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**The equilibrium exchange rate
according to PPP and UIP**

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The equilibrium exchange rate according to PPP and UIP

Abstract¹

This paper uses Purchasing Power Parity (PPP) and Uncovered Interest Rate Parity (UIP) to estimate a time-varying equilibrium for the \$NZ/\$US nominal exchange rate over the period 1992 to 2003. While PPP is supported, the data does not support the strictest form of UIP. The estimated equilibrium can be considered a Behavioural Equilibrium Exchange Rate (BEER) that is conditional on interest rates and price levels. The large swings in New Zealand's exchange rate during the 1990s were broadly consistent with the estimated conditional equilibrium, while the equally large swings in the exchange rate since 2000 were moves away from the conditional equilibrium. This may be because some factor other than interest rates or price levels has driven the exchange rate away from the conditional equilibrium since 2000. Alternatively, the long-run relationship between interest rates and the exchange rate may have changed since the 1990s.

¹ The views expressed in this paper are those of the author and do not necessarily reflect the views of the Reserve Bank of New Zealand. Wai Kin Choy provided considerable assistance for an earlier version of this paper – I would like to thank him for his direction on existing literature, for advice in setting up the estimation technique, and for his comments on early drafts. Anne-Marie Brook, Nils Björkstén, and David Archer also provided valuable comments. Remaining errors or omissions are mine alone. © Reserve Bank of New Zealand

1 Introduction

Since floating in 1985, the value of the New Zealand dollar has undergone large cycles, from below US 40c to above US 70c. Of particular interest to a central bank is whether these exchange rate cycles are consistent with some kind of fundamental equilibrium, or whether they are disequilibrium phenomena. This paper attempts to assess when the \$NZ/\$US exchange rate has been in a state of equilibrium or disequilibrium with respect interest rates and price levels, over the period of low and stable inflation in New Zealand.

There are many concepts of exchange rate “equilibrium” in the literature, each with a different use. Among RBNZ discussion papers, Brook and Hargreaves (2001) estimated a time-invariant long-run equilibrium, Brook and Hargreaves (2000) estimated an equilibrium that varies over time but is never the less unconditional on other financial or policy variables, and MacDonald (2002) estimated a time-varying “Behavioural Equilibrium Exchange Rate” (BEER). The current paper estimates a time-varying BEER using only Purchasing Power Parity (PPP) and Uncovered Interest Rate Parity (UIP) as determining forces. For the purposes of this paper, the equilibrium exchange rate at a point in time is defined as *the nominal exchange rate that would have been consistent with current interest rates and price levels according to PPP and UIP*, and hence can be considered a conditional equilibrium.

The empirical evidence for either PPP or UIP individually is mixed at best. This paper combines the two arbitrage conditions into a single relationship, as the empirical literature is more supportive of such a combined relationship than of either PPP or UIP separately. Johansen's cointegration method is used to verify the existence of a long-run relationship between the NZ\$/US\$ exchange rate, NZ and US prices, and NZ and US 5-year interest rates. Using the estimated relationship, we are able to determine whether prices, interest rates and the exchange rate were consistent with PPP and UIP over the sample period. We then calculate the exchange rate that would have restored PPP and UIP – this is the equilibrium nominal exchange rate according to PPP and UIP.

The remainder of this paper is organised as follows. Section 2 briefly reviews the theories of PPP and UIP, and explains how the two theories are combined. Section 3 covers estimation. Section 4 then uses the estimation results to calculate the NZ\$/US\$ nominal exchange rate that would have been consistent with PPP and UIP over time since 1992. In section 5 the equilibrium is re-estimated using 90-day rates instead of 5-year rates, showing that the estimate is not sensitive to the choice of interest rate. Section 6 summarises the key findings and concludes.

2 The theory of Purchasing Power Parity and Uncovered Interest Rate Parity

2.1 Purchasing Power Parity

Purchasing Power Parity (PPP) states that nominal exchange rates should move to equate the price of goods and services across countries – ie NZ\$100 should buy as much as NZ\$100 exchanged into US dollars and used to purchase goods in America. Relative PPP allows for a permanent wedge between the price levels of two countries, caused by, for example, productivity differentials and non-traded goods and services.² Relative PPP is formally expressed in the following way:

$$s_t + c = p_t^* - p_t, \quad (1)$$

where s_t = log nominal exchange rate, defined as the number of foreign currency units required to purchase one domestic currency unit

p_t = log domestic price level

p_t^* = log foreign price level

c is a constant, representing the permanent deviation from absolute PPP due to productivity differentials and other factors.

² Brook and Hargreaves (2001) includes a good explanation of how productivity differentials affect the PPP relationship.

