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UIP, Expectations and the Kiwi

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UIP, Expectations and the Kiwi

Abstract[1]

This paper looks at reduced form descriptions of changes in the USD/NZD exchange rate, with emphasis on the interest rate–exchange rate relationship. In the estimated reduced form equations, high domestic short term interest rates relative to foreign interest rates are associated with continued upward pressure on the New Zealand dollar. This effect is most pronounced for the 6-month forward interest differential, and is reinforced by some "inertia" but moderated by deviations from equilibrium as "over- or under-valuation" erodes expected returns. Changes in commodity export prices are estimated to have short term effects. Some aspects of the estimated equations are consistent with forward-looking rational expectations, a standard feature of open economy models. Other aspects of the estimated equations suggest random walk exchange rate expectations consistent with Meese and Rogoff (1983). The cross correlation between interest differentials and the exchange rate may be difficult to reconcile with rational expectations. The forecasting performance of a reduced form equation is also assessed.

[1] The views expressed in this paper are those of the author(s) and do not necessarily reflect the views of the Reserve Bank of New Zealand. The paper has benefited from useful comments from David Archer, Nils Bjorksten, Paul Dickie, Kirdan Lees, Jon Nicolaisen, Christie Smith, Grant Spencer, Shaun Vahey and participants at the New Zealand Econometrics Study Group, Auckland, July 2004. Correspondence: Reserve Bank of New Zealand, 2 The Terrace, P.O. Box 2498, Wellington, New Zealand, email: munroa@rbnz.govt.nz.

1 Introduction

The relationship between the exchange rate and fundamentals – and between the exchange rate and interest rates in particular – is central to understanding the transmission of monetary policy in a small open economy. Although this nexus is an important feature of open economy macroeconomics, theoretical models often do not fit the data particularly well (see Bergin 2004).

Forward-looking rational expectations and uncovered interest parity (UIP) imply that the exchange rate behaves as a forward-looking asset price (the sum of expected future returns). Agents incorporate expected central bank responses to fundamentals in the expected forward interest rate path. Therefore interest rate changes consistent with achieving the policy objective should have little effect on the exchange rate. Higher interest rates today imply lower interest rates later for a given inflation objective and a given degree of inflationary pressure. Unexpected changes in the policy interest rate affect the exchange rate because they reveal either information about fundamentals or changes in central bank behaviour.

UIP based on pure forward-looking rational expectations is a standard representation of exchange rate behaviour in macroeconomic models, but often does not fit the data well. This implies either a time-varying risk premium, or a departure from rational expectations. Froot and Frankel (1989) use market exchange rate forecasts to disentangle the two and find that both are responsible. Departures from rationality have been modelled in terms of: learning;[2] heterogeneous agents some of whom have less than full information or do not trade every period;[3] or limits to speculation.[4]

This paper estimates reduced form equations, based on the cointegration/ error-correction framework of Johansen and Juselius (1992), to examine the roles of UIP, purchasing power parity (PPP) and commodity prices in explaining changes in the United States-New Zealand dollar exchange rate (USD/NZD). While a reduced form equation may not reveal the data generating process, it is a useful way of estimating the implicit risk

[2] See Lewis (1989), Orphanides and Williams (2003) and Ireland (2003).

[3] For example, Bacchetta and van Wincoop (2005).

[4] For example, Lyons (2001).

premium and looking at the stylized facts as a basis for taking models to the data.

The New Zealand dollar is appealing for empirical analysis for two reasons. First, capital flows in and out of the New Zealand are large relative to the size of the economy.[5] This suggests that the asset price perspective should be pertinent in explaining the New Zealand dollar. Second, the New Zealand dollar has floated without intervention for over twenty years.[6]

The estimated equations suggest both systematic changes in the risk premium and departure from pure rationality. Proxies for the risk premium considered here are a constant, the long term interest differential (which captures a downward trend), and exchange rate overvaluation.

