness Hypothesis

• Covered interest rate parity
  • Doesn’t matter where you invest – you’ll have the same domestic currency return as long as the foreign exchange risk is covered using a forward contract

• Uncovered interest rate parity
  • Domestic and foreign investments have same expected returns
  • In the context of Kevin’s investment, suggests that the pound is not a great investment relative to the dollar – in fact, it suggests that the pound will depreciate by 3.57%

• Unbiasedness hypothesis
  • No systematic difference between the forward rate and the expected future spot rate
7.2 Uncovered Interest Rate Parity and the Unbiasedness Hypothesis

\[ E_t \left[ \frac{S(t + 1)}{S(t)} \right] [1 + i(£)] = [1 + i(\$)] = \frac{F(t)}{S(t)} [1 + i(£)] \]

Uncovered Interest Rate Parity  
Covered Interest Rate Parity

\[ E_t S(t + 1) = F(t) \]
7.2 Uncovered Interest Rate Parity and the Unbiasedness Hypothesis

• Forecast error
  • The difference between the actual future spot exchange rate and its forecast
    \[ S(t+1) - E_t S(t+1) \]

• Unbiased predictors
  • Implies expected forecast error = 0
  • Can have large errors as long as not favoring one side
7.2 Uncovered Interest Rate Parity and the Unbiasedness Hypothesis

• The unbiasedness hypothesis and market efficiency
  • If the forward rate were biased then one side or the other of a bet (i.e., futures contract) would be expected the win
    • Then no one would volunteer to be on the other side of that bet
  • Consistency problem
    • If unbiased from one perspective, it must be biased in the other perspective, i.e., $/£ and £/$
    • Known as the Siegel Paradox – not important in practice, however
7.3 Risk Premiums in the Foreign Exchange Market

• How much are you willing to pay for fire insurance?
  • If your home is worth $250,000
  • Probability of a fire is 0.1%
  • $250,000 × 0.001 = $250
  • Some are willing to pay more because they are risk averse

• Analogous premiums in other areas to avoid uncertainty
  • Risk premium

• What determines risk premium?
  • Expected return on the asset in excess of the risk-free rate
  • Modern portfolio theory posits that risk-averse investors like high expected returns but dislike a high variance
7.3 Risk Premiums in the Foreign Exchange Market

• Systematic risk
  • Risk associated with an asset’s return arising from the covariance of the return with the
    return on a large, well-diversified portfolio
    • Correlation: how two assets covary with each other [-1, 1]
    • The part of risk that commands a risk premium

• Unsystematic (idiosyncratic) risk
  • Risk that is attributed to the individual asset and can be diversified away
7.3 Risk Premiums in the Foreign Exchange Market

- Capital Asset Pricing Model (CAPM)
  - Nobel Prize (1990) – William Sharpe
  - Determines an asset’s systematic risk
    - \( E(r_{asset}) = r_f + \beta(r_m - r_f) \)
    - \( \beta(r_m - r_f) \) is the premium
    - \( \beta = \frac{Covariance(r_{asset}, r_m)}{Variance(r_m)} \)
7.3 Risk Premiums in the Foreign Exchange Market

• Applying the CAPM to forward market returns
  • Since forward contract is an asset, there could be an associated risk premium
    • Dollar profits / losses can covary with the dollar return on the market portfolio
    • Can be viewed as risky and therefore deserving of premium
      • The other side would have to hold with knowledge that they expect a loss
      • i.e., like fire insurance, or in this case, portfolio insurance
More on Risk Premiums in the Foreign Exchange Market

• A general statement of the CAPM relationship for excess returns on asset $j$:

\[
E_t \left\{ R_j(t+1) - [1+i(t,\$)] \right\} = \beta_j E_t \left\{ R_M(t+1) - [1+i(t,\$)] \right\}
\]

where \( \beta_j = \frac{\sigma_{jM}}{\sigma_{MM}} \). \( \sigma_{jM} \) is the covariance of \( R_j(t+1) \) with \( R_M(t+1) \)

\( \sigma_{MM} \) is the variance of \( R_M(t+1) \)

• Now we are interested in the excess return on a foreign investment

\[
exr(t+1) = \frac{S(t+1)}{S(t)} \times (1+i(t,£)) - (1+i(t,\$)) = R_£(t+1) - (1+i(t,\$))
\]
Risk premium continued

• Applying the general formula, we have:

\[ E_t\left[ \text{exr}(t+1) \right] = \beta_u E_t \left\{ R_M(t+1) - [1 + i(t, S)] \right\} \]

where

\[ \beta_j = \frac{Cov_t \left[ R_E(t+1), R_M(t+1) \right]}{Var_t \left[ R_M(t+1) \right]} \]