Since goods arbitrage may be slow, PPP is more of a long-term relationship than equation (1) suggests. There are many factors which could drive the exchange rate temporarily away from PPP, such as interest rates, commodity prices, relative growth differentials, or speculative price movements. When there is a deviation from PPP, we expect that the exchange rate will drift in the direction of restoring relative PPP, expressed algebraically by:

$$\Delta s_{t+1} = \alpha(p_t^* - p_t - s_t - c), \quad (2)$$

where α = some constant between 0 and 1.

Long-run PPP has been extensively tested and studied, and the empirical evidence is mixed at best. Surveys by Breuer (1994), Froot and Rogoff (1995), and MacDonald (1995) provide a comprehensive literature review of the evidence for long-run PPP.

2.2 Uncovered Interest Rate Parity

The theory of Uncovered Interest Rate Parity (UIP) is the capital market analogue to PPP. It states that if interest rates in New Zealand are higher than similar interest rates in USA, then investors must be expecting the New Zealand exchange rate to depreciate. If this were not the case, then investors would have more incentive to purchase New Zealand assets, driving the New Zealand spot exchange rate up (or the New Zealand interest rate down). UIP can be expressed algebraically as follows:

$$E_t(s_{t+1}) - s_t = i_t^* - i_t + u, \quad (3)$$

where

i_t = domestic interest rate

i_t^* = an equivalent foreign interest rate

E_t denotes an expectation at time t , and

u = the risk premium associated with holding New Zealand dollar assets.

The values of β_1, \dots, β_6 implied by equation (6) are displayed beneath equation (7). Combined PPP and UIP is tested for in section 3, by comparing β_1, \dots, β_6 with their predicted values.

In estimating equation (6), we estimate some long run value around which q_t varies. The estimated difference between q_t and this long run value gives us an indication of how far the five variables are from equilibrium with one another. In section 4 we estimate how far, and in which direction, the exchange rate would have needed to adjust in order to restore q_t to its long run average at any point in the sample period. This is our estimate of “exchange rate misalignment.” We then calculate the equilibrium nominal exchange rate as the exchange rate that would have restored PPP and UIP.

3 Empirical estimation

3.1 Previous empirical work

Johansen and Juselius (1992) first tested combined PPP and UIP, for the United Kingdom, over the period 1972Q1 to 1987Q2. They rejected the hypothesis that the PPP relation is stationary by itself. However, they found support for combined PPP and UIP. Other papers that support the combination of PPP and UIP into a single relationship include Sjoo (1995), and Pesaran et al (2000).

MacDonald (2001) used long term interest rates, among other variables, to estimate a BEER for the New Zealand Trade Weighted Index. However, there are some important differences between MacDonald (2001) and the present paper. MacDonald’s BEER is augmented with other long run variables, while we focus only on interest rates and prices; by studying the real exchange rate, MacDonald implicitly imposes instantaneous adjustment to PPP, while we allow slow adjustment to PPP; and MacDonald requires New Zealand and foreign interest rates to have equal and opposite effects on the exchange rate, while we relax this assumption. However, the two papers are rather similar in conception. The present paper serves partly as an interesting update on MacDonald’s

work, adding three years of exchange rate appreciation to the sample period.

3.2 Estimation technique

There is now a variety of ways to test for cointegration. The two most popular ones are the Engle-Granger (EG) two-step cointegration methodology and the Johansen (1988) full-information maximum likelihood technique.³ We employ the Johansen technique, because the results obtained using the EG procedure are not invariant to the choice of the variable(s) selected for *normalisation*, and the EG method relies on a *two-step* procedure, which may induce error (see Enders, 1995).

We estimate a cointegrating relationship between the nominal NZ\$/US\$ exchange rate, New Zealand and US prices, and New Zealand and US interest rates. This involves estimating a Vector Error Correction (VEC) model. Before we proceed to the VEC model, however, we begin by specifying the corresponding unrestricted five-dimensional Vector Autoregressive (VAR) model (omitting the constant for simplicity), each having j lags, as follows:

$$X_t = \Pi_1 X_{t-1} + \dots + \Pi_j X_{t-j} + \Omega D_t + \varepsilon_t \quad (8)$$

where

$$X_t = [s_t \quad p_t \quad p_t^* \quad i_t \quad i_t^*]$$

(since we are testing PPP and UIP jointly)

$\Pi_h =$ matrices of parameters ($h = 1, 2, \dots, j$)

$\varepsilon_t \sim \text{iid}[0, \Sigma]$

$D_t =$ centred seasonal dummies with corresponding parameters in Ω

and $s_t, p_t, p_t^*, i_t,$ and i_t^* are as defined previously.

³ Other methods include the two-stage least squares and generalised least squares as applied by Frenkel (1981) and Davutyan and Pippingier (1985), as well as the fractional cointegration as used by Diebold, Husted and Rush (1991). The results are at best mixed (see Bahmani-Oskooee and Barry, 1997).