Since we cannot measure the sum of future expected interest differentials, isolating a rational expectations UIP relationship is very difficult. However, the contemporaneous exchange rate response to changes in commodity export prices is consistent with rational expectations (expected future returns are immediately priced-in) and the classification of the New Zealand dollar as a "commodity currency".[7]

Other aspects of the data suggest a departure from rationality. High short term interest rates relative to foreign interest rates are estimated to exert continued upward pressure on the New Zealand dollar. This is suggestive of random walk expectations, consistent with the enduring findings of Meese and Rogoff (1983). If the expected change in the exchange rate is zero, then the return to uncovered arbitrage is the interest differential. This gives an incentive to trade on yields, putting continued upward pressure on the higher yielding currency until interest rates or risk premia (e.g., exchange rate "overvaluation") adjust to bring expected returns back to zero. This feature of the data can also be seen in the cross correlation between the exchange rate and the short-term interest differential. The exchange rate lags the interest rate cycle while forward looking rational expectations would imply that the exchange rate leads the interest rate cycle, or is at least contemporaneous if all current information is priced in. While the estimated equations explain only about a quarter of month-to-month variation in the exchange rate, they generate exchange rate cycles similar to those observed. The reduced form equation out-performs a random walk exchange rate forecast at all horizons since the introduction of the official cash rate (OCR) in 1999, but not significantly so.

[5] The New Zealand dollar is the 13th most traded currency (BIS 2004), well above New Zealand's ranking in terms of GDP.

[6] The RBNZ has not intervened in the foreign exchange market to influence the level of the exchange rate since the NZ dollar was floated in 1985. A broader intervention capability was approved in March 2004.

[7] See Chen and Rogoff (2002).

The rest of the paper is set out as follows. Section 2 shows how the UIP condition varies relative to different forms of exchange rate expectations. Section 3 considers the implications of capital market integration and changes in the monetary regime for UIP. Section 4 sets out the cointegration and error correction approach. Section 5 presents the empirical results. The cointegration analysis is set out in section 5.1, the error correction representation in section 5.2, and its forecast performance is examined in section 5.3. Section 6 concludes.

2 UIP and exchange rate expectations

Efficient capital markets arbitrage away excess returns until the expected return to securities with similar risk characteristics is equal. Assuming that capital markets are efficient, the difference between the interest returns on equivalent debt securities denominated in different currencies should be offset by the expected change in the exchange rate so that there are no excess returns to be exploited through arbitrage. Uncovered interest parity is the parity condition consistent with efficient markets:

$$E_t[e_{t+1}] - e_t + (i_t - i_t^*) - rp_t = 0 \qquad (1)$$

where i and i^* are nominal interest rates on domestic and foreign debt securities, rp_t is a time varying risk premium, e_t is the log of the nominal exchange rate, and $E_t[e_{t+1}]$ is the log of the expected exchange rate at time t+1. Here the exchange rate is the foreign price of domestic currency (an increase is an appreciation of the domestic currency).[8]

[8] If $E[e_{t+1}]$ is replaced with the forward exchange rate, the equation describes covered interest parity (CIP) which abstracts from uncertainty associated with exchange rate

The treatment of expectations is crucial to understanding UIP. If traders have *perfect foresight* $E[e_{t+1}] = e_{t+1}$ so that:

$$\Delta e_{t+1} \quad + \quad (i_t - i_t{*}) \quad + rp_t = 0 \tag{2}$$

With a constant risk premium, this form of UIP suggests that the currency with higher interest rates will depreciate, which is contrary to what we tend to see in practice. Empirically this is usually tested as in Fama (1984):

$$\Delta e_{t+1} \quad = \quad \alpha - \beta(i_t - i_t{*}) \quad + \varepsilon_t \tag{3}$$

in which case the null hypothesis is that α=0 and β = 1.[9] This is systematically rejected in the data for interest rates at short maturities (see Sarno 2005 for a recent review). The empirical failure of this form of UIP suggests either a time varying risk premium that is negatively correlated with the interest differential or a departure from rationality. In practice, β tends to be negative and less than –0.5 which implies that the variance of the risk premium must be greater than the variance in the expected change in the exchange rate (Fama 1984).

