A New Look at the Forward Premium Puzzle

Jacob Boudoukh, IDC
Matthew Richardson, NYU
Robert Whitelaw, NYU
Background

- **The Unbiasedness Hypothesis (UH)**  
  \[ f_t^1 = E_t[s_{t+1}] \]
  \( f \) — (log) forward exchange rate, e.g., USD/GBP  
  \( s \) — (log) spot exchange rate

- **Covered Interest Parity (CIP)**  
  \[ f_t^1 - s_t = i_{t,1} - i_{t,1}^* \]
  \( i \) — (log) domestic (1-period) interest rate  
  \( i^* \) — (log) foreign (1-period) interest rate

- **Uncovered Interest Parity (UIP)**  
  \[ E_t[s_{t+1} - s_t] = i_{t,1} - i_{t,1}^* \]
The Forward Premium Puzzle

Regression: \[ s_{t+1} - s_t = \alpha + \beta (i_{t,1} - i_{t,1}^*) + \epsilon_{t,1} \]

Theory: \[ \beta = 1 \]

Data: annual, monthly overlapping, 1980-2010, G10

Results:

<table>
<thead>
<tr>
<th>Exchange Rate</th>
<th>( \beta )</th>
<th>Std. Err.</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/GBP</td>
<td>-0.84</td>
<td>0.88</td>
<td>2.11</td>
</tr>
<tr>
<td>USD/DEM</td>
<td>-0.71</td>
<td>0.71</td>
<td>1.77</td>
</tr>
<tr>
<td>USD/CHF</td>
<td>-1.26</td>
<td>0.60</td>
<td>6.41</td>
</tr>
</tbody>
</table>

- Negative coefficients (~-1)
- Little (if any) explanatory power (Della Corte et al. [2009])

Could it be time-varying risk premiums? (Fama [1984])
Long Horizons

Why?
- Why not?
- Evidence on PPP, expectations hypothesis of interest rates

Long-horizon regressions (Chinn & Meredith [2005])

\[ s_{t+j} - s_t = \alpha + \beta [j(i_{t,j} - i^*_{t,j})] + \varepsilon_{t,j} \]

Econometric issues!
The Insight

- An alternative formulation
- Under UH, difference forward exchange rates at 2 horizons
  \[ f_t^2 - f_t^1 = E_t[s_{t+2} - s_{t+1}] \]
- Apply CIP
  \[ s_{t+2} - s_{t+1} = \alpha + \beta(if_t^{1,2} - if_t^{1,2*}) + \epsilon_{t,2} \]

Monte Carlo evidence
The Evidence

Regression:  \[ s_{t+1} - s_t = \alpha + \beta \left( \text{if}_{t-j} - \text{if}_{i-j}^* \right) + \epsilon_{t-j, j+1} \]

Results:

<table>
<thead>
<tr>
<th>j</th>
<th>USD/GBP</th>
<th>USD/DEM</th>
<th>USD/CHF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \beta )</td>
<td>Std. Err.</td>
<td>( R^2 )</td>
</tr>
<tr>
<td>0</td>
<td>-0.84</td>
<td>0.88</td>
<td>2.11</td>
</tr>
<tr>
<td>1</td>
<td>0.92</td>
<td>1.30</td>
<td>0.94</td>
</tr>
<tr>
<td>2</td>
<td>3.41</td>
<td>1.01</td>
<td>14.61</td>
</tr>
<tr>
<td>3</td>
<td>1.94</td>
<td>1.02</td>
<td>5.22</td>
</tr>
<tr>
<td>4</td>
<td>2.54</td>
<td>0.87</td>
<td>11.28</td>
</tr>
</tbody>
</table>
Coefficients

\[ s_{t+1} - s_t = \alpha + \beta \left( \text{if}^{j,j+1}_{t-j} - \text{if}^{*j,j+1}_{t-j} \right) + \varepsilon_{t-j,j+1} \]

1. Switch signs
2. Increasing in horizon
3. >1 at longer horizons
R-squareds

\[ s_{t+1} - s_t = \alpha + \beta (i_{t-j}^{j,j+1} - i_{t-j}^{*j,j+1}) + \epsilon_{t-j,j+1} \]

1. U-shaped
2. Higher with stale information
A Model/Story: The Basics

Key features
- Reduced form
- 2-period
- Symmetric
- Inflation only

Monetary policy—Taylor rule:
\[ E_t[r_{t,t+1}] = i_t - E_t[\pi_{t,t+1}] = \gamma \pi_{t-1,t} \quad \gamma \geq 0 \]

Inflation:
\[ \pi_{t,t+1} = \theta \pi_{t-1,t} + \varepsilon_{t,t+1} \]

Expectations hypothesis of interest rates:
\[ if_{t}^{1,2} = E_t[i_{t+1}] \]
Exchange Rate Determination