The five-equation Vector Error Correction (VEC) model counterpart to the VAR model is shown below:⁴

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \dots + \Gamma_{j-1} \Delta X_{t-j+1} + \Pi \begin{bmatrix} X_{t-j} \\ 1 \end{bmatrix} + \Omega D_t + \varepsilon_t \quad (9)$$

where of notations not previously defined,

ΔX_t = the first difference of the variables in the X_t matrix

Γ_h = short-run adjustment parameters for the variables ΔX_{t-h} for $h = 1, 2, \dots, j-1$

$\Pi = \alpha\beta'$, where β' is the matrix of cointegrating parameters.

β' is the object of interest in this study. It consists of one or more cointegrating vectors, corresponding to β_1, \dots, β_6 from equation (7).

3.3 The data

Quarterly data was used throughout the study, since New Zealand price data is only available at the quarterly frequency. Plots of each series are shown in figures 1 – 4 of the appendix. Quarterly averages of daily observations were used for exchange rate and interest rate data. Consumer price indices were used as the price measures for both USA and New Zealand.⁵ The interest rates chosen were New Zealand 5-year government bonds and US Treasury constant maturity 5-year bonds. However, the results of using 90-day rates instead are summarised in section 6 for completeness.

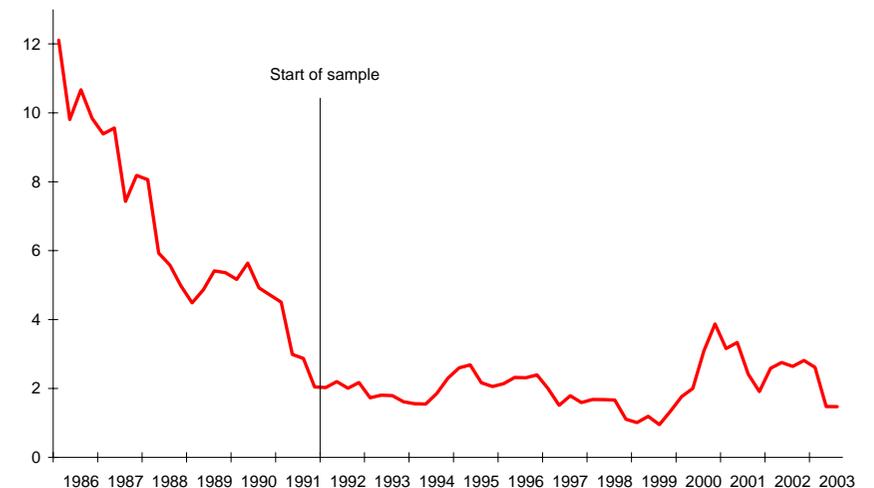
Data was available from 1986Q1 to 2003Q3. However, the 1986 to 1991 period was one of falling inflation, as New Zealand emerged from a period of financial and price instability (see figure 1 below, as well as figures A1 – A4 of the appendix). We therefore exclude this data to concentrate on the period of low and stable inflation in New Zealand, from 1992Q1 to 2003Q3. While longer data sets are usually preferred for studies of cointegration, estimating only over the period of low inflation will be less susceptible to charges of

⁴ All estimations and tests were carried out using CATS in RATS.

⁵ In New Zealand, CPI ex interest rates and GST was used until 1999:2, and CPI was used thereafter.

regime change. Future research could usefully add to the current paper by including more data from the period of low and stable inflation in New Zealand. For completeness, the results of including the earlier data in the study are summarised in tables A1 and A2 of the appendix. The cointegrating vectors are not much affected by the inclusion of the earlier data.

Figure 1:
Inflation in New Zealand has been low and stable only since 1992



A precondition for cointegration is that all series are integrated of the same order. Results of both the Phillips-Perron and Augmented Dickey-Fuller unit root tests, conducted on all series over the 1992 – 2003 sample period, are reported in table A3 of the appendix. Both tests suggested that all series were I(1). One might expect interest rates to be I(0), since in a stable inflation environment there may exist a neutral real rate (NRR), around which interest rates vary symmetrically. However, RBNZ research has found some evidence that the NRR itself may not be stationary (see Basdevant, Björkstén and Karagedikli, 2004).

3.4 Specifying the Model

To decide the number of lags, j , in equations (8) and (9), Sim's (1980) methodology was used, first determining the VAR order in equation (8) and then applying the results to the corresponding VEC model. The VAR model is first estimated with 6 lags. The likelihood ratio test is used to test for the exclusion of the 6th lag. If the exclusion of the 6th lag is not rejected, the VAR order is reduced to 5, and the significance of the 5th lag is tested. The method continues until the reduction of the lag order by 1 at the 5 percent significance level cannot be rejected. Three lags were suggested.