There is a subtle difference between perfect foresight and *forward-looking rational expectations*: the latter assumes that the expected exchange rate is, *on average*, equal to the actual future exchange rate (the forecast error is uncorrelated with information at time t). Substituting for the expectations term in equation (1) and iterating forward, the exchange rate can be written as an asset price:

$$e_t \quad = \quad \sum_{k=0}^{\infty} E[(i - i{*} - rp)_{t+k}] \quad + E[e_{eq}] \tag{4}$$

The exchange rate today is its expected future equilibrium value $E_t[e_{eq}]$, plus the expected sum of future interest differentials. The intuition behind this is similar to that in the Dornbusch (1976) overshooting model: the exchange rate initially overshoots its equilibrium value and subsequently depreciates so that domestic and foreign returns are equal over the life of the securities in line with efficient markets. This helps to reconcile efficient markets with what we observe: the New Zealand dollar tends to be strong when domestic interest rates are high relative to foreign interest rates.

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fluctuations. CIP is an arbitrage condition and holds well empirically: a forward exchange rate contract is generally priced so that the forward discount ($f_{t,t+1}$ - e_t) offsets the interest rate differential so the return to holding domestic and foreign securities is equal.

[9] Note that here the exchange rate is the inverse of that in Fama 1984. This equation is often estimated with the forward discount (and a sign change) in place of the interest differential.

Both the size of the interest rate differential and its expected duration determine the exchange rate response. This is consistent with findings of MacDonald and Nagayasu (2000) who estimate larger coefficients for longer maturity interest rate differentials, which because of the term of the security, persist for longer. For shorter term maturities, the horizon of investors and the expected persistence of the differential are potentially important. However, equation (4) is difficult to examine empirically because the time-varying risk premium makes it difficult to decompose the yield curve into implied forward rates.[10]

A commonly considered departure from rationality relates to the enduring findings of Meese and Rogoff (1983): today's exchange rate is the best forecast of tomorrow's exchange rate for horizons less than a year. Random walk expectations (which could be consistent with learning or a heterogeneous agents framework) imply that $E_t[\Delta e_{t+1}]=0$. Random walk expectations thus have important implications for UIP. If the expected change in the exchange rate is zero, the expected return to uncovered interest arbitrage is the risk adjusted interest differential. In this case, there is an incentive to trade on yields until either interest rates or the risk premium adjusts to bring expected returns back to zero. For example, capital should flow to the higher-yielding currency, putting upward pressure on the exchange rate,[11] until exchange rate overvaluation increases the risk premium. Thus, uncertainties may lead to behaviour very different from that under rational expectations. This formulation also gives short term interest differentials a greater role in exchange rate

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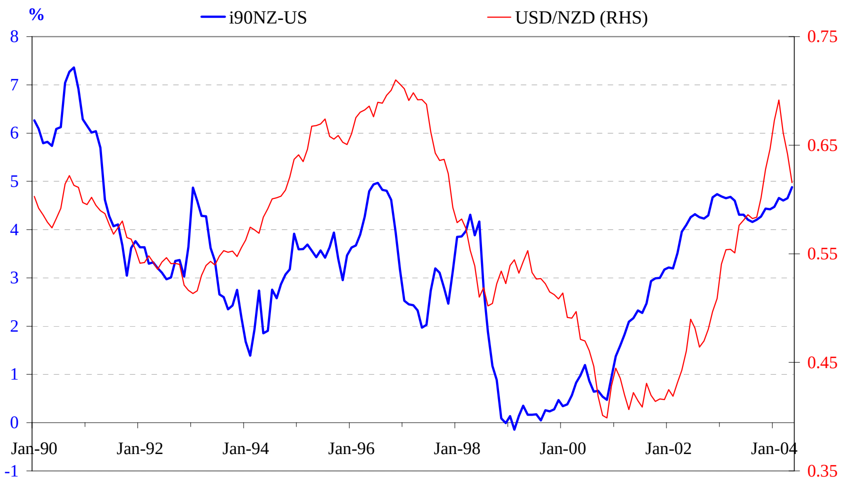
[10] An attempt was made to decompose the yield curves into implied forward interest rates for up to 5 years. The estimated exchange rate response to the 5 year sum was weaker than to the 90 day interest differential.

[11] The exchange rate may be bid up in the absence of actual capital flows.

determination. In the extreme case, high domestic interest rates may be translated into exchange rate appreciation, shifting the weight of monetary restraint to the exchange rate channel.

