Revisiting the Forward Premium Anomaly: Market Inefficiency or Risk Premium

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The Unbiased Hypothesis of Forward Exchange Rates

1. Covered Interest Arbitrage:

\[ f_{t|k} - s_t + i_{t|k}^* = i_{t|k} \]

2. Foreign exchange excess return:

\[ (s_{t+k} - s_t + i_{t|k}^*) - i_{t|k} = s_{t+k} - f_{t|k} \]

3. The hypothesis of forward rate unbiasedness under the assumptions of rational expectations and risk neutrality is

\[ f_{t|k} = E_t(s_{t+k}) \text{ for any maturity } k, \]

where \( E_t(\cdot) \) is a mathematical expectation conditional on a time \( t \) information set.
Empirical Regularities on Predictability

1. There is considerable evidence that foreign excess returns are predictable [forward premium anomaly].
   - negative correlation between spot return $s_{t+1} - s_t$ and the forward premium $f_{t|1} - s_t$

2. Predictable Excess Returns in other financial markets: in equity markets, [dividend yields, short term interest rates, defaults spread, yield spread]

3. What has yet to be established is whether predictable returns are evidence of market inefficiency or time-varying risk premium in an efficiency market.
Why revisiting?: Serial Dependence

Use a nonparametric serial dependence test which identifies a testable restriction on serial dependence of excess returns to rule out (identify) a competing economic alternative.

- Serial dependence of foreign excess returns
  1. Prediction of the rational expectations risk premium alternative [Fama (1984)]: negative serial dependence
  2. Prediction of the expectations error alternative [Frankel and Rose (1989)]: positive serial dependence

- Empirical evidence on serial dependence of stock returns
  2. Lo and Mckinlay (1988): positive serial dependence [short horizon]
Summary of Results

1. Foreign excess returns exhibit **positive serial dependence** which does not support the risk premium alternative.

2. Another Empirical evidence:
   
   (i) Deviations from the unbiasedness are strongly detected based on the entire sample in 1975-07.
   
   (ii) The unbiased hypothesis tends to hold or the deviations become weak in the sample that **excludes** observations of only 8 years in **80-87**.

   → Link new empirical evidence with speculative bubbles due to changes in the fraction of **noise traders** in foreign exchange markets.
Outline of the talk

1. The Forward Premium Anomaly
2. A Present Value Model of Exchange Rates: Economic Alternatives to Unbiasedness of Forward Exchange rates
3. Serial Dependence Test
   3.1 Econometric Methods
   3.2 Results for Competing Alternatives
   3.3 The 1980-1987 period
4. Conclusions and Future Research
A Present Value Model of Exchange Rates

- In the typical monetary models of exchange rates:
  - Home money demand: \( m_t - p_t = \gamma y_t - ai_t \)
  - Real exchange rate: \( \omega_t = s_t + p_t^* - p_t \)
  - Define the linear combination of home and foreign fundamentals by: \( w_t = (m_t - m_t^*) - \gamma(y_t - y_t^*) \)
  - Home and foreign money market eq.:
    \[
    s_t = a(i_t - i_t^*) + w_t + \omega_t = a(f_t - s_t) + w_t + \omega_t
    \]

- Deviations from uncovered interest parity
  \[
  E_t[s_{t+1}] - s_t = f_{t|1} - s_t - p_t,
  \]
A Present Value Model of Exchange Rates II

- Spot exchange rate:

\[ s_t = (1 - b) \sum_{i=0}^{\infty} b^i E_t[w_{t+i} + \omega_{t+i}] + b \sum_{i=0}^{\infty} b^i E_t p_{t+i}. \]

where \( b = \frac{a}{1+a} \) is the discount factor.