The residuals of each equation in the VAR systems proved to be mostly free of heteroskedasticity and autocorrelation when subjected to standard tests.⁶

Before testing for cointegration, one must decide upon the deterministic elements of the model. Since the choice of deterministic components in the VEC model above affects the asymptotic distributions of the rank test statistics, we tested the joint hypothesis of both the rank order (the number of cointegrating vectors) and the specification of the deterministic components using the Pantula principle (see Pantula, 1989). The test procedure is to move through from the most restrictive model to the least restrictive alternative at each stage, comparing the trace test statistic to its critical value, stopping only when the null hypothesis is not rejected (see Hansen and Juselius, 1995). The Pantula principle suggested a constant in the cointegrating vector (β_6), but no other deterministic elements. Using the trace test, three cointegrating vectors were identified.

Table 1 details the normalised β' , the associated trace-test results, and the appropriate 90 per cent critical values.

⁶ Autocorrelation could not be rejected in the VAR equation for p_t (p-value 0.033). Heteroskedasticity could not be rejected in the equation for s_t (p-value 0.026). Given that the p-values are relatively high, and that all of the other equations in the VAR system were free of non-normalities, we continue as if the errors in the VAR were normal.

Table 1:
Unrestricted cointegrating vector

Exchange Rate	NZ CPI	US CPI	NZ interest rate	US interest rate	Constant	Trace test	Trace Test Critical Value
1.000	71.189	-55.155	-0.588	0.653	-74.572	56.08	49.42
-0.046	1.000	-0.731	0.009	0.006	-1.380	32.45	31.88
-0.079	-2.349	1.000	0.242	-0.311	6.222	16.26	17.79

The cointegrating vectors are only identified up to some arbitrary normalisation, and therefore only relative signs and magnitudes matter. Each vector is normalised on a different variable.

We are trying to form an estimate of the exchange rate equilibrium by *combining* PPP and UIP in a single linear combination of the exchange rate, prices, and interest rates that is stationary. We have identified three such stationary linear combinations. We proceed by choosing the first cointegrating vector, for the following reasons:

- (1) The first cointegrating vector has the highest eigenvalue, and is therefore the “most associated with the stationary part of the model” (Johansen and Juselius, 1992, p 192). In their study of Swedish data, Johansen and Juselius found multiple cointegrating vectors but chose to test the first for PPP, advising that the first cointegrating vector has a special significance.
- (2) The literature has established that the Johansen method tends to overestimate the number of cointegrating vectors.⁷ The first cointegrating vector, with the highest eigenvalue, is the least likely to have been spuriously identified as stationary, and is therefore the safest to adopt (note in the third row of the table

⁷ Maddala and Kim (1998) pp 214 – 220 reviews the literature on this topic, stating that the Johansen procedure is always biased towards finding too many cointegrating vectors, but may be especially vulnerable if the VAR is of low order, if the errors exhibit non-normalities, or if one or more of the variables has a stationary root that is close to unity, such as 0.8.

that the null hypothesis of at most two cointegrating vectors was only narrowly rejected at the 90 per cent level).

- (3) The first cointegrating vector has signs that match the theory of combined PPP and UIP, while the second cointegrating vector does not.

Pesaran et al (2000) establish that combining the PPP and UIP relations into a single cointegrating vector in this way performs better than attempting to attribute each relationship to different cointegrating vectors in the system. They argue treating PPP and UIP jointly allows for gradual convergence to PPP, since deviations from PPP are more persistent than deviations from UIP.

Confirmation of cointegration supports the hypothesis that the exchange rate, prices, and interest rates are related in the long run. The next step is to test whether or not the cointegrating vector matches the theoretical restrictions postulated by strict PPP and/or UIP, as represented in equation (6). If combined PPP and UIP is not rejected, then it will be imposed and the restricted cointegrating vector will be used to estimate the equilibrium exchange rate. In the event that combined PPP and UIP is rejected, we can test progressively less restrictive alternatives. The restrictions that are tested are:

1. *Strict form PPP & UIP:* $\beta_1 = \beta_2 = -\beta_3 = 1$ and $\beta_4 = -\beta_5$
Matches equation (6) exactly.
2. *Strict PPP & weak form UIP:* $\beta_1 = \beta_2 = -\beta_3 = 1$
Tests for relative PPP in its “strict” form, whereby price differentials affect the exchange rate proportionally, while allowing interest rates in the two countries to affect the exchange rate non-symmetrically. This is considered “weak form” UIP, since there is still evidence that interest rates affect the exchange rate in some way. For a small country like New Zealand, one might expect that New Zealand interest rates are more important for the \$NZ/\$US exchange rate, and the absolute value of the coefficient on New Zealand interest rates might be higher.

