Tests of the Uncovered Interest Parity: Evidence from Australia and New Zealand

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Abstract. This paper carries out an empirical investigation of uncovered interest rate parity (UIP) model using both short- and long-horizon data for Australia and New Zealand. In contrast to previous studies using OLS estimate that yields biased and inconsistent estimates in the present of an omitted risk premium, we apply GMM model that relates the risk premium to underlying economic variables. Similar to other studies, our paper indicates that short-run horizon regression yield negative coefficients of about minus unity while three out of four coefficients yield positive values in the long-horizon regression.

Key words: Exchange rates, Uncovered interest parity, GMM
JEL classification: F31

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1. Introduction

One of the most extensively studied topics in international economics over the past decade has been the efficiency of the foreign exchange market. The Uncovered Interest Rate Parity (UIP), one of the most popular approaches to assess the efficiency of the foreign exchange, has reported unfavourable results. Extensive surveys of the relevant literature by Froot and Thaler (1990), Taylor (1995), Lucio (2005), Chinn (2006), Isard (2006) reveal that the majority of studies, using a variety of estimation techniques, currencies and time periods, find the coefficient on the interest rate differential which is not only smaller than the theoretical value of unity but also displays the ‘wrong’ sign.

Recent developments of econometrics model using GMM have led to a renewed interest in the UIP model. The main aim of this paper is to carry out an empirical investigation of the UIP comparing traditional OLS and GMM models. To do so, we first apply the OLS with Heteroskedasticity and Autocovariance Consistent (HAC) estimators developed by Newey and West (1987) to estimate the UIP condition. However, Lucio (2005) argues that OLS can be problematic in the present of an omitted risk premium in the regression and yields biased and inconsistent estimates of $\beta$. Unfortunately, risk premia are unobservable and this led to a number of researchers to model these currency risk premia. Some researchers, for example Christensen (2000), Tai (2001) employ the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) framework to model the risk premium. The main problem with these “pure statistical” methods is that they do not provide economic determinants of the risk premium. Our paper tries to derive risk premium from theoretical model using GMM that relates the risk premium to underlying economic variables. For this purpose, our paper is similar to Sarantis (2006).

The paper investigates Australian and New Zealand markets using monthly data for the period from January 1985 to December 2009. Our results indicate that short-run horizon regressions yield negative coefficients on short-term interest rate
differential of about minus unity, while three out of four coefficients yield positive values in the long-horizon regressions.

The paper is structured as follows. Our treatment begins in section 2 with a review of the unbiasedness hypothesis, summarizes the existing theories and empirical results on the UIP condition. Next, section 3 describes the data used in the empirical works. Then, in section 4, the empirical methodology and results are explored. Finally, a brief conclusion is provided in section 5.

2. Theoretical framework

The UIP can be derived by using the Covered Interest Parity (CIP), the unbiasedness hypothesis, rational expectations and risk-neutrality assumptions. As long as no arbitrage opportunity exists, the forward discount - the difference between the forward rate and the spot exchange rate at time $t$ - will equal to the interest rate differential between the two countries, i.e.;

$$f_{t,t+k} - s_t = i_{t,k} - i^*_{t,k}$$

(1)

where $f_{t,t+k}$ and $s_t$ denote the natural log of the forward exchange rate for $k$ period ahead ($F_{t,t+k}$) and the spot exchange rate ($S_t$); $i_{t,k}$ is the k-period yield on the domestic instrument, and $i^*_{t,k}$ is the corresponding yield on the foreign instrument. Equation (1) is called Covered Interest Rate Parity (CIP). If the interest rate parity equation is violated, then the covered interest arbitrage is possible, i.e. the forward exchange rate parity using equation (1) is not exactly the same as the actual forward rate.

Moreover, equation (1) is a risk-free arbitrage condition that holds regardless of investor preferences. If all market participants are risk neutral and the transaction cost is zero for all transactions, the market will set the forward exchange rate, $F_{t,k}$, equals to the spot rate which is expected to be observed on the date on which the forward contract matures.
To the extent that investors are risk averse, however, the forward rate can differ from the expected future spot rate by a premium that compensates for the perceived riskiness of holding domestic versus foreign assets. Chinn (2006) defines the risk premium, $\eta_{t,t+k}$, as:

$$f_{t,t+k} = s_{t,t+k}^e + \eta_{t,t+k}$$  \hspace{1cm} (2)

Assuming that the CIP holds, the substitution of equation (2) into equation (1) allows the expected exchange rate depreciation from period $t$ to period $t+k$ to be expressed as a function of the interest differential and the risk premium.

$$s_{t,t+k}^e - s_t = i_t - i_{t+k} - \eta_{t,t+k}$$  \hspace{1cm} (3)

The UIP refers to the proposition embodies in equation (3) when the risk premium is zero. The UIP would hold if all investors were risk-neutral or if the underlying bonds were perfect substitutes. In this case, the expected exchange rate depreciation equals the current interest rate differential. In other words, the UIP can be seen as a combination of the interest rate parity and the unbiased forward rates.