- \( w_t = w_{t-1} + \eta_t. \)
- \( \omega_t = E[\omega] + \varphi \omega_{t-1} + \epsilon_t. \)
The rational expectations risk premium alternative

- Assume that the risk premium follows: \( p_t = \varphi p_{t-1} + \epsilon_t \).
- with feedback mechanism

\[ \zeta_{t+1} := s_{t+1} - f_{t|1} = \eta_{t+1} + \frac{b}{1 - b\varphi} \epsilon_{t+1} - p_t. \]

- Assume that \( \epsilon_t \) is uncorrelated with \( \eta_t \)

\[ \text{Cov}(\zeta_{t+1}, \zeta_{t+2}) = \left[ \frac{-b}{1 - b\varphi} + \frac{\varphi}{1 - \varphi^2} \right] \sigma^2_{\epsilon} = \frac{(\varphi - b)\sigma^2_{\epsilon}}{(1 - b\varphi)(1 - \varphi^2)}. \]

- Prediction: negative serial dependence.
The expectations error alternative I

- Assume that the market expectation of future exchange rates:
  \[ E^m_t[s_{t+1}] = (1 - \lambda) E_t[s_{t+1}] + \lambda E^n_t[s_{t+1}], \]

- and that noise traders’ expectations are regressive:
  \[ E^n_t[s_{t+1}] = (1 - g)s_t + g\bar{s}_t, \]
  where \( \bar{s}_t \) is a long-run equilibrium exchange rate level.

- Uncovered interest parity is now defined by
  \[ f_{t|1} - s_t = E^m_t[s_{t+1}] - s_t = E_t[s_{t+1}] - s_t - p_t, \]
  where \( p_t = \lambda(E_t[s_{t+1}] - E^g_t[s_{t+1}]) \)
The expectations error alternative II

- Define the real exchange rate by $\omega_t = s_t - \bar{s}_t$ and

$$\omega_t = E[\omega] + \varphi\omega_{t-1} + \epsilon_t.$$  

- Then, the spot exchange rate is

$$s_t = (1 - \bar{b}) \sum_{i=0}^{\infty} b^i E_t w_{t+i} + \bar{b} \sum_{i=0}^{\infty} b^i E_t p_{t+i}$$

where $\bar{b} = \frac{b(1-\lambda)}{1-b\lambda}$ and $p_t = \frac{1-b(1+\lambda g)}{b(1-\lambda)} \omega_t$.  

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The expectations error alternative III

- A feedback mechanism

\[
\begin{align*}
    s_{t+1} - f_{t+1} &= \eta_{t+1} + \frac{1 - b(1 + \lambda g)}{1 - b\lambda} \frac{1}{1 - b\varphi} \epsilon_{t+1} \\
    &\quad + \left[ \frac{1 - b(1 + \lambda g)}{1 - b\lambda} \frac{\lambda(\varphi - 1)}{1 - b\varphi} + \lambda g \right] \omega_t,
\end{align*}
\]

- Positive serial dependence for reasonable parameter values.
- One example: \( b = 0.976, \varphi = 0.91, g = 0.25 \) [quarterly].
An Econometric Framework

- The excess return on foreign currency can be decomposed by

\[ \xi_{t+k} := s_{t+k} - f_{t|k} = s_{t+k} - E_t[s_{t+k}] + E_t[s_{t+k}] - f_{t|k}. \]

- The null hypothesis for no predictability of excess returns is stated by

\[ H_0 : E_t \left[ \xi_{t+k} \right] = E_t[s_{t+k} - f_{t|k}] = \alpha, \]

so that \( \xi_{t+k} \) is uncorrelated under \( H_0 \) and \( \alpha \) is constant.

- The alternative hypothesis forms \( E_t[s_{t+k}] - f_{t|k} = \eta_t \) under
  - the rational expectation risk premium alternative
  - the expectations error alternative
A nonparametric serial dependence test: I

- Based on the Variance Ratio test by Lo and Mckinlay (1988)
- Under the null, the variance of the sum of $q$ consecutive excess returns should be $q$ times greater than that of $\xi_t$:

$$VR(q) = \frac{\text{Var}(\sum_{i=1}^{q-1} \xi_{t+i})}{q \text{Var}(\xi_t)} = 1 + 2 \sum_{i=1}^{q-1} \left(1 - \frac{i}{q}\right) \gamma_{\xi}(i)$$

where $\gamma_{\xi}(i) = \frac{\text{Cov}(\xi_t, \xi_{t+i})}{\text{Var}(\xi_t)}$.

