An Empirical Analysis of Uncovered Interest Rate Parity and the Forward Discount Anomaly

by

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Abstract

This paper looks to empirically examine the hypothesis of uncovered interest rate parity. We present the economic theory underlying this relationship, a description of the data as well as the techniques employed in testing this hypothesis. We specifically examine the pound, yen and Canadian dollar with respect to the U.S. dollar from 1986 to 1998. The results of our findings are examined and compared to the existing literature. Primary findings include a rejection of the uncovered interest rate parity hypothesis with all three exchange rates.

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1 Introduction

The condition of uncovered interest parity (UIP) is one of the most tested hypotheses in international economics. Uncovered interest rate parity asserts that the interest rate spread between two substitutable assets with different currency denominations is equal to the difference between the expected future log exchange rate and the current log spot exchange rate. In other words, if a domestic investor were to borrow money and invest in a foreign currency, the expected excess return should be zero.

We attempt to examine this theory using data from countries with a floating exchange rate regime and open capital markets. We use data collected by Maynard and Phillips (2001) from Midlands Bank for the United Kingdom, Japan, Canada and the United States. All rates are in terms of U.S. dollars. We run an ordinary least squares regression of the change in log spot rates on the difference between the log forward rate and the log spot rate. We then test whether or not $\beta_1$ is equal to 1 and the constant, $\beta_0$, is equal to zero, which is equivalent to UIP holding. Our findings are that uncovered interest rate parity does not hold; a finding which is consistent with existing literature in this area.

In the next section we examine the theory behind the UIP hypothesis and look at the existing literature surrounding the forward discount anomaly. We review methods that have been explored to explain the puzzle. The third section outlines the data sources. Section four explains the methods of testing utilized and details the results and section five concludes.

2 Theory

The efficient markets hypothesis tells us that in an efficient speculative market, the price should fully reflect the information available to the market participants. Therefore, they should not be able to earn excess returns via speculation. Economists have long attempted to study this idea with respect to exchange rates by testing the joint hypothesis that market
participants have rational expectations and that they are risk neutral. If theory holds, then the expected return from holding one currency rather than another must be offset by the opportunity cost of holding funds in that currency versus another. In other words, the domestic interest rate must be higher than the foreign interest rate by an amount equal to the expected depreciation of the domestic currency. The uncovered interest rate parity condition is thus:

\[ s_{t+k} - s_t = i_t - i_t^* + \epsilon_t, \]  

where \( s \) is the logarithm of the spot exchange rate at time \( t \) (and \( k \) is the time to maturity), and \( i \) and \( i^* \) are the nominal interest rates in the domestic and foreign securities respectively.

There is a vast literature on testing whether or not uncovered interest rate parity holds empirically. There are currently two main ways in which this hypothesis is tested. The first is to test whether or not the exchange rate follows a random walk. Empirically it has been found that for most major nominal exchange rates it is hard to distinguish empirically from random walks.

Another common means of testing UIP is via regression analysis. Using another parity condition from international finance, the covered interest rate parity (CIP), we can derive an OLS regression which tests our hypothesis. CIP tells us that the nominal domestic interest rate must be higher than the nominal foreign interest rate by an amount equal to the forward discount on the domestic currency. The difference between CIP and UIP is that when you take a covered position you are eliminating uncertainty by using a forward rate. Therefore CIP is:

\[ i_t = i_t^* + f_t - s_t, \]

where \( f_t \) is the logarithm of the \( k \)-period ahead forward rate at time \( t \). By substituting equation (2), CIP, into equation (1), UIP, and adding an error term, \( \epsilon \), we get a regression

\[ 1 \] Taylor (1995)
\[ 2 \] Taylor (1995)
of the form:
\[ s_{t+k} - s_t = \beta_0 + \beta_1 (f_t - s_t) + \epsilon_t. \]  
(3)

This then predicts that the log forward rate is an unbiased predictor of the log future spot rate. In running the OLS regression in (3) we test UIP via the joint hypothesis that \( \beta_0 = 0 \) and \( \beta_1 = 1 \).