3. *PPP symmetry & weak form UIP:* $\beta_2 = -\beta_3$
Tests for “semi-strong” PPP (and allows weak form UIP). PPP symmetry implies that relative price movements affect the exchange rate no matter which country they originate in, but they do not necessarily affect the exchange rate proportionally. If even PPP symmetry is rejected, but we have nevertheless found cointegration, then only “weak-form” PPP holds. In other words, domestic and foreign price movements affect the exchange rate, but do so neither symmetrically nor proportionally.

The validity of the restrictions are tested using the likelihood ratio test.⁸ The P-values from the various hypothesis tests are reported in table 2 below.

Table 2:
P-values from hypothesis tests for PPP and UIP

	<i>Strict PPP and UIP</i>	<i>PPP Proportionality</i>	<i>PPP symmetry</i>
<i>P-value</i>	0.01	0.18	0.10

Strict combined PPP and UIP was rejected at the 5 per cent significance level. There is evidence supporting strict PPP combined with weak form UIP. Accordingly, the equilibrium exchange rate will be estimated with PPP imposed, but strict form UIP not imposed. The restricted cointegrating vector is shown in table 3 - our prior that New Zealand interest rates would be the more dominant influence on the exchange rate is confirmed.

Table 3:
Restricted cointegrating vector

Exchange	NZ CPI	US CPI	NZ i	US i	Constant
1.000	1.000	-1.000	-0.284	0.093	1.698

⁸ These tests are explained in detail in Johansen and Juselius (1992).

4 Valuing the New Zealand dollar according to PPP and UIP

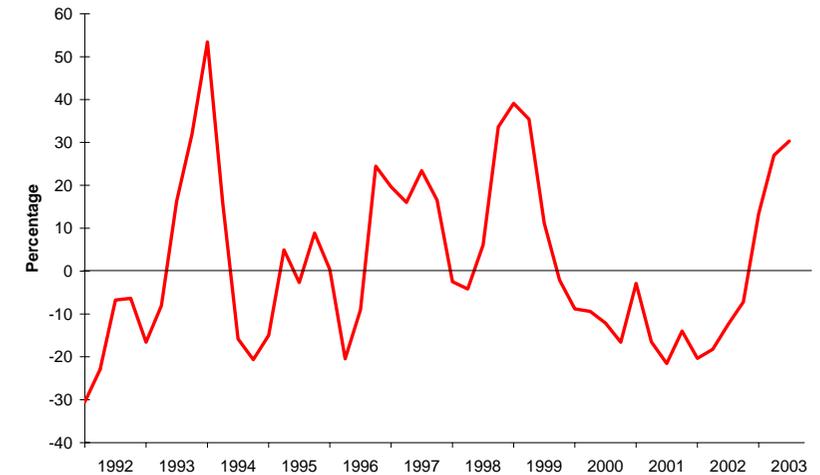
This section derives the estimate of conditional equilibrium for the New Zealand Dollar, defined as the exchange rate that would have restored the exchange rate, prices, and interest rates to their long run relationship according to PPP and UIP. In terms of equation (6) (reproduced below), this is the exchange rate, s_t , that would return q_t to its long run average.

$$s_t + p_t - p_t^* + \frac{1}{\alpha}(i_t^* - i_t) - k = q_t \quad (6)$$

Cointegration implies that q_t is stationary, tending to return to some long-run value, \bar{q} . While \bar{q} was not directly estimated in section 3, stationarity and the absence of a trend implies that the average of q_t over the sample period is an appropriate estimator. Thus, $q_t - \bar{q}$ is a measure of how far the exchange rate, interest rates and prices are from their long-run relationship according to PPP and UIP – defined as exchange rate ‘misalignment’ for the purposes of this paper.

In terms of equation (6), ‘misalignment’ is the change in the exchange rate that would have been required to ensure that $q_t = \bar{q}$ at any point in time, given the values of the other variables in the system. Note that since the coefficient on s_t is unity, $q_t - \bar{q}$ is the amount that the log nominal exchange rate would have to fall in order to return the system to PPP and UIP. Alternatively, converting from logs to natural numbers, $\exp(q_t - \bar{q})$ measures the percentage exchange rate misalignment according to PPP and UIP in New Zealand, as graphed in figure 2.

Figure 2:
Percentage misalignment according to PPP and UIP



In log terms, the actual exchange rate minus the estimated ‘misalignment’ gives the logarithm of the exchange rate that would have ensured equilibrium according to PPP and UIP at any point in time. Exponentiating gives the value of the New Zealand Dollar according to PPP and UIP. Figure 3 below plots the estimated conditional equilibrium over history alongside the actual exchange rate. The variability in the estimated conditional equilibrium is largely attributable to volatility in New Zealand interest rates. Since we think that the exchange rate will respond only slowly to deviations from PPP and UIP, it makes sense to smooth the line. Figure 4 shows the actual exchange rate graphed against a 5-period centred moving average of the conditional equilibrium.