- $VR(q) = 1$ if excess returns are not serially correlated
- $VR(q) > 1$ if positively correlated
- $VR(q) < 1$ if the returns are negatively correlated.
A nonparametric serial dependence test: II

- Use a method which takes into account of \( MA(k-1) \) components in excess returns [Moon and Velasco (2009)] to yield efficiency gains since the forecasting interval is different from the sampling interval.

- Modify the test using ranks: define the rank of \( \xi_t \) among \( \xi_1, \ldots, \xi_T \) by \( r(\xi_t) \) and consider

\[
    r_t = \left( r(\xi_t) - \frac{T + 1}{2} \right) \div \sqrt{\frac{(T - 5)(T + 1)}{12}} \tag{1}
\]

where \( r_t \) is standardized \( \sim (0, 1) \).

- Employ a parametric bootstrap method to improve finite sample properties of the test. [Moon and Velasco (2009)]
A nonparametric serial dependence test: III

How to use overlapping observations.

- Let $S = \{\xi_1, \xi_2, \ldots, \xi_T\}$ be the whole sample and define each of $k$ subsamples by $S_i = \{\xi_i, \xi_{k+i}, \ldots, \xi_{T-k+i}\}$.
- Define the estimates $\hat{\sigma}^2_{a|k}$ and $\hat{\sigma}^2_{b|k}(q)$ of $\text{Var}(\xi_t)$ by

$$
\hat{\sigma}^2_{a|k} = \frac{1}{k} \sum_{j=1}^{k} \hat{V}_j(1) \quad \text{and} \quad \hat{\sigma}^2_{b|k}(q) = \frac{1}{k} \sum_{j=1}^{k} \hat{V}_j(q),
$$

where

$$
\hat{V}_j(q) = \frac{1}{qm_k(q)} \sum_{t=q}^{T/k} \left( \xi_{k(t-1)+j} + \cdots + \xi_{k(t-q)+j} - q\hat{\mu}_j \right)^2,
$$

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Revisiting the Forward Premium Anomaly
A nonparametric serial dependence test: IV

The procedure of the parameteric bootstrap method:

1. Fit an MA(\(q\)) model with intercept to the original sample \(S = \{\xi_1, \xi_2, \ldots, \xi_T\}\) and obtain residuals \(\hat{e}_t\), setting initial values to zero.

2. Obtain an independent resample of size \(2T\), \(\{\hat{e}_1^*, \hat{e}_2^*, \ldots, \hat{e}_{2T}^*\}\), from the empirical distribution of the residuals \(\hat{e}_t\).

3. Take moving averages of the resampled errors \(\hat{e}_t^*\) from step 2 using parameter values from the estimation in step 1 and construct the bootstrap sample \(S^* = \{\xi_1^*, \xi_2^*, \ldots, \xi_T^*\}\).

4. Divide the bootstrap sample into \(k\) subsamples, \(S_j^* = \{\xi_j^*, \xi_{k+j}^*, \ldots, \xi_{T-k+j}^*\}\) and calculate variance ratios.

5. Repeat from 2. to 4. \(b\) times.
Data

- 12 currencies in the sample: the German deutschmark (GDM), the British pound (BRP), the Japanese yen (JPY), the Canadian dollar (CAD), the Swiss franc (SWF), the Danish krone (DAK), the Swedish krona (SWK), the Norwegian kroner (NWK), the French franc (FRF), the Italian lira (ITL), the Belgian franc (BEF), and the Dutch guilder (DUG).

- Sample period 1975:1 to 2007:12.

- Log excess returns are annualized in the following way: $(5200/k) (s_{t+k} - f_t|_k)$.

- Weekly series for one-month ($k = 4$) and three-month ($k = 13$) returns are obtained from the daily data.