In contrast to rational expectations which imply that the exchange rate leads the interest differential (equation 4), random walk expectations imply that the exchange rate lags the interest differential: the *change* in the exchange rate is proportional to the interest differential, so the *level* of the exchange rate is proportional to a sum of past interest differentials. This is what we see in the data for the USD/NZD (figures 1 and 2).[12]

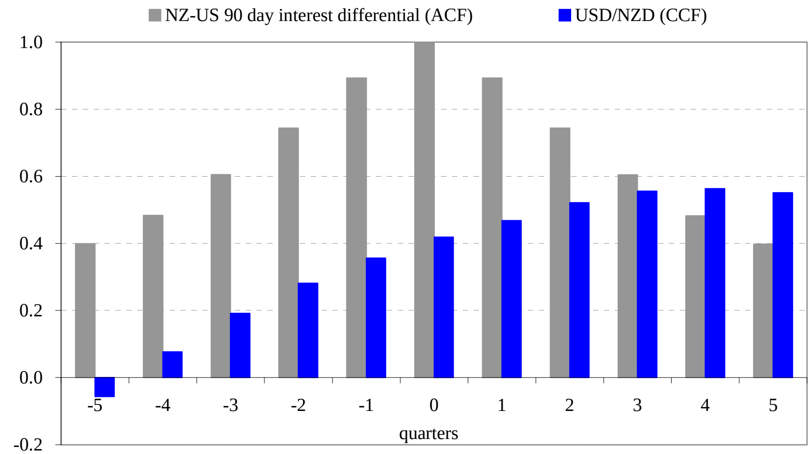
Figure 1
NZ-US 90 day interest differential and exchange rate



Source: RBNZ data.

[12] This cross-correlation is also true for more recent periods for the NZD/USD and for the AUD/USD and the CAD/USD exchange rates. In contrast, the NZD/AUD and GBP/USD exchange rate–interest differential cross correlations look more consistent with forward-looking rational expectations. In both the rational expectations and the random walk case, the level of the exchange rate is proportional to a sum of interest differentials, suggesting non-stationarity.

Figure 2
Correlation of interest differential and exchange rate



Correlation relative to path of interest differential. Sample: Jan 1990 - June 2005.
ACF: autocorrelation function; CCF: cross correlation function. Source: RBNZ data.

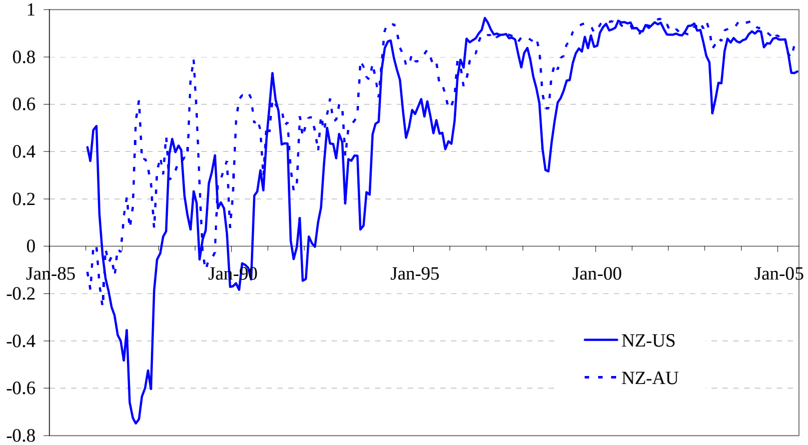
Recent empirical studies of New Zealand exchange rates include Conway and Franulovich (1999) who look at the AUD/NZD exchange rate, Chen and Rogoff (2000) who look at the role of commodity prices and the terms of trade, MacDonald (2002) who constructs a behavioral effective exchange rate (BEER), Wren-Lewis (2004) who constructs fundamental equilibrium exchange rate (FEER) measures, Huang (2004) who considers a wide range of fundamental variables and Stephens (2004) who looks at the role of the 5-year interest differential.

3 UIP, capital market integration and monetary policy

Over the twenty years of the New Zealand dollar float there have been important developments in financial markets and monetary policy that may have influenced the exchange rate response to interest rates.