The existing literature has approached this puzzle from a number of different ways. Empirically, the finding of a negative estimate of \( \beta_1 \) in equation (3) is robust. Backus, Gregory and Telmer (1993) confirmed this finding for the Canadian dollar, French franc, mark, yen and pound all relative to the dollar utilizing monthly data from 1974 to 1990. All of those countries during that time period however had a floating exchange rate regime. It has been found that if you instead look at fixed exchange rate data that \( \beta \) becomes positive (although it still rejects the null of unity).\(^3\)

### 3 Data

The data used to test the uncovered interest rate parity hypothesis was a series of daily spot rates and one month forward rates from three different countries. As described in Maynard and Phillips’ *Journal of Applied Econometrics* paper, the spot and forward rates for the United Kingdom, Japan, and Canada are all from Midlands Bank and are in units of foreign currency per US dollar.\(^4\) This data is freely available from the *Journal of Applied Econometrics* on-line database. The spot and forward rates both cover the time period from October 31, 1986 until March 6, 1998 for each trading day.

While Maynard and Phillips had many different series of spot and forward rates from different sources, we chose the Midlands Bank data (coded MB) because, while the Standard and Poor’s DRI was shown to be the best of their data sets, it was not freely available.

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\(^3\)Flood and Rose (1996)
\(^4\)Maynard and Phillips (2001)
Additionally, Maynard and Phillips’ look into the effects of measurement error on measures of persistence found that of the four banks, the Midlands Bank was the ‘cleanest.’

4 Evidence

In testing the hypothesis of uncovered interest rate parity we employ regression analysis. We estimate equation (3) for the United Kingdom, Japan and Canada with respect to the United States. We examine the coefficient on the difference between the one month forward rate and the daily spot rate and compare it to our hypothesized value of one. We also examine the constant term and test its difference from the null value of zero.

As shown in Table 1, we find that $\beta_0$ is significantly different from the null for both Japan and Canada, however the null cannot be rejected in the case of the United Kingdom. In testing $\beta_1$, we find that for all three countries we reject the null hypothesis. We therefore conclude that UIP does not hold. This finding is consistent with the current literature.

<table>
<thead>
<tr>
<th>Country</th>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-statistic</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>$f_t - s_t$</td>
<td>-2.727234</td>
<td>.2814878</td>
<td>-13.24</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>constant</td>
<td>-.0075747</td>
<td>.0008518</td>
<td>-8.89</td>
<td>0.000</td>
</tr>
<tr>
<td>Canada</td>
<td>$f_t - s_t$</td>
<td>-.75352</td>
<td>.1389315</td>
<td>-12.62</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>constant</td>
<td>.0011624</td>
<td>.0002963</td>
<td>3.92</td>
<td>0.000</td>
</tr>
<tr>
<td>UK</td>
<td>$f_t - s_t$</td>
<td>-.0365919</td>
<td>.3025137</td>
<td>-3.43</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>constant</td>
<td>-.0009513</td>
<td>.0009859</td>
<td>-0.96</td>
<td>0.335</td>
</tr>
</tbody>
</table>

The t-statistics test if the coefficient on $f_t - s_t$ is significantly different from one while the t-statistic on the constant term tests if the coefficient is significantly different from zero. The joint test is then a F-test that jointly tests the two individual hypotheses.

In examining the $\beta_1$ coefficient we see that it is significantly different from one, but negative in all three cases (although not to a degree of statistical significance in the case of

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5Maynard and Phillips (2001)
the United Kingdom). This negative coefficient implies that when the forward rate exceeds the spot rate the US dollar tends to appreciate. This is in contrast to the depreciation dictated by the null.

Since \( t + k \) is greater than unity, we find that this induces \( \epsilon \) to have a moving average “overlapping observation” structure. We take this into account by estimating our covariance matrices with the Newey and West (1987) estimator, with 30 off-diagonal bands. The results are reported in Table 2.