- Data Source: London close bid and ask prices and obtained from the database of Global Insight.
Test Results for Two Competing Economic Alternatives: Serial Dependence of Foreign Excess Returns

- The test results on the serial dependence of excess returns do not support the hypothesis of the rational expectations risk premium and are in favor of the expectations error alternative.
- $\hat{VR}(q) > 1$ for all currencies and for all the aggregation values considered.
- They are also statistically significant at the 1% level with $q$ up to 60 months for all currencies except for NWK.
Figure 1: Patterns of Variance ratios for One-month Excess returns $s_{t+1} - f_{t|4}$ (1975-2007): $\tilde{R}_k(q)$
Figure 2: Patterns of Variance ratios for One-month Excess returns $s_{t+4} - f_{t+4}$ (1975-2007): $\tilde{R}_k(q)$
New empirical findings

- The tests decisively reject the null using observations in the entire sample period of 75:1-07:12.
- But the tests do not reject the null in the sample that excludes observations only between 80 and 87.
- Parameter stability tests using 8-year rolling samples and find that strong rejections against the null only appear in the rolling samples which include observations from 80-87.
- Economic alternatives now have to explain why deviations appear very strongly only in 80-87 relative to other time periods.
- Foreign exchange markets in 80-87.
Figure 5: Patterns of Variance ratios for One-month Excess returns $s_{t+4} - f_{t|4}$ (1975-2007) except for observations in 80-87: $\hat{R}_k(q)$
Figure 6: Patterns of Variance ratios for One-month Excess returns $s_{t+4} - f_{t+4}$ (1975-2007) except for observations in 80-87: $\tilde{R}_k(q)$
What happened between 1980 and 1987?

- Long swings in the dollar: large appreciation between 80 and 85:2; large depreciation between 85 and 87.
- Speculative bubbles [Evans (1986), Meese (1986)].
- Unanticipated shift in US money demand.
- Significant increase in the demand for the US assets.
- All the above events are significantly related to the US economy.
Reconsider the speculative bubble hypothesis proposed by Frankel and Froot (1990) for explaining changes in $\lambda$.

Recall that

$$E_t^m[s_{t+1}] = (1 - \lambda)E_t[s_{t+1}] + \lambda E_t^n[s_{t+1}]$$

Is there evidence that $\lambda$ changes over time? Yes.
Techniques used by forecasting services

Frankel and Froot (1990, p. 184) provide evidence on changes in the fraction of chartists over time in foreign exchange markets, based on the survey results conducted by Euromoney magazine.

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Chartist</th>
<th>Fund</th>
<th>Both</th>
</tr>
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<tr>
<td>1978</td>
<td>23</td>
<td>3</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>1981</td>
<td>13</td>
<td>1</td>
<td>11</td>
<td>0</td>
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<tr>
<td>1983</td>
<td>11</td>
<td>8</td>
<td>1</td>
<td>1</td>
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<td>1984</td>
<td>13</td>
<td>9</td>
<td>0</td>
<td>2</td>
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<tr>
<td>1985</td>
<td>24</td>
<td>15</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>1988</td>
<td>31</td>
<td>18</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

Reproduction of Table 2 in Frankel and Froot (1990)
What about Changes in \( \lambda \) after 1988? I

- No direct evidence on their forecasting methods
- Provide several indirect evidences:
  - The unbiased test results on the sample after 1988 (unbiased hypothesis tends to hold).
  - Tests on the validity of the definition of the market expectation using survey data: (Froot and Frankel)
What about Changes in \( \lambda \) after 1988? II

- When unbiased hypo holds, test if the survey forecasts represent the market expectation

- Using the survey data, allocate part of the deviation to each of the alternatives:

\[
s_{t+k} - f_{t|k} = s_{t+k} - s_{t|k}^m + s_{t|k}^m - f_{t|k},
\]

- under the unbiased hypo, the market expectation is the rational expectation (\( \lambda = 0 \)): \( s_{t+k} - s_{t|k}^m \) should not be predictable if \( s_{t|k}^m \) represents the market expectation.

- under the unbiased hypo, \( s_{t|k}^m - f_{t|k} \) should not be correlated with the risk premium if \( s_{t|k}^m \) represents the market expectation.
What about Changes in $\lambda$ after 1988? III

- When the unbiased hypo does not hold: (We study if the survey expectations are rational)
  - If the survey expectation is not rational then either only $s_{t+k} - s^m_{t|k}$ or both terms can be attributed to the deviation.
  - If the survey expectation is rational then only $s^m_{t|k} - f_{t|k}$ can be attributed to the deviation.
Tests on the validity of the def of the market expectation I

- We run the return regression for the \textbf{unbiased} hypothesis.
- the expectation error alternative:

\[
\begin{align*}
s_{t|k}^m - s_{t+k} &= \alpha_k^a + \delta_k^a (f_{t|k} - s_t) + u_{t+k}^a \\
\end{align*}
\]

where \( H_0 : \delta_k^a = 0 \).