With capital market integration, differences in expected returns are arbitraged in increasingly deep and efficient markets. As foreign exchange markets have come to be dominated by capital market (as opposed to goods market) transactions,[13] the exchange rate has come to be seen as an asset price,[14] meaning that it reflects the market's current expectation of a discounted stream of returns to holding assets denominated in New Zealand dollars relative to those denominated in other currencies. As illustrated by the growing co-movement between 10-year interest rates in New Zealand and its major trading partners (figure 3), capital market integration has increased steadily over the past two decades, with markets now highly integrated.

Figure 3
Capital market integration and long term interest rates



Correlation coefficient of monthly changes in 10 year bond yields over previous year.
Source: RBNZ data

The maturity of the interest differential is important for two reasons. First a long term interest differential implies more persistence than a short term

[13] In 2004, international trade in goods and services accounted for about 1 per cent of foreign exchange market turnover. Annual current account debits plus credits amounted to about US$ 71 billion, while NZD/USD turnover in the New Zealand and Australian foreign exchange markets amounted to US$ 24.8 billion per day. See BIS 2004.

[14] The view that the exchange rate is best regarded as an asset price goes back at least to the early 1980s. See Frankel and Mussa (1980), Mussa (1982).

interest differential. Second, the balance between interest rate adjustment and exchange rate adjustment toward UIP may be very different for short and long maturity interest differentials.

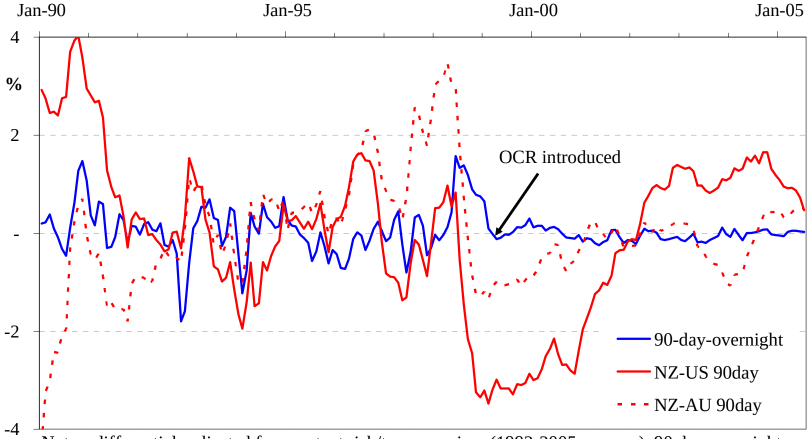
At longer maturities, interest rates are determined in international capital markets with interest differentials arbitraged away quickly through interest rate adjustment (figure 3),[15] with little pressure on the exchange rate. Thus at longer maturities, UIP may be mainly achieved through interest rate adjustment. Indeed long term interest differentials are dominated by short term interest differentials in explaining changes in the value of the New Zealand dollar (Munro 2004).

In contrast, short term interest rates are strongly influenced by monetary policy and adjust very little in response to arbitrage. Monetary policy, both in New Zealand and internationally, has shifted toward controlling a short term interest rate. In New Zealand the shift occurred in March 1999 with the introduction of the official cash rate (OCR). In New Zealand the overnight interest rate is defended within a ±25 basis point band.[16] More effective monetary policy control of interest rates (figure 4) implies (i) persistent short term interest differentials when economic cycles are out of phase, and (ii) less adjustment of interest rates to arbitrage implies correspondingly greater exchange rate adjustment to deviations from UIP. This is the relationship examined in this paper.

[15] See Munro (2004) for an empirical analysis of the evolving behaviour of New Zealand long term interest rates in a cointegration-error correction framework.

[16] The ±25 basis point band is narrow compared to 100 to 150 basis point bands for the Federal Reserve (one sided), the Bank of England, and the European Central Bank, but the are the same as the band applied by the Reserve Bank of Australia.