Recall that the UIP condition bases on joint hypotheses that market participants have rational expectations and that they are risk-neutral. The rational expectations assumption can be defined as:

$$s_{t,t+k} = s_{t,t+k}^e + \xi_{t,t+k}$$  \hspace{1cm} (4)

where $\xi_{t,t+k}$ is the white noise error term that is, by definition, uncorrelated with all information known at time $t$ including the interest rate differential and the spot exchange rate. The rational expectations theory states that future realizations of $s_{t,t+k}$ will equal to the value expected at time $t$ plus a white-noise error term $\xi_{t,t+k}$.

Now substituting equation (4) into equation (3) enables us to apply the rational expectations assumption into the UIP condition.

$$s_{t,t+k} - s_t = i_t - i_{t+k} - \eta_{t,t+k} + \xi_{t,t+k}$$  \hspace{1cm} (5)

Equation (5) is commonly referred as the UIP regression. The LHS of the equation (5) measures realized exchange rate depreciation from time $t$ to $t+k$.  

Moreover, according to the unbiasedness hypothesis, the last two terms in equation (5) are assumed to be orthogonal to the interest differential \((i_{t,k} - i^*_{t,k})\).

In order to test the UIP condition in equation (5) the following regression models will be estimated

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

(6)

The combined assumptions of the UIP holds and the rational expectations hypothesis is called the “risk-neutral efficient-markets hypothesis” (RNEMH). Under these assumptions the error term \(\varepsilon_{t+k}\) is simply the rational expectations’ forecast error \(\xi_{t+k}\) which is orthogonal to all information available at time \(t\) including the interest differential (Chinn (2006)). Therefore, the UIP condition can be tested using the joint hypothesis of \(\alpha = 0, \beta = 1\) and \(\varepsilon_{t+k}\) is orthogonal to all information available at time \(t\).

Non-zero values of the constant term in equation (6) may still be consistent with the UIP condition. This can be explained by the Jensen’s inequality which states that the expectation of the natural log of the future exchange rate is not the same as the natural log of the expectation of the future exchange rate. However, Engel (1996) notes that the constant term due to Jensen’s inequality is likely to be small in practice. Alternatively, when we relax the risk-neutral investors’ assumption, the constant term may reflect a constant risk premium demanded by investors on foreign versus domestic assets (Chinn and Meredith (2004)).

In addition, assuming the CIP condition in equation (1) hold, we can test the UIP condition through estimating

\[
s_{t+k} - s_t = \alpha + \beta (f_{t,t+k} - s_t) + \varepsilon_{t+k}
\]  

(7)

and test the same hypothesis as above.\(^2\)

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\(^2\) If CIP holds, estimation of equation 7 implies testing UIP condition and forward rate unbiasedness hypothesis, that is, \(f_{t,t+k} = s_{t+k}\)
The procedure is in fact a joint test for the rational expectations hypothesis and the risk neutrality. A rejection of the UIP condition means one or both of these hypotheses do not hold Taylor (1995). Departures from the UIP condition are attributed to non-rationality of market expectation and/or risk aversion of investors who demand a premium when investing risky assets.

Alper, et al. (2009) highlight the failure of these assumptions may influence the empirical evidence on the UIP condition in two manners. (1) The failure of rational expectations; in this case the forecast error \( \xi_{t+k} \) in equation (4) depends on the information available at time \( t \). This creates excess returns even when investors are risk neutral; (2) the failure of risk neutrality: Risk-averse investors demand a premium for holding assets that are perceived to be risky. In this context, foreign asset involves an exchange rate risk.

Estimations of equation (6) and equation (7) are in general unfavourable. Specifically, the majority of papers report the so-call ‘forward premium bias’ i.e, both forward premium and interest rate differential predict the spot exchange rate depreciation in the “wrong” direction. The results are robust to the estimation techniques, period of study and data sets (see the surveys of Froot and Thaler (1990), Engel (1996), Lucio (2005), Chinn (2006) and Isard (2006)). For example a comprehensive survey by Froot and Thaler (1990) on 75 published papers finds \( \beta \) is frequently less than zero with the average is -0.88 and none is equal to or greater than unity. Chinn (2006) reports the failure of the unbiasedness hypothesis in the short horizons. Four out of six coefficients have the “wrong” sign with the average is around -0.8.

Chinn and Meredith (2004) show that while the forward bias is very robust when using short-horizon data, estimates of \( \beta \) in long-horizon the UIP regressions have the “correct” (positive) sign and are generally close to unity than to zero. They develop a small macroeconomic model that enriches the framework of McCallum (1994) to explain the differences in estimates of slope coefficient at short and long horizon. The model’s fundamentals play a more decisive role in the long-horizon.
While in the short horizon, the existence of a monetary policy reaction to exchange rate through interest rate policy leads to the joint determination of the expected depreciation and interest rate differential. The monetary policy reaction sets interest rate differential in order to avoid exchange rate shock and smooth interest rate movements (McCallum (1994)). Also, Christensen (2000) makes a thorough econometric analysis of McCallum’s UIP specification and shows that in most cases McCallum’s theory is supported by the data and passes conventional econometric tests.