- the risk premium

\[
\begin{align*}
s_{t|k}^m - s_t &= \alpha_k^b + \delta_k^b (f_{t|k} - s_t) + u_t^b. \\
\end{align*}
\]

No correlation between \( s_{t|k}^m - f_t \) and the forward premium implies \( \delta_k^b = 1 \) since

\[
\begin{align*}
f_{t|k} - s_t &= f_{t|k} - s_{t|k}^m + s_{t|k}^m - s_t. \\
\end{align*}
\]
Tests on the validity of the definition of the market expectation II

- Under the unbiased hypothesis: both $\delta^a_k = 0$ and $\delta^b_k = 1$ if the survey forecasts represent the market expectation.

- When the unbiased hypothesis does not hold: both $\delta^a_k \neq 0$ and $\delta^b_k = 1$ if the expectations error mainly causes the deviation. On the other hand, $\delta^b_k \neq 1$ if there exists the risk premium.
Survey Data

- The survey forecasts data obtained from FX4casts.
- Our survey data includes one- and three-month prices of USD against GDM, BRP, JPY, CAD, SWF, DAK, SWK, FRF, ITL.
- The data cover the sample periods of 88:1-00:9 for the 1-month return horizon and 88:1-07:12 for the 3-month horizon.
- The data frequency is monthly.
The regression of the survey forecast error on the forward premium: one-month returns

<table>
<thead>
<tr>
<th></th>
<th>GDM</th>
<th>BRP</th>
<th>JPY</th>
<th>CAD</th>
<th>SWF</th>
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</thead>
<tbody>
<tr>
<td>Panel A: OLS Reg of $s_{t+k} - s_t$ on $f_{t+k} - s_t$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>-0.91*</td>
<td>-0.14</td>
<td>-2.22***</td>
<td>-0.97***</td>
<td>-1.87**</td>
</tr>
<tr>
<td>se</td>
<td>1.13</td>
<td>1.68</td>
<td>1.19</td>
<td>0.47</td>
<td>1.26</td>
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<table>
<thead>
<tr>
<th></th>
<th>DNK</th>
<th>SWK</th>
<th>FRF</th>
<th>ITL</th>
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<td>Panel B: OLS Reg of $s_{t+k}^m - s_t$ on $f_{t+k} - s_t$</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>$\delta^c_1$</td>
<td>2.55*</td>
<td>2.21</td>
<td>2.19*</td>
<td>2.23***</td>
</tr>
<tr>
<td>se</td>
<td>1.37</td>
<td>1.71</td>
<td>1.27</td>
<td>0.68</td>
</tr>
</tbody>
</table>

We do not reject the hypothesis of $\delta^c_k = 0$ when the unbiased hypothesis ($\beta^c_k = 1$) holds but do reject the hypotheses when the unbiased hypothesis is rejected.
### OLS Regressions of $s_{t|k}^m - s_t$ on $f_{t|k} - s_t$

#### Panel C: One-month returns: 88:1-00:9

<table>
<thead>
<tr>
<th></th>
<th>GDM</th>
<th>BRP</th>
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<th>CAD</th>
<th>SWF</th>
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</thead>
<tbody>
<tr>
<td>$\delta_1^a$</td>
<td>1.64</td>
<td>0.26</td>
<td>-0.01*</td>
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<tr>
<td>se</td>
<td>0.45</td>
<td>0.62</td>
<td>0.59</td>
<td>0.57</td>
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<tr>
<td>$T$</td>
<td>152</td>
<td>152</td>
<td>152</td>
<td>151</td>
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<table>
<thead>
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<th>SWK</th>
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<tr>
<td>$\delta_1^a$</td>
<td>0.85</td>
<td>1.14</td>
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</tr>
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<td>se</td>
<td>0.39</td>
<td>0.37</td>
<td>0.55</td>
<td>0.56</td>
</tr>
<tr>
<td>$T$</td>
<td>152</td>
<td>152</td>
<td>131</td>
<td>131</td>
</tr>
</tbody>
</table>