• We will spend some time deriving this model soon!
7.5 Empirical Evidence on the Unbiasedness Hypothesis

• An econometric test of the unbiasedness hypothesis
  
  \[ fp(t, \$/£) = \frac{F(t, \$/£) - S(t, \$/£)}{S(t, \$/£)} = \frac{E_t[S(t+30, \$/£) - S(t, \$/£)]}{S(t, \$/£)} = E_t[s(t + 30), \$/£] \]

• \( fp \) (left-hand side variable) is the 30-day forward premium/discount
• If hypothesis holds, the expected return to currency speculation will be exactly zero
• Problem: Statisticians cannot observe how market participants form their expectations, so assumptions have to be made
  • Investors act rationally (no mistakes or bias)
  • Realized appreciation = Expected appreciation + Forecast error where error is news-induced (i.e., unexpected)

• A test using the sample means
  • Weakest implication of unbiasedness hypothesis is that the unconditional mean of the realized appreciation is equal to the unconditional mean of the forward premium
Exhibit 7.4 Means of Monthly Rates of Appreciation, Forward Premiums, and the Differences Between the Two

<table>
<thead>
<tr>
<th>Exchange rate</th>
<th>Rate of appreciation (s.e.)</th>
<th>Forward premium (s.e.)</th>
<th>Difference (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conf.</td>
<td>Conf.</td>
<td>Conf.</td>
</tr>
<tr>
<td>$/€</td>
<td>1.65</td>
<td>1.19</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>(1.82)</td>
<td>(0.23)</td>
<td>(1.83)</td>
</tr>
<tr>
<td></td>
<td>0.64</td>
<td>1.00</td>
<td>0.19</td>
</tr>
<tr>
<td>$/£</td>
<td>-0.24</td>
<td>-1.80</td>
<td>1.55</td>
</tr>
<tr>
<td></td>
<td>(1.74)</td>
<td>(0.21)</td>
<td>(1.75)</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
<td>1.00</td>
<td>0.63</td>
</tr>
<tr>
<td>¥/$</td>
<td>-1.78</td>
<td>-2.88</td>
<td>1.10</td>
</tr>
<tr>
<td></td>
<td>(1.91)</td>
<td>(0.23)</td>
<td>(1.93)</td>
</tr>
<tr>
<td></td>
<td>0.65</td>
<td>1.00</td>
<td>0.43</td>
</tr>
<tr>
<td>¥/€</td>
<td>-0.72</td>
<td>-1.70</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>(1.94)</td>
<td>(0.17)</td>
<td>(1.95)</td>
</tr>
<tr>
<td></td>
<td>0.29</td>
<td>1.00</td>
<td>0.39</td>
</tr>
<tr>
<td>£/€</td>
<td>2.20</td>
<td>3.00</td>
<td>-0.80</td>
</tr>
<tr>
<td></td>
<td>(1.49)</td>
<td>(0.25)</td>
<td>(1.51)</td>
</tr>
<tr>
<td></td>
<td>0.86</td>
<td>1.00</td>
<td>0.40</td>
</tr>
<tr>
<td>¥/£</td>
<td>-2.45</td>
<td>-4.68</td>
<td>2.23</td>
</tr>
<tr>
<td></td>
<td>(2.11)</td>
<td>(0.23)</td>
<td>(2.12)</td>
</tr>
<tr>
<td></td>
<td>0.75</td>
<td>1.00</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Regression refresher

Suppose that our model has $Y_t$ as a function of only one variable, $X_{1t}$:

$$Y_t = a + b_1 X_{1t} + U_t.$$ 

Since $\text{cov}(X_t, U_t) = 0$ (we are assuming it is valid to estimate by a regression), then we have

$$\text{cov}(Y_t, X_{1t}) = b_1 \text{var}(X_{1t}).$$

This tells us that maybe one way we could estimate the parameter $b_1$ is to take sample estimates of $\text{cov}(Y_t, X_{1t})$ and $\text{var}(X_{1t})$ (call these estimates $\hat{\text{cov}}(Y_t, X_{1t})$ and $\hat{\text{var}}(X_{1t})$, and then take our estimate of $b_1$ as $\hat{\text{cov}}(Y_t, X_{1t})/\hat{\text{var}}(X_{1t})$. In fact, that is exactly the ordinary least squares regression formula for the estimate of $b_1$. 
Exhibit 7A.1 Regression Residuals with Fitted Values
7.5 Empirical Evidence on the Unbiasedness Hypothesis