3. Data

The UIP model is applied to two bilateral exchange rates Australian dollar/US dollar (AUD/USD) and New Zealand dollar/US dollar (NZD/USD). Exchange rates are defined as major currencies per US dollar. Hence, the numerator refers to Australia dollar and New Zealand dollar and the denominator is the US dollar. We use monthly data over the period of 1985:01-2009:12. Data on spot exchange rates are taken from the Reserve Bank of Australia (RBA) and the Reserve Bank of New Zealand (RBNZ). 1- 3- 6- and 12-month forward exchange rates are provided by Thomson Reuters Datastream. All spot exchange rates are quoted at 11.00 am UK time.

To see whether the validity of the UIP model is sensitive to the maturity of interest rates, we use bank accepted bills 90-day (3-month) and 180-day (6-month) interest rates for short term maturity. Data in interest rates for Australian and New Zealand Bank accepted bills are provided by the RBA and the RBNZ. American bank accepted bills are provided by Federal Reserve Bank of St. Louis and Thomson Reuters Datastream. Due to the availability of data on US bank accepted bills, the period to for short term interest rates spans from 1985:01 to 2005:09. We also use government treasury bonds 2-, 5- and 10-year for long term maturity. These data are provided by RBA, RBNZ and Federal Reserve Bank of America.
Stock returns are measured by $\ln\left(\frac{P_t}{P_{t-1}}\right)$, where $P$ is stock price index (SP500 for USA, S&P/ASX 200 for Australia and total market index (TOTMKNZ) calculated by Datastream for New Zealand)

All data are annualized and observed at the last trading day of each month.

4. **Empirical methodology and results**

Descriptive statistics of returns on bank accepted bills and government bonds are reported in Table 1, panel A and B. Distribution of returns is characterised by Skewness and Kurtosis. Jarque-Bera test statistic which confirms the non-normality of the series. As expected, longer maturity instruments offer higher returns and exhibit larger volatility. However, the volatility of long term government bonds is lower than that of short-term bank accepted bills. This may be explained by the fact that bank accepted bills are riskier than government securities. Exchange rate depreciation from $t$ to $t + k$ with $k$ equals to 3, 6, 24, 60, 120 month are reported in Table 1, panel C.

Correlation coefficients among AUD/USD, NZD/USD spot exchange rates and $i_{AU}^k$, $i_{NZ}^k$ and $i_{US}^k$ interest rates at $k$-month to maturity in Australia (AU), New Zealand (NZ) and the US in Table 2 show us the following; **First**, interest rates across countries exhibit a relatively high and positive correlation. **Second**, exchange rates and interest rates correlation are quite low and usually exhibit negative signs. However, correlation between Australia and New Zealand exchange rates is high and positive.

Negative correlation of exchange rate depreciation and interest rate differentials are also recorded in the period of study. Figure 1 shows that five out of six correlation coefficients are below zero with the average of -0.15. However, Figure 1A in appendix shows that there is no clear relationship between interest rate differential and exchange rate depreciation. OLS and GMM regressions analysis in the next part may provide a better explanation to understand if the UIP holds or not.

Unit root test are traditionally used to test order of integration or the stationarity of variables. Among many recent methods, the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) methods for unit root tests are the most popular. ADF is an
augmented version of the Dickey-Fuller test for a larger and more complicated set of
time series model. The ADF statistic always obtains negative value and the more
negative it is, the stronger the rejection of the hypothesis that there is a unit roots at
some level of confidence. Unlike the ADF test, the PP test makes a non-parametric
correction to the t-test statistic. The test is robust with respect to unspecified
autocorrelation and heteroscedasticity in the disturbance process. Table 3 examines
the stationarity of the changes in exchange rates from \( t \) to \( t+k \) using standard unit
root tests. As expected, the PP test produces results similar to those of the ADF test.
All exchange rates changes under consideration are stationary in their levels with and
without constant. Thus, the LHS of equations (6) and (7) is therefore considered as
I(0).

Analysis using longer time horizon needs to address inference bias due to
overlapping observation. When the horizon for exchange rate depreciation is more
than the frequency of data (1 month), the left hand side variable overlaps across
observations, and the error term \( \epsilon_{t,t+k} \) in equations (6) and (7) above will be a moving
average process of order \( m-1 \) and thus OLS parameter estimates would be inefficient
and hypothesis test be biased (see Hansen and Hodrick (1980)). One way to deal with
the problem of overlapping observation is to use a reduced sample with none of the
observations overlap. For example with 10-year period of monthly data only 10
annual observations will be used. This procedure will definitely eliminate the
autocorrelation problem but it is obviously inefficient. Another and more efficient way
to deal with this problem is to use the overlapping data and to account for the moving
average error term in hypothesis testing. Harri and Brorsen (2009) investigate the
estimation methods involving the use of overlapping data in regression analysis in the
three leading journals during 1996-2004, conclude that the use of OLS non-
overlapping data and Newey-West estimation methods are used most often. However,
the OLS with non-overlapping method may be inefficient since it “throws away
information”. Thus, in this paper, we use Heteroskedasticity and Autocovariance
Consistent (HAC) estimators developed by Newey and West (1987) for OLS
estimation.
Alternatively, we estimate the model with the Generalized Method of Moments (GMM), introduced by Hansen (1982). GMM makes use of the orthogonality conditions to allow for efficient estimation in the present of heteroskedasticity of unknown form. Since exchange rates and interest rates are jointly determined, we consider interest rate differential as an endogenous variable. Hence, equation (6) is a linear model with two endogenous variables, exchange rate depreciation and interest rate differential. The instruments chosen for the two endogenous variables include lag values of exchange rate, short-run interest rate differential, 10-year government bond yield differential, and stock return differential. Instrumental variables must satisfy two requirements: (1) it must be correlated with the included endogenous variables and (2) orthogonal to the error process. The overidentifying restrictions can be tested via the J statistic of Hansen (1982). The J-statistic is distributed as $\chi^2$ with degree of freedom equals to the number of overidentifying restriction. A rejection of the null hypothesis implies that the instruments do not satisfy the orthogonality conditions required for their employment.