- PPP
- The “carry trade” effect
- “Crashes” (reversion to fundamentals)

\[
\Delta s_{t+1} = (\pi_{t+1} - \pi_{t+1}^*) + \delta \left( E_{t+1} [r_{t+1,t+2}] - E_{t+1} [r_{t+1,t+2}^*] \right) \\
+ D_{t+1} \sum_{v=1}^{\tilde{W}} \left[ - \delta \left( E_{t+2-v} [r_{t+2-v,t+3-v}] - E_{t+2-v} [r_{t+2-v,t+3-v}^*] \right) \right]
\]

\[
D_{t+1} = \begin{cases} 
1 & \text{w/ prob. } p_t \\
0 & \text{w/ prob. } 1 - p_t
\end{cases} \\
p_t = \frac{w \times PPPD_t}{1 + w \times PPPD_t}
\]
Implications: Calibration

- Time-varying crash probability

\[ p_t = \frac{w \times PPPD_t}{1 + w \times PPPD_t} \]

- \( \theta = 0.8, \gamma = 0.5, \delta = -10, p = 7\% \)

\[ \Delta s_{t,t+1} = \alpha + \beta \left( \text{if}_{t-j} \cdot j+1 - \text{if}_{t} \cdot j+1^* \right) + \varepsilon_{t-j,j+1} \]

<table>
<thead>
<tr>
<th>j=</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/GBP</td>
<td>-0.84</td>
<td>0.92</td>
<td>3.41</td>
<td>1.94</td>
<td>2.54</td>
</tr>
<tr>
<td>USD/DEM</td>
<td>-0.71</td>
<td>0.68</td>
<td>0.76</td>
<td>2.02</td>
<td>3.17</td>
</tr>
<tr>
<td>USD/CHF</td>
<td>-1.26</td>
<td>-0.16</td>
<td>0.42</td>
<td>1.40</td>
<td>2.07</td>
</tr>
<tr>
<td>Model ( \beta )</td>
<td>-0.41</td>
<td>0.27</td>
<td>1.03</td>
<td>1.82</td>
<td>2.61</td>
</tr>
<tr>
<td>Model ( R^2 )</td>
<td>0.21</td>
<td>0.06</td>
<td>0.53</td>
<td>1.06</td>
<td>1.41</td>
</tr>
</tbody>
</table>
Other Implications

- Decomposing the “carry trade” and “crash” effects

- Using interest rates

\[ \Delta s_{t,t+1} = \alpha_j + \phi_j (i_{f-j} \cdot j+1 - i_{f-j} \cdot j+1^*) + \phi_0, j [(i_{t,1} - i_{t,1}^*) - (i_{f-j} \cdot j+1 - i_{f-j} \cdot j+1^*)] + \varepsilon_{t,t+1} \]

- Using deviations from PPP (real exchange rates)
  - The real exchange rate
    \[ q_t = s_t + (p^*_t - p_t) \]
    - \( q \) – real exchange rate
    - \( p \) – price level
  - The specification (Jorda & Taylor [2012])
    \[ \Delta s_{t,t+1} = \alpha + \psi_1 (i_{t,1} - i_{t,1}^*) + \psi_2 q_t + \varepsilon_{t,1} \]
# Real Exchange Rates

**Regression:**

\[ \Delta s_{t,t+1} = \alpha + \psi_1 (i_{t,1} - i_{t,1}^*) + \psi_2 q_t + \varepsilon_{t,1} \]

**Results:**

<table>
<thead>
<tr>
<th></th>
<th>$\psi_1$</th>
<th>Std. err.</th>
<th>$\psi_2$</th>
<th>Std. err.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/GBP</td>
<td>-0.84</td>
<td>0.88</td>
<td>-0.49</td>
<td>0.12</td>
<td>2.11</td>
</tr>
<tr>
<td>USD/DEM</td>
<td>-1.49</td>
<td>0.68</td>
<td>-0.54</td>
<td>0.10</td>
<td>33.44</td>
</tr>
<tr>
<td>USD/CHF</td>
<td>-0.71</td>
<td>0.71</td>
<td>-0.33</td>
<td>0.12</td>
<td>1.77</td>
</tr>
<tr>
<td></td>
<td>-1.69</td>
<td>0.53</td>
<td>-0.42</td>
<td>0.11</td>
<td>18.24</td>
</tr>
<tr>
<td></td>
<td>-1.26</td>
<td>0.60</td>
<td>-0.29</td>
<td>0.13</td>
<td>6.41</td>
</tr>
<tr>
<td></td>
<td>-2.45</td>
<td>0.59</td>
<td>-0.45</td>
<td>0.11</td>
<td>33.56</td>
</tr>
</tbody>
</table>
Conclusions

- Exchange rate movements do reflect fundamentals
- However, the process for exchange rates is complex
  - PPP
  - Carry trade
  - Crashes (reversions to fundamentals)
- Decomposing these effects is the key to developing a good empirical model

Extensions

- Real fluctuations
- Sophisticated Taylor rules
- Asymmetry
- Violations of the expectations hypothesis of interest rates
- More realistic reversion to fundamentals/over-reaction