- Regression tests of the unbiasedness of forward rates

\[
\frac{S(t+30) - S(t)}{S(t)} = a + b \cdot fp(t) + \varepsilon(t+30)
\]

- Unbiasedness hypothesis is true if \( a = 0 \) and \( b = 1 \)
- Results suggest existence of a forward rate bias
Exhibit 7.5 Regression Tests of the Unbiasedness Hypothesis

\[
s(t+30) = a + b f_p(t) + \epsilon(t+30)
\]

<table>
<thead>
<tr>
<th>Currency</th>
<th>Const. (s.e)</th>
<th>Const. (a = 0)</th>
<th>Forward premium (s.e)</th>
<th>Forward premium (b = 1)</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/€</td>
<td>2.52 (2.02)</td>
<td>0.79</td>
<td>-0.73 (0.74)</td>
<td>0.99</td>
<td>0.003</td>
</tr>
<tr>
<td>$/£</td>
<td>-2.49 (1.95)</td>
<td>0.80</td>
<td>-1.25 (0.75)</td>
<td>1.00</td>
<td>0.010</td>
</tr>
<tr>
<td>¥/$</td>
<td>-4.74 (2.52)</td>
<td>0.94</td>
<td>-1.03 (0.61)</td>
<td>1.00</td>
<td>0.006</td>
</tr>
<tr>
<td>¥/€</td>
<td>-2.06 (2.44)</td>
<td>0.60</td>
<td>-0.79 (0.87)</td>
<td>0.98</td>
<td>0.002</td>
</tr>
<tr>
<td>£/€</td>
<td>2.72 (1.95)</td>
<td>0.84</td>
<td>-0.17 (0.54)</td>
<td>0.98</td>
<td>0.0003</td>
</tr>
<tr>
<td>¥/£</td>
<td>-4.77 (3.63)</td>
<td>0.81</td>
<td>-0.50 (0.60)</td>
<td>0.99</td>
<td>0.001</td>
</tr>
</tbody>
</table>
7.6 Alternative Interpretations of the Test Results

• Market inefficiency
  • Interest rate differentials contain information from which profit can be obtained
  • Exploiting forward bias and carry trades: use regression results to calculate expected return on forward position
    • Strategy called “carry trade”:
      • If positive – go long; negative – go short
7.6 Alternative Interpretations of the Test Results

- Example: Spot = ¥100/$; F3mo= ¥99.17/$
  - $4 \times (99.17 - 100)/100 = -3.32\%$
- Japanese investor buys $ forward hoping the spot will not change much
  - $fmr(t + 1) = s(t + 1) - fp(t) = s(t + 1) + 3.32\%/4$
    - Last term is her carry
  - As long as the yen does not appreciate more than this (83 bp) over the next 3 months, the investor comes out ahead
- Popular strategy among hedge funds
  - Standard strategy is to go long in 3 currencies that trade at steepest forward discounts against $ and go short 3 currencies that trade at highest forward premiums against $
7.6 Alternative Interpretations of the Test Results

• Have carry trades been profitable?
  • Sharpe ratio – excess return per unit of risk
    • In U.S. stock market – 0.3 – 0.4; excess return 5-6% and annualized standard deviation is 15%
  • Leverage
    • Makes correcting for volatility even more important
  • Many financial institutions held abnormally high risk and were wiped out in the crisis
7.6 Alternative Interpretations of the Test Results

- Existence of risk premiums suggested by regression results, but is it definitely risk?
  - Some economists argue that market participants are irrational
  - Basic models of risk, such as CAPM, have a hard time generating risk premiums as variable as implied by the regressions
    - The implication is that the exchange rate risk premium on a foreign deposit increases as the foreign interest rate goes up relative to the home interest rate.
    - That could happen if the beta of the foreign investment increases as the foreign interest rate rises relative to the domestic interest rate.
7.6 Alternative Interpretations of the Test Results

• Problems interpreting the statistics
  • Unstable coefficients in the unbiasedness hypothesis regressions
  • Assumption of rational expectations may be a potential issue
7.6 Alternative Interpretations of the Test Results

• Peso problem
  • Expecting something dramatic to happen and it does not (at least not when you expect it to)
  • Named from Mexico’s experience with fixed exchange rates – rational investors anticipated a devalue of the peso
• Can peso problem explain carry trades performance?
  • Yes, if one assumes agents become very risk averse when an unwinding happens (i.e., time-varying risk premiums)