The Wald test is one of the most popular ways of testing the significance of particular explanatory variables in a statistical model. To perform the Wald test, we rewrite the null and alternative hypotheses in a more general way. The null and the alternative hypothesis can be written as

$$H_0 : R \beta_0 - r = 0$$

And

$$H_1 : R \beta_0 - r \neq 0$$

where $h$ is the number of restriction, $R$ is $hxK$ matrix, $\beta_0$ is $Kx1$ coefficient matrix and $r$ is $hx1$ constant matrix. In our regression in equation (6), the UIP condition $H_0 : \alpha = 0 and \beta = 1$ can be rewritten as

$$R = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} ; \beta_0 = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} and r = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$
The Wald test uses the sample analogue \((R\hat{\beta} - r = 0)\) to test \(R\beta_0 - r = 0\) where \(\hat{\beta}\) is the OLS estimator of \(\beta_0\).

Since \(\hat{\beta}_{\text{OLS}}\) follows \(N(\beta_0, \hat{\Sigma})\) distribution, \(\hat{\beta}_{\text{OLS}} - r\) follows \(N(0, R\hat{\Sigma}R')\).

Under the null hypothesis, the Wald statistic is a quadratic form of

\[
w_i = (R\hat{\beta}_{\text{OLS}} - r)' (R\hat{\Sigma}R')^{-1} (R\hat{\beta}_{\text{OLS}} - r)
\]

And it is distributed \(\chi^2(h)\) where \(h\) is equal to \(\text{dim}(r)\). We can reject \(H_0\) if \(w_i\) exceeds \(\chi^2_\alpha(h)\).

F and chi-squared statistics reported in columns 8 and 9 of table 4, 5 and 6 are really the same thing in that, after normalization, chi-squared is the limiting distribution of the F as the denominator degrees of freedom goes to infinity.

As noted in the literature reviews, the UIP estimation using the values for \(k\) up to one year consistently reject the unbiasedness restriction on the slope parameter. Froot and Thaler (1990), Engel (1996), Lucio (2005), Chinn (2006) and Isard (2006) all report a result suggesting a rejection of the unbiasedness with few slope coefficients are positive, but none is equal to or greater than unity. Moreover, Chinn and Meredith (2004) argue that the common perception that short-run exchange rate movements are best characterized as random walk is not strictly true.

To assess the performance of the UIP for the exchange rates movement of AUD and NZD in short-horizon, Table 4 and Table 6 present estimates of equation (6) for the period from 1985:01 to 2005:09. 3-month and 6-month exchange rates depreciation are regressed against differentials in bank accepted bill yields of the same maturity. OLS estimation using 3- and 6 month horizon data at a monthly frequency led to overlapping observations, including moving average (MA) terms in the residuals. We use OLS with Newey and West (1987) to correct standard errors of the parameter estimates for MA serial correlation. Following Schwert (1989), we
determine the number of lags of the residual auto-correlations\(^3\) is 15. Results of the GMM estimates are presented in table 6. The GMM estimator selects parameter estimates so that the correlations between instruments and disturbances are as close to zero as possible. Since we use more instruments than parameters to estimate, the validity of overidentifying restrictions can be tested by Hansen (1982) in which the null hypothesis is that overidentifying restrictions are satisfied. In our model, we have four instruments and two parameters so there are two overidentifying restrictions.

The results of the OLS and the GMM estimation confirm the failure of the UIP in the short run, which is consistent to other studies. All four estimated coefficients have the ‘wrong’ sign as compare with the unbiasedness hypothesis. The average of coefficient is around -0.90, similar to the value reported by Froot and Thaler (1990), Chinn and Meredith (2004). The hypothesis that \(\beta\) is equal to unity is strongly rejected even at the 1% significance level for all exchange rates and at both 3-month and 6-month horizons. The \(R^2\) statistics of these regressions are very low. The adjusted \(R^2\) statistics (not shown) are also very low and sometimes negative.