Figure 3:
The equilibrium and actual nominal exchange rate

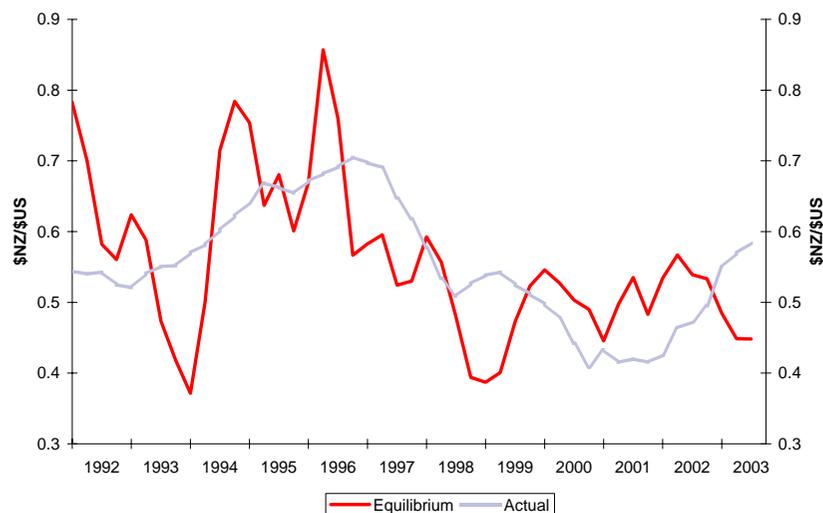


Figure 4:
Smoothed equilibrium and actual exchange rate

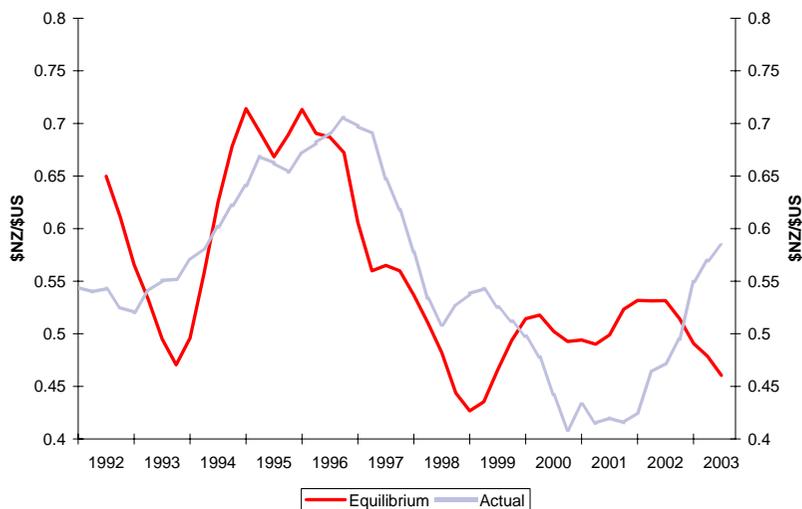


Figure 4 vividly illustrates the main conclusion of this paper – that the exchange rate cycle of the mid-nineties was broadly consistent with the PPP–UIP conditional equilibrium, while the latest post-2000 cycle has not been. More detailed observations of figure 4 include:

- The exchange rate appreciation from 1994 until early 1996 was broadly consistent with PPP and UIP.
- The equilibrium fell sharply in mid 1996, as New Zealand interest rates fell. The exchange rate around one year to respond, but subsequently adjusted sharply to equilibrium
- The exchange rate depreciation below 50 US cents over 2000 appears to have been an autonomous move away from equilibrium. The exchange rate stayed below equilibrium for an unprecedented three years, from 2000 to 2002 inclusive.
- The rise in the exchange rate over 2002, to around 50 US cents, was consistent with a correction to equilibrium. However, since 2003, the exchange rate appears to have overshot, rising above 60 US cents. Over the same period, interest rate differentials have driven the equilibrium down to historically low levels.

It is interesting to note that over the period 1992 – 1999 the estimated conditional equilibrium is broadly consistent with the BEER equilibrium that MacDonald (2002) estimated for the TWI (see figure 8 of MacDonald (2002)). However, the relationship between interest rates, prices, and the exchange rate appears to have broken down after 1999. The exchange rate varies far more widely around its PPP–UIP equilibrium in the post-2000 period than it did in the nineties. Conceptually, the explanation for this break-down could lie in one of three areas:

- 1) Factors other than interest rates and price levels, which are also important for the exchange rate, have become more variable since the 1990s.
- 2) The exchange rate may have begun responding to different variables than previously.
- 3) Interest rates may have been closely aligned to some other variable during the 1990s, and are no longer related to that variable. In this case, the *estimation* carried out in section 3

would have erroneously mistaken the influence of the other variable for the influence of interest rates themselves.