Figure 4
Monetary policy and short term interest rates



Notes: differentials adjusted for constant risk/term premium (1992-2005 average). 90 day-overnight interest differential calculated as difference between 90 day rate and average overnight rate for the 90day period. Source: RBNZ data

4 Empirical methodology

The framework used here is based on Johansen and Juselius (1992), and Juselius (1995). In the basic model the set of variables is x=(e, i, i*, p, p*), and:

$$\Delta x_t \quad = \quad a_0 \quad + \quad \sum_{i=1}^{n}\Gamma_i \Delta x_{t-i} \quad + \Pi x_{t-1} \quad + u_{1,t} \qquad (5)$$

where e is the USD/NZD exchange rate (an increase in e is an appreciation of the NZ dollar), i and i* are domestic and foreign 90 day interest rates[17]

[17] Originally, 10 year and overnight interest rates were also included. The 10 year interest differential was not found to be significant in the exchange rate equation, which is the focus here. Overnight rates, which were not significant in the first half of the period, behave much like 90 day rates since the introduction of the OCR in 1999.

respectively, p and p* are domestic and foreign consumer prices,[18] a_0 is a vector of constants, Γ_i is a matrix of short run response coefficients and Π is the long run multiplier matrix, or cointegration space.

The data set used here also includes the NZ export commodity price index (ANZ index denominated in US dollars), consistent with the important role of commodity prices for the New Zealand dollar (Chen and Rogoff 2000), and some dummy variables. Following the approach of Pesaran, Shin and Smith (2000), the possibility of treating commodity prices as weakly exogenous with respect to the long run multiplier parameters (cointegration vectors) in the exchange rate equation is considered. If a variable is found to be weakly exogenous (ie, can be excluded from the cointegration vectors), then the system (equation 5) can be expressed as:

$$\Delta x_t \quad = \quad c_0 \quad + \quad \Lambda \Delta y_t \quad + \sum_{i=1}^{p-1}\Psi_i \Delta x_{t-1} \quad + \Pi^* z_{t-1} \quad + u_{2,t} \qquad (6)$$

where y_t is a vector of weakly exogenous variables, and $x_t = (y_t , z_t)$. The weakly exogenous variables y_t do not enter the cointegration relationships, but may enter the error correction equation as contemporaneous terms. The error correction equation estimated in this paper is the exchange rate equation from this system. Assuming rational expectations, the right hand side of the exchange rate equation in (6) minus (*i*-*i**) corresponds to the time-varying risk premium plus forecast error in equation (1).

Johansen and Juselius (1992) examine the interest differential and PPP as potential cointegration vectors, but both are nonstationary and are rejected. Juselius (1995) considers a combination of PPP and UIP as a cointegration vector which is accepted. A similar approach is taken here. The error correction parameters for the UIP and PPP components of the cointegration vector are estimated separately to examine parameter constancy. This gives identical parameter estimates to joint estimation, but means that standard errors of the parameter estimates may be unreliable,

[18] In theory, producer prices should be a better measure of the real exchange rate as they have a higher traded component. This was not found to be the case here.

particularly for the PPP term, which is clearly non-stationary for this sample.[19]

All data are monthly. New Zealand prices, which are available quarterly, are interpolated so that inflation is constant for 3 months of the quarter. Estimating the equation using monthly data does not help with cointegration, but improves parameter estimates in an otherwise small sample. In the error correction equations, prices enter as part of the real exchange rate (where fluctuations in the nominal exchange rate dominate) and directly as a 3 month lag of inflation (which is not significant). Interest rates are end-month 90 day interest rates, expressed in monthly rates of return. Exchange rate and price variables are in logs. Ideally, exchange rate data would also be end-month, but because large short term fluctuations are often reversed leading to noisy end-month data, monthly average data were used. All equations are estimated using maximum likelihood.

5 Empirical results

5.1 Cointegration analysis

The data are shown in Appendix A and unit root tests are presented in Appendix B. Unit root tests suggest that all variables are I(1), although some interest rate differentials test as stationary under the Phillips and Perron test, but not under the Elliot, Rothenberg and Stock test.

Estimating the unrestricted system with 2 lags, there is evidence of residual ARCH, and some heteroskedasticity and non-normality. These may result from large outliers in the 2000-2001 period (figure 6), changes in the monetary policy regime in the late 1990s, increased volatility with capital market integration, or the interaction between risk and return (ARCH). Including dummy variables for the four largest outliers (Sept 2000, Dec 2000, Aug 2001 and July 2002) eliminates this misspecification

[19] The empirical non-stationarity of PPP is often challenged by studies that employ long or panel data sets to capture slow mean reversion, and nonlinear adjustment models. While real interest differentials are stationary, nominal interest differentials will only be stationary if the inflation differential is stationary, which we expect in a modern monetary framework. With a policy commitment to low inflation in both countries, standard deviations of parameters on the nominal interest differential should not result in severe problems.