We next present the empirical results for the UIP model in the long horizon. Due to the availability of data the estimation period consisted of 1985:03-2009:12. The OLS with Newey and West (1987) standard error correction for HAC, with the number of lags included are 14 and 13 for 5-year and 10-year horizon respectively, is presented in Table 5. Looking at the parameter estimates, the first surprising and interesting observation relates to the slope coefficient, \(\beta\). Three out of four estimated coefficients display the anticipated positive signs and are statistically significant, which is contrary to the negative evidence for the UIP in the short run. However, the point estimates are close to zero than to unity. For Australia the results are favourable to the UIP hypothesis. The slope coefficients are 0.130 and 0.358 for 5-year and 10-year respectively. The hypothesis that \(\beta\) equals to unity cannot be rejected at 1%. However, the standard errors of the estimated parameters are sufficiently large (0.413 and 0.358 respectively) that it would be difficult to reject any hypothesis. For New

\(^3 l = \text{int} \left\{12(T/100)^{1/4}\right\}\)
Zealand, slope coefficients are very close to zero with small standard errors. Like in the short horizon, it is possible to reject the hypothesis that $\beta$ equals to unity. These results are consistent with expectation of Chinn and Meredith (2004) that the coefficient on the interest differential in the long horizon regression to be biased toward zero and away from its hypothesized value of unity. The $R^2$ statistics of these regressions are even lower than those of in short horizon especially for New Zealand dollar. The differences between short and long horizon can be explained by Chinn and Meredith (2004) using a small macroeconomic model. Chinn and Meredith (2004) develop McCallum (1994) model by incorporating a reaction function that cause interest rates to respond to innovations in output and inflation. Lucio (2005) argues that the differences between long and short horizon may be explained by the fact that the model’s ‘fundamental’ play a more important role over longer horizon, while interest rate differentials are biased predictors of exchange rate movements in the short term, owing to the behaviour of the authorities in reducing exchange rate shocks via their effect on output and inflation.

5. **Conclusions**

We find strong evidence for Australia and New Zealand countries that there is a negative relationship between interest rate differentials and exchange rate depreciation in the short-run. The average slope coefficients of around -0.90 is similar to almost all previous studies. In the long-horizon these coefficients differ sharply. Interest rate differentials coefficients are closer to zero. Especially in Australia, we cannot reject the null hypothesis of $\beta$ equals to unity. These results are consistent with Chinn and Meredith (2004), Froot and Thaler (1990) that the UIP may work better in the longer horizons. However, low $R^2$ in all regressions suggests that the UIP is still likely to explain only a very small proportion of variation in exchange rates.
References


Tables and figures

Table 1: Descriptive statistics of returns on bank accepted bills, government bonds and natural log changes in exchange rates.

Table 1 reports the summary statistics of yearly returns on market indices, AU3M, AU6M, NZ3M, NZ6M, US3M and US6M, return on 3- and 6- month bank accepted bill in the sample period spans from January 1985 to September 2005; AU2Y, AU5Y, AU10Y, NZ2Y, NZ5Y, NZ10Y, US2Y, US5Y, US10Y, returns on 2-, 5- and 10-year government bond indices in the period from 1985:03 to 2009:12; DAUD3M, DAUD6M, DAUD2Y, DAUD5Y, DAUD10Y, DNZD3M, DNZD6M, DNZD2Y, DNZD5Y and DNZD10Y natural log changes in AUD/USD and NZD/USD exchange rates. The countries in consideration are Australia (AU) New Zealand (NZ) and US. Mean is measured by annual percentage. Min (minimum), Max (maximum) and Std. Dev (standard deviations) are in percentage. Skew and Kurt refer to Skewness and Kurtosis indices respectively. The Jarque-Bera (J-B) test for normality follows $\chi^2_{df}$ with df = 2 degrees of freedom. *, ** and *** denote 1%, 5% and 10% significance levels respectively.

Panel A: Bank Accepted Bills’ returns

<table>
<thead>
<tr>
<th></th>
<th>AU3M</th>
<th>AU6M</th>
<th>NZ3M</th>
<th>NZ6M</th>
<th>US3M</th>
<th>US6M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>8.65</td>
<td>8.65</td>
<td>10.07</td>
<td>10.07</td>
<td>5.14</td>
<td>5.16</td>
</tr>
<tr>
<td>Median</td>
<td>6.17</td>
<td>6.23</td>
<td>7.59</td>
<td>7.60</td>
<td>5.46</td>
<td>5.48</td>
</tr>
<tr>
<td>Max</td>
<td>19.55</td>
<td>19.08</td>
<td>28.05</td>
<td>27.20</td>
<td>9.86</td>
<td>9.90</td>
</tr>
<tr>
<td>Min</td>
<td>4.25</td>
<td>4.11</td>
<td>4.13</td>
<td>4.30</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>4.54</td>
<td>4.46</td>
<td>5.64</td>
<td>5.60</td>
<td>2.19</td>
<td>2.14</td>
</tr>
<tr>
<td>Skews</td>
<td>0.93</td>
<td>0.90</td>
<td>1.35</td>
<td>1.34</td>
<td>-0.22</td>
<td>-0.24</td>
</tr>
<tr>
<td>Kurt</td>
<td>2.31</td>
<td>2.26</td>
<td>4.02</td>
<td>3.93</td>
<td>2.28</td>
<td>2.32</td>
</tr>
<tr>
<td>J-B</td>
<td>40.65*</td>
<td>39.15*</td>
<td>86.28*</td>
<td>83.36*</td>
<td>7.40*</td>
<td>7.07*</td>
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</table>
### Panel B: Government bond returns