$\delta_1^a = 1$ is not rejected for all currency for the one-month return horizon and $\delta_3^a = 1$ is not rejected for all but three currencies for the three-month return horizon.
Changing the base currency: Peso problems

- Engel and Hamilton (1990), Kaminsky (1993), and Evans and Lewis (1995): relate long swings of dollar to peso problems.
- All these studies paid attention to the behavior of the bilateral dollar rates.
- We investigate how the deviations from the null hypothesis behave during the subsample period of 80-87 once we control for the effects of the US dollar on the exchange rates.
- In the absence of transaction costs, triangular arbitrage requires that

\[
\frac{GDM}{JPY}_t = \frac{GDM}{USD}_t \times \frac{USD}{JPY}_t
\]

- JPY is chosen as the base currency.
Changing the base currency: Peso problems II

- The results from the two tests by changing a base currency are consistent with those of the US bilateral rates.
- The unbiased hypothesis is decisively rejected for most currencies in the whole sample. Exceptions are DAK, SWK, NWK, FRF, and ITL.
- The null hypothesis is not rejected for all currencies except for BEF in the subsample which excludes observations in 80-87 and is marginally rejected for GDM and SWF.
Results of one-month return regression (1) using JPY as base currency

<table>
<thead>
<tr>
<th></th>
<th>GDM</th>
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<th>USD</th>
<th>CAD</th>
<th>SWF</th>
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<td>Panel A. The whole sample: 75-07</td>
<td></td>
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<tr>
<td>$\beta_4$</td>
<td>-1.02***</td>
<td>-1.88***</td>
<td>-1.54***</td>
<td>-1.55***</td>
<td>-1.24***</td>
<td>0.77</td>
</tr>
<tr>
<td>s.e.</td>
<td>0.61</td>
<td>0.80</td>
<td>0.63</td>
<td>0.78</td>
<td>0.60</td>
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<td>Panel B. Sample period: except for 80-87</td>
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<tr>
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</tr>
<tr>
<td>s.e.</td>
<td>0.74</td>
<td>1.53</td>
<td>0.91</td>
<td>1.12</td>
<td>1.00</td>
<td>0.54</td>
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<tr>
<td>Panel A. The whole sample: 75-07</td>
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<tr>
<td>$\beta_4$</td>
<td>1.07</td>
<td>1.39</td>
<td>0.60</td>
<td>0.45</td>
<td>-0.23***</td>
<td>-2.13***</td>
</tr>
<tr>
<td>s.e.</td>
<td>0.74</td>
<td>0.51</td>
<td>0.42</td>
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<td>0.34</td>
<td>1.09</td>
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<td>Panel B. Sample period: except for 80-87</td>
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<td>$\beta_4$</td>
<td>1.07</td>
<td>1.45</td>
<td>0.54</td>
<td>0.80</td>
<td>-0.08**</td>
<td>0.48</td>
</tr>
<tr>
<td>s.e.</td>
<td>0.74</td>
<td>0.52</td>
<td>2.04</td>
<td>2.58</td>
<td>0.51</td>
<td>2.08</td>
</tr>
</tbody>
</table>
Conclusions

- The unbiased hypothesis of the forward exchange rates with the variance ratio test is reconsidered.
- Empirical evidence on positive serial dependence of foreign excess returns rejects the rational expectations risk premium alternative and supports the expectation errors alternative.
- The rejections are significantly affected by a particularly influential subset of the data: markets put much more weight on the expectations of noise traders (e.g., chartists, or technical analysts) than on those of fundamentalists in 80-87, relative to other sample periods.
Future Studies

- Information in the term structure of forward exchange rates: Cointegration tests between one-week and one-year forward exchange rates or euro currency interest rates.
- Predictable stock returns: evidence of market inefficiency or the risk premium (stock returns exhibit positive serial dependence)
- Speculative bubbles: Investigate how the weight of the fundamentalists in the market expectations is determined.