(table 1).[20] As none of the outliers corresponds to events expected to alter long run relationships, they are treated as short term effects and are not included in the cointegration space. In the error correction equations, dummy variables are found to have little effect on the estimated parameters.

Table 1
Unrestricted system misspecification tests

	AR 1/ *p-value*	Normality 2/ *p-value*	ARCH 3/ *p-value*	Heteroskedasticity 4/ *p-value*
Unrestricted System	0.74	0.02 *	0.001 **	0.04 *
Include 4 dummy variables	0.56	0.53	0.39	0.29

1/ Autocorrelated residuals, LM test. 2/ Doornik and Hansen (1984). 3/ Engle (1982).
4/ White (1980). * = 5% level of significance; ** = 1% level of significance.

Cointegration analysis for the system z = (e, i, i*, p, p*, $p^{ANZ,}$ c) is shown in table 2. Two eigenvectors are significant at the 1 per cent level, a third is significant at the 5 per cent level, and a fourth is close to being significant at the 5 per cent level for the trace test. Therefore the rank is at least 2, but may be as large as 4. Restricting the rank to 3, the eigenvectors and exchange rate equation responses to these vectors are shown in the bottom panel of table 2. The exchange rate appears to respond to the second vector and particularly to the third vector. To uniquely determine cointegration vectors requires subject matter input. One possibility is to accept the estimated vectors (or a linear combination of these), but these are unlikely to coincide with the structural relations (Doornik and Hendry 1995).

[20] See Eckhold (1998) for a discussion of the Eurokiwi market and Drage, Munro and Sleeman (2005) for an update. While Eurokiwi issuance reflects interest differentials and swap spreads, maturities are less closely related to interest differentials (the process already modeled here). While these maturities are known by the main players in the markets in advance, and should therefore already be priced into the exchange rate, particularly large maturities may still have short term liquidity effects. Similarly, a spike in the trade deficit in December 2000 coincides with the purchase of a frigate which had a significant effect on the trade balance. Although the purchase was anticipated, it may have had short term liquidity effects in the foreign exchange markets.

Table 2
Cointegration analysis (full system)

	Maximum Eigenvalue Test			Trace Test		
rank	test statistic	adjusted	95% value	test statistic	adjusted	95% value
p==0	88.30 **	83.35 **	40.3	199.80 **	188.60 **	102.1
p<=1	49.60 **	46.82 **	34.4	111.50 **	105.30 **	76.1
p<=2	29.73 *	28.07	28.1	61.94 **	58.46 *	53.1
p<=3	14.27	13.47	22.00	32.20	30.40	34.90

Cointegration Restrictions:

		e	i	i*	p	p*	pANZ	exchange rate response	p-value
rank=3	b1	1.00	-122.0	-51.0	1.99	-1.65	0.012	0.00	
	b2	0.08	1.00	-2.94	-1.11	0.93	-0.003	-0.06	1.00
	b3	0.00	-0.75	1.00	-0.02	0.01	0.001	-4.01	
	LR =ab'	-0.004	2.90	-3.90	0.15	-0.10	-0.003		
rank=3	b1	-	-	-	-	-	-	0	
	b2	-	-	-	-	-	0	-	1.00
	b3	-	-	-	-	-	0	-	

Notes: Estimated for period 1986/3-2003/12.
- indicates no restriction; * indicates rejection at 5% level; ** indicates rejection at 1% level

While commodity prices are expected to play an important long term role in New Zealand's exchange rate through their effect on PPP (MacDonald, 1997), the estimated long run response to the commodity price index is small. The combined restrictions that the commodity price index does not enter the second two vectors (the last element of b2 and b3 is zero) and that the exchange rate responds only to these two vectors is easily accepted. This allows the system to be partitioned and still leaves open the possibility that commodity prices have a contemporaneous short term impact effect on the exchange rate.

Cointegration analysis for the partitioned system is shown in table 3. Again, the rank appears to be at least 2, but may be as great as 4. If the rank is