<table>
<thead>
<tr>
<th></th>
<th>AU2Y</th>
<th>AU5Y</th>
<th>AU10Y</th>
<th>NZ2Y</th>
<th>NZ5Y</th>
<th>NZ10Y</th>
<th>US2Y</th>
<th>US5Y</th>
<th>US10Y</th>
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</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>7.84</td>
<td>8.12</td>
<td>8.28</td>
<td>8.85</td>
<td>8.71</td>
<td>8.66</td>
<td>5.18</td>
<td>5.73</td>
<td>6.15</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>6.26</td>
<td>6.44</td>
<td>6.64</td>
<td>6.99</td>
<td>7.03</td>
<td>6.94</td>
<td>5.40</td>
<td>5.73</td>
<td>6.02</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>15.80</td>
<td>15.20</td>
<td>15.05</td>
<td>22.21</td>
<td>19.90</td>
<td>18.71</td>
<td>10.43</td>
<td>11.29</td>
<td>11.65</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>2.55</td>
<td>3.27</td>
<td>3.99</td>
<td>3.48</td>
<td>3.88</td>
<td>4.49</td>
<td>0.67</td>
<td>0.67</td>
<td>1.55</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>3.58</td>
<td>3.32</td>
<td>3.14</td>
<td>4.45</td>
<td>3.91</td>
<td>3.63</td>
<td>2.22</td>
<td>2.01</td>
<td>1.86</td>
</tr>
<tr>
<td><strong>Skews</strong></td>
<td>0.92</td>
<td>0.78</td>
<td>0.68</td>
<td>1.34</td>
<td>1.31</td>
<td>1.26</td>
<td>-0.13</td>
<td>0.12</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Kurt</strong></td>
<td>2.39</td>
<td>2.12</td>
<td>1.94</td>
<td>3.67</td>
<td>3.54</td>
<td>3.33</td>
<td>2.31</td>
<td>2.35</td>
<td>2.41</td>
</tr>
<tr>
<td><strong>J-B</strong></td>
<td>46.27*</td>
<td>40.18*</td>
<td>37.12*</td>
<td>94.28*</td>
<td>89.50*</td>
<td>80.65*</td>
<td>6.62**</td>
<td>5.97**</td>
<td>11.40*</td>
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</table>

### Panel C: natural log exchange rate depreciations

<table>
<thead>
<tr>
<th></th>
<th>Australia dollar ($\Delta S_{i,j+k}^{AU}$)</th>
<th>New Zealand dollar ($\Delta S_{i,j+k}^{NZ}$)</th>
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<tbody>
<tr>
<td></td>
<td>k=3</td>
<td>k=6</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>0.00</td>
<td>-0.02</td>
</tr>
<tr>
<td><strong>Median</strong></td>
<td>0.00</td>
<td>-0.01</td>
</tr>
<tr>
<td><strong>Max</strong></td>
<td>0.35</td>
<td>0.33</td>
</tr>
<tr>
<td><strong>Min</strong></td>
<td>-0.20</td>
<td>-0.41</td>
</tr>
<tr>
<td><strong>Std. Dev.</strong></td>
<td>0.06</td>
<td>0.15</td>
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<tr>
<td><strong>Skews</strong></td>
<td>1.13</td>
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<tr>
<td><strong>Kurt</strong></td>
<td>7.85</td>
<td>2.68</td>
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<tr>
<td><strong>J-B</strong></td>
<td>354.47*</td>
<td>3.19</td>
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</table>