Explanation (1) could be identified statistically by looking at variables that are correlated with the exchange rate. Explanations (2) and (3) would be far harder to identify statistically, since they necessarily imply some change in the underlying relationships between economic variables. While identifying what has driven the exchange rate away from its equilibrium according to PPP and UIP since 2000 would be an interesting area for future research, there is probably far too few data points to conduct such a study at present.

5 Alternative estimation – using 90-day rates instead of 5-year rates

This section shows the effect of estimating the equilibrium using 90-day interest rates instead of 5-year interest rates. The technique is exactly the same as that described in sections 3 and 4. Therefore, we only need to summarise the results tables here.

Table 4: Unrestricted cointegrating vector

90-day interest rates

Exchange	NZCPI	USCPI	NZ i	US i	Constant
1.000	12.214	-10.145	-0.123	0.047	-8.486
0.045	1.000	-0.774	0.004	0.004	-1.146

Table 5: P-values from hypothesis tests for PPP and UIP

90-day interest rates

	<i>Combined PPP and UIP</i>	<i>PPP Proportionality</i>	<i>PPP symmetry</i>
P-values	0.01	0.18	0.11

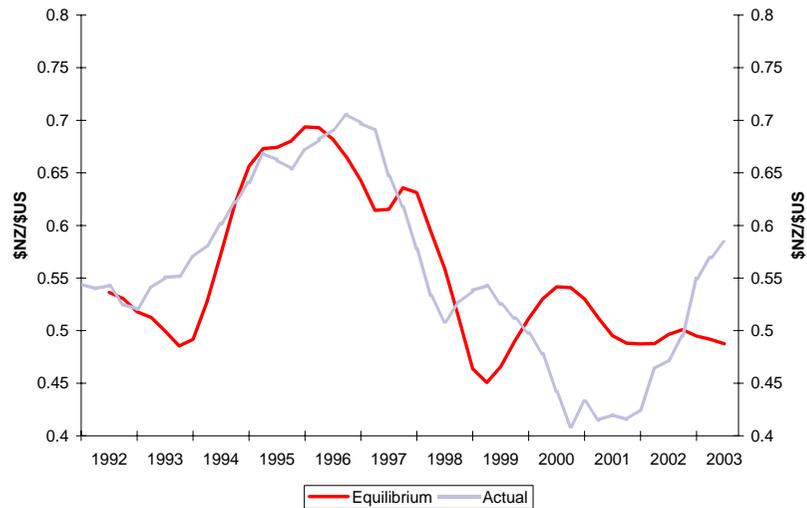
Table 6: Restricted cointegrating vector

90-day interest rates

Exchange	NZCPI	USCPI	NZ I	US i	Cons
1.000	1.000	-1.000	-0.102	0.001	1.211

The results of the hypothesis tests are qualitatively the same using 90-day interest rates as when 5-year interest rates were used. PPP proportionality was accepted, while combined PPP and UIP was rejected. The restricted cointegrating vector therefore matches the earlier one, with PPP imposed but UIP not imposed. The main difference when 90-day rates are used appears to be that the effect of US interest rates falls away to almost zero in the restricted cointegrating vector. The lower coefficient on the New Zealand 90-day interest rate in table 6 probably reflects the higher volatility of 90-day rates compared to 5-year rates, which are more stable. However, using 90-day rates instead of 5-year rates does not change the overall picture of the equilibrium, as shown in figure 5.

Figure 5:
Actual exchange rate and smoothed equilibrium using 90-day rates



Overall, the equilibrium when 90-day rates are used is broadly similar to the equilibrium estimated using 5-year rates. Again, one notes that the latest exchange rate cycle from 2000 to 2003 is less in line with PPP and UIP than previous cycles were. The estimated equilibrium value is currently approaching historical lows while the exchange rate is very high.

6 Conclusion

This paper has provided evidence of a systematic long-run relationship between the exchange rate, interest rates and prices. This relationship does not match the strictest form of PPP and UIP, since New Zealand interest rates appear to affect the exchange rate more than foreign interest rates affect the exchange rate. The estimated relationship used strict PPP and weak UIP, and was used to estimate a conditional equilibrium nominal exchange rate.

Movements in the \$NZ/\$US exchange rate over the 1990s were largely consistent with the estimated conditional equilibrium. Since 2000, the exchange rate appears to have autonomously diverged from the conditional equilibrium far more. This suggests that the current exchange rate cycle is quite different to the cycle of the mid-nineties. Interest rates may not be driving the current exchange rate cycle, while they may have played a more significant role in the mid-nineties.

The finding that the current exchange rate cycle is quite different to the cycle of the mid-nineties may suggest that some other factor is driving the exchange rate away from the conditional equilibrium. Alternatively, it could suggest that the relationship between interest rates and the exchange rate has changed. Establishing which variables are driving the current exchange rate cycle would be a useful area for future research when more data becomes available.