Table 2: UIP 1986-1998 with Newey-West estimator

<table>
<thead>
<tr>
<th>Country</th>
<th>Test</th>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-statistic</th>
<th>F-statistic</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>Individual</td>
<td>( f_t - s_t )</td>
<td>-.2727234</td>
<td>1.083929</td>
<td>-3.44</td>
<td>-</td>
<td>0.000</td>
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<td></td>
<td>Individual constant</td>
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<td>-.0075747</td>
<td>.0031311</td>
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<td>-</td>
<td>0.016</td>
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<tr>
<td></td>
<td>Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>87.72</td>
<td>0.000</td>
</tr>
<tr>
<td>Canada</td>
<td>Individual</td>
<td>( f_t - s_t )</td>
<td>-.75352</td>
<td>.4709211</td>
<td>-3.72</td>
<td>-</td>
<td>0.000</td>
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<td></td>
<td>Individual constant</td>
<td></td>
<td>.0011624</td>
<td>.0011104</td>
<td>1.05</td>
<td>-</td>
<td>0.295</td>
</tr>
<tr>
<td></td>
<td>Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>88.69</td>
<td>0.000</td>
</tr>
<tr>
<td>UK</td>
<td>Individual</td>
<td>( f_t - s_t )</td>
<td>-.0365919</td>
<td>1.415151</td>
<td>-0.73</td>
<td>-</td>
<td>0.500</td>
</tr>
<tr>
<td></td>
<td>Individual constant</td>
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<td>-</td>
<td>0.762</td>
</tr>
<tr>
<td></td>
<td>Joint</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>23.24</td>
<td>0.000</td>
</tr>
</tbody>
</table>

The t-statistics test if the coefficient on \( f_t - s_t \) is significantly different from one while the t-statistic on the constant term tests if the coefficient is significantly different from zero. The joint test is then a F-test that jointly tests the two individual hypotheses. The restricted sum of squares residual was calculated by collecting the squared residuals from the \( s_{t+k} - s_t = f_t - s_t \) line and summing them.

We find that we continue to reject that \( \beta_1 \) is equal to one for Japan and Canada, however, it cannot be rejected for the United Kingdom. The constant term in the regressions for all three countries is shown not to be significantly different from zero at the 1% level. This is in contrast to our non-Newey-West approach which was able to reject that relationship for Japan as well as Canada.

In testing the joint hypothesis that \( \beta_0 = 0 \) and \( \beta_1 = 1 \) the restricted model then is of the

\[^6\text{Flood and Rose (1996)}\]
The right-hand side was simply subtracted from the left-hand side and the sum of the squared residuals were calculated. From these sum of squared residuals as well as those from the Newey-West regression reported in Table 2 we calculated the F-statistic. This serves as a first-pass approximation to the UIP hypothesis. There are problems with this method however, as it assumes homoskedastic errors. While the Newey-West estimator controls for that in the unrestricted regression, the restricted model has no heteroskedastic correction. However, the F-statistics are all large and significant, leading us to reject the hypothesis of UIP. This is in-line with the existing literature and thus our first-pass approximation provides a consistent finding.

5 Conclusion

Our primary finding is that UIP does not hold. We find that this is true for Canada, the UK, and Japan both with and without correcting for the overlapping observations problem. We also find that in addition to rejecting our null hypothesis of UIP, that the coefficient, $\hat{\beta}_1$ is negative. This implies that high interest rate currencies continue to appreciate. This is in the opposite direction that UIP dictates.

Given both the findings presented here as well as those in the existing literature, there is much work to be done on this puzzle, with many possible directions for future research. One avenue would be to examine the assumption that market participants are risk-neutral. In reality, it is more likely that agents are risk averse and therefore work on risk premium models may lead to a better explanation of the variation in the excess return.

A second possibility is to explore the possibility that expectations are not rational. The work done in this paper could be extended using survey data on the expectations of exchange rates. There has already been a vast literature on some of these issues. Examples of these
problems are rational bubbles and the “peso problem,” which occurs when agents attach some small probability to a large change in the economic fundamentals leading to a skewed distribution in the forecast errors.

While we have yet to “solve” the puzzle of the forward discount anomaly, we are surely closer than when we started. “What we have learned is that many simple explanations for the forward exchange bias do not work. We have ruled many things out, but have not yet settled on the ‘true’ story.”

References


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7 Engel (1995)