### Table 2: Correlations between variables

<table>
<thead>
<tr>
<th></th>
<th>$i_{3A}^{AU}$</th>
<th>$i_{6A}^{AU}$</th>
<th>$i_{60A}^{AU}$</th>
<th>$i_{120A}^{AU}$</th>
<th>$i_{3N}^{NZ}$</th>
<th>$i_{6N}^{NZ}$</th>
<th>$i_{60N}^{NZ}$</th>
<th>$i_{120N}^{NZ}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$i_{3A}^{AU}$</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i_{6A}^{AU}$</td>
<td>0.998</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i_{60A}^{AU}$</td>
<td>0.953</td>
<td>0.959</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i_{120A}^{AU}$</td>
<td>0.926</td>
<td>0.932</td>
<td>0.995</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$i_{3N}^{NZ}$</td>
<td>0.878</td>
<td>0.875</td>
<td>0.859</td>
<td>0.849</td>
<td>1.000</td>
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<td></td>
<td></td>
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<tr>
<td>$i_{6N}^{NZ}$</td>
<td>0.881</td>
<td>0.878</td>
<td>0.861</td>
<td>0.851</td>
<td>0.999</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$i_{60N}^{NZ}$</td>
<td>0.919</td>
<td>0.917</td>
<td>0.931</td>
<td>0.928</td>
<td>0.962</td>
<td>0.965</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>$i_{120N}^{NZ}$</td>
<td>0.922</td>
<td>0.920</td>
<td>0.942</td>
<td>0.942</td>
<td>0.944</td>
<td>0.947</td>
<td>0.996</td>
<td>1.000</td>
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<tr>
<td>$i_{3US}$</td>
<td>0.759</td>
<td>0.766</td>
<td>0.766</td>
<td>0.753</td>
<td>0.667</td>
<td>0.668</td>
<td>0.706</td>
<td>0.707</td>
</tr>
<tr>
<td>$i_{6US}$</td>
<td>0.745</td>
<td>0.753</td>
<td>0.756</td>
<td>0.742</td>
<td>0.659</td>
<td>0.661</td>
<td>0.696</td>
<td>0.697</td>
</tr>
<tr>
<td>$i_{60US}$</td>
<td>0.774</td>
<td>0.782</td>
<td>0.868</td>
<td>0.880</td>
<td>0.740</td>
<td>0.744</td>
<td>0.810</td>
<td>0.817</td>
</tr>
<tr>
<td>$i_{120US}$</td>
<td>0.788</td>
<td>0.795</td>
<td>0.895</td>
<td>0.914</td>
<td>0.765</td>
<td>0.768</td>
<td>0.842</td>
<td>0.855</td>
</tr>
<tr>
<td>$i_{3AUD}$</td>
<td>-0.251</td>
<td>-0.263</td>
<td>-0.268</td>
<td>-0.253</td>
<td>-0.180</td>
<td>-0.179</td>
<td>-0.148</td>
<td>-0.141</td>
</tr>
<tr>
<td>$i_{6AUD}$</td>
<td>-0.204</td>
<td>-0.260</td>
<td>-0.276</td>
<td>-0.253</td>
<td>-0.002</td>
<td>-0.023</td>
<td>-0.054</td>
<td>0.079</td>
</tr>
</tbody>
</table>
Table 2: - Continued

<table>
<thead>
<tr>
<th></th>
<th>(i_{US}^{US})</th>
<th>(i_{US}^{US})</th>
<th>(i_{US}^{US})</th>
<th>(i_{US}^{US})</th>
<th>(AUD_{USD})</th>
<th>(NZD_{USD})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_3)</td>
<td>1.000</td>
<td>0.998</td>
<td>0.836</td>
<td>0.787</td>
<td>-0.250</td>
<td>-0.028</td>
</tr>
<tr>
<td>(t_6)</td>
<td></td>
<td>1.000</td>
<td>0.833</td>
<td>0.783</td>
<td>-0.272</td>
<td>-0.050</td>
</tr>
<tr>
<td>(t_{60})</td>
<td></td>
<td></td>
<td>1.000</td>
<td>0.986</td>
<td>-0.155</td>
<td>0.082</td>
</tr>
<tr>
<td>(t_{120})</td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
<td>-0.163</td>
<td>0.092</td>
</tr>
<tr>
<td>(AUD_{USD})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
<td>0.891</td>
</tr>
<tr>
<td>(NZD_{USD})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.000</td>
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</table>

Table 3: Unit-root tests on exchange rate depreciation

<table>
<thead>
<tr>
<th></th>
<th>Augmented Dickey-Fuller</th>
<th>Phillips-Perron</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>Constant</td>
</tr>
<tr>
<td>(S_{AU}^{AU} - S_{t}^{AU})</td>
<td>-7.08*</td>
<td>-7.08*</td>
</tr>
<tr>
<td>(S_{t+6}^{AU} - S_{t}^{AU})</td>
<td>-4.40*</td>
<td>-4.43*</td>
</tr>
<tr>
<td>(S_{t+60}^{AU} - S_{t}^{AU})</td>
<td>-1.65**</td>
<td>-1.67</td>
</tr>
<tr>
<td>(S_{t+120}^{AU} - S_{t}^{AU})</td>
<td>-2.56**</td>
<td>-2.55</td>
</tr>
<tr>
<td>(S_{t+3}^{NZ} - S_{t}^{NZ})</td>
<td>-6.08*</td>
<td>-6.08*</td>
</tr>
<tr>
<td>(S_{t+6}^{NZ} - S_{t}^{NZ})</td>
<td>-3.43*</td>
<td>-3.45*</td>
</tr>
<tr>
<td>(S_{t+60}^{NZ} - S_{t}^{NZ})</td>
<td>-1.62***</td>
<td>-1.58</td>
</tr>
<tr>
<td>(S_{t+120}^{NZ} - S_{t}^{NZ})</td>
<td>-2.56**</td>
<td>-2.55</td>
</tr>
</tbody>
</table>

Note: (*) , (**) and (***) are significance at 1%, 5% and 10% levels respectively
Table 4: Short run OLS estimation of the UIP condition

\[ s_{t+m} - s_t = \alpha + \beta \left( \frac{m^* i_{t,m}}{12} - \frac{m^* i^r_{t,m}}{12} \right) + \varepsilon_{t+m} \]