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Appendix

Table A1:
Cointegrating Vectors using full data set,
1986:1 – 2003:3

5 Year government bonds (1986:1 – 2003:3): 3 cointegrating vectors

Exchange	NZCPI	USCPI	NZ i	US i	Cons
1.000	5.153	-5.330	-0.247	-0.000	2.796
-0.034	1.000	-0.702	0.003	0.019	-1.505
0.024	-0.971	1.000	-0.001	0.022	-0.311

Table A2:
P-values from hypothesis tests for PPP and UIP using full sample, 1986:1 – 2003:3

	<i>Proportionality</i>	<i>Symmetry</i>	<i>UIP</i>
<i>P-values</i>	0.86	0.26	0.01

Table A3:
Unit root tests

This table reports the test statistics from unit roots tests conducted on each series in the study. The Augmented Dickey Fuller test and the Phillips Perron tests were conducted on the series to test for the presence of at least one unit root. They were then applied to the first difference of each series to test for the presence of more than one unit root. For all series, the evidence suggested a single unit root.

	Augmented Dickey Fuller		Phillips Perron	
	One unit root	Two unit roots	One unit root	Two unit roots
Exchange Rate	-1.49 (1)	-3.77 (0)***	-1.38	-3.86***
NZ 90	-2.79 (1)*	-5.15 (1)***	-1.97	-4.13***
US 90	-1.97 (2)	-3.69(0)***	-0.92	-3.79***
NZ 5-year	-2.69 (1)*	-5.69 (1)***	-2.11	-4.74***
US 5-year	-1.86 (3)	-5.14 (0)***	-2.11	-5.08***
NZ CPI	0.23 (1)	-5.73 (0)***	0.87	-5.72***
US CPI	-0.64 (3)	-5.28 (0)***	-0.13	-5.22***

Numbers in brackets indicate the number of lags used in the Augmented Dickey Fuller Test. Lag lengths were determined using Akaike's Information Criterion for ADF tests. Four lags were used in all Phillips Perron tests.

* = H(0) of a unit root rejected at the 10% level

** = H(0) rejected at the 5% level

*** = H(0) rejected at the 1% level

Figure A1:
New Zealand exchange rate

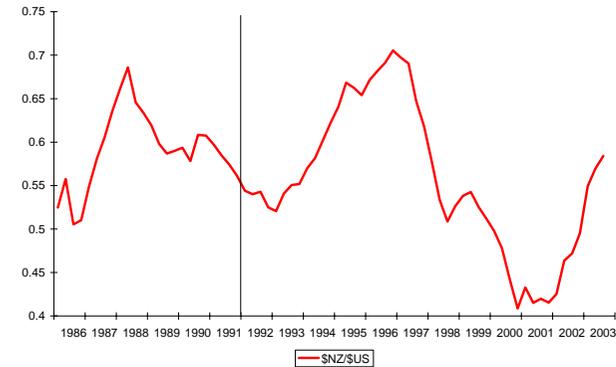


Figure A2:
Logarithm of New Zealand and US CPI

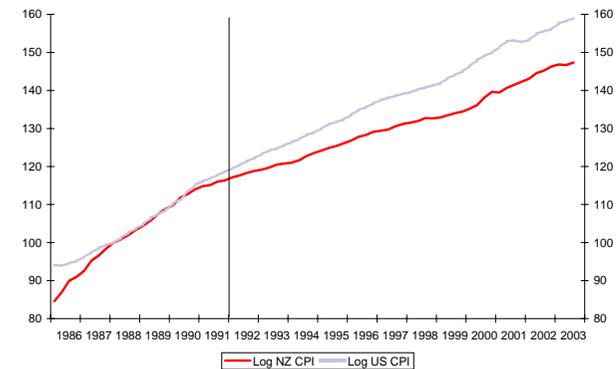


Figure A3:
New Zealand and US 5-year interest rates

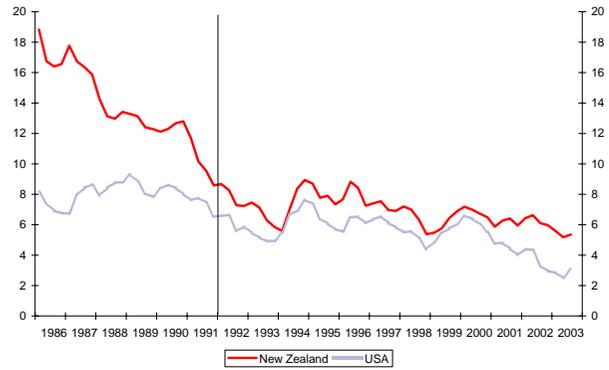


Figure A4:
New Zealand and US 90-day interest rates