<table>
<thead>
<tr>
<th></th>
<th>Estimates (std. errors)</th>
<th>( R^2 )</th>
<th>SE</th>
<th>DW</th>
<th>( \chi^2(1) )</th>
<th>( F(2,*) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUD 3 months</td>
<td>0.007</td>
<td>0.017</td>
<td>0.053</td>
<td>0.635</td>
<td>10.648</td>
<td>16.224</td>
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<tr>
<td>(0.008)</td>
<td>(0.571)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>0.012</td>
<td>0.034</td>
<td>0.070</td>
<td>0.325</td>
<td>10.181</td>
<td>17.656</td>
</tr>
<tr>
<td>(0.016)</td>
<td>(0.571)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta )</td>
<td>-0.865</td>
<td>0.043</td>
<td>0.054</td>
<td>0.617</td>
<td>23.967</td>
<td>41.534</td>
</tr>
<tr>
<td>NZD 3 months</td>
<td>0.007</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.009)</td>
<td>(0.411)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months</td>
<td>0.012</td>
<td>0.069</td>
<td>0.076</td>
<td>0.321</td>
<td>19.625</td>
<td>37.632</td>
</tr>
<tr>
<td>(0.019)</td>
<td>(0.433)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: (*), (**), and (***)) are significance at 1%, 5% and 10% levels respectively.

Standard errors are in brackets using Newey-West correction for autocorrelation.

Table 5: Long run OLS estimation of the UIP condition

\[ s_{t+m} - s_t = \alpha + \beta \left( \frac{m^* i_{t,m}}{12} - \frac{m^* i^r_{t,m}}{12} \right) + \varepsilon_{t+m} \]

<table>
<thead>
<tr>
<th></th>
<th>Estimates (std. errors)</th>
<th>( R^2 )</th>
<th>SE</th>
<th>DW</th>
<th>( \chi^2(1) )</th>
<th>( F(2,*) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUD 5 years</td>
<td>-0.040</td>
<td>0.003</td>
<td>0.229</td>
<td>0.036</td>
<td>4.419</td>
<td>13.835</td>
</tr>
<tr>
<td>(0.093)</td>
<td>(0.413)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 years</td>
<td>-0.059</td>
<td>0.090</td>
<td>0.208</td>
<td>0.058</td>
<td>4.134</td>
<td>10.489</td>
</tr>
<tr>
<td>(0.088)</td>
<td>(0.316)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.130</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>NZD 5 years</td>
<td>-0.052</td>
<td>0.000</td>
<td>0.273</td>
<td>0.028</td>
<td>10.551</td>
<td>33.710</td>
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<tr>
<td>(0.102)</td>
<td>(0.293)</td>
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</tr>
<tr>
<td>10 years</td>
<td>0.012</td>
<td>0.020</td>
<td>0.206</td>
<td>0.051</td>
<td>52.730</td>
<td>43.629</td>
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<tr>
<td>(0.067)</td>
<td>(0.152)</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Note: (*), (**), and (***)) are significance at 1%, 5% and 10% levels respectively.

Standard errors are in brackets using Newey-West correction for autocorrelation.
Table 6: GMM estimates of the standard UIP relation in short run

\[ s_{t+m} - s_t = \alpha + \beta \left( \frac{m^* i_{t,m}}{12} - \frac{m^* i^*_{t,m}}{12} \right) + \varepsilon_{t+m} \]

<table>
<thead>
<tr>
<th></th>
<th>Estimates (std. errors)</th>
<th>( R^2 )</th>
<th>SE</th>
<th>J(2)</th>
<th>DW</th>
<th>( \chi^2 )(1)</th>
<th>( F(2,* )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \alpha )</td>
<td>( \beta )</td>
<td></td>
<td></td>
<td></td>
<td>( H_0 : \beta = 1 )</td>
<td>( H_0 : \alpha = 0 &amp; \beta = 1 )</td>
</tr>
<tr>
<td>3-month</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUD/USD</td>
<td>0.004 (0.005)</td>
<td>-0.654 (0.447)</td>
<td>0.053</td>
<td>0.147</td>
<td>0.635</td>
<td>13.689</td>
<td>21.050</td>
</tr>
<tr>
<td>NZD/USD</td>
<td>-0.002 (0.007)</td>
<td>-0.040 (0.744)</td>
<td>0.049</td>
<td>4.967</td>
<td>0.54</td>
<td>1.953</td>
<td>5.659</td>
</tr>
<tr>
<td>6-month</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>AUD/USD</td>
<td>0.009 (0.006)</td>
<td>-0.653** (0.291)</td>
<td>0.070</td>
<td>2.46</td>
<td>0.32</td>
<td>32.357</td>
<td>49.715</td>
</tr>
<tr>
<td>NZD/USD</td>
<td>-0.002 (0.010)</td>
<td>-0.0079 (0.495)</td>
<td>0.072</td>
<td>17.3</td>
<td>0.227</td>
<td>4.140</td>
<td>21.161</td>
</tr>
</tbody>
</table>

Note: (*) and (**) are significance at 1%, 5% and 10% levels respectively.
Figure 1: Correlation of exchange rate depreciation and interest rate differentials

Figure 2: Australian 3-month exchange rate depreciation and interest rate differentials

Figure 3: Australian 6-month exchange rate depreciation and interest rate differentials
Figure 4: New Zealand 3-month exchange rate depreciation and interest rate differentials

Figure 5: New Zealand 3-month exchange rate depreciation and interest rate differentials
Appendix

Figure 1A: Scatter diagram of interest rate differential and exchange rate depreciation

Panel A: Australia

Panel B: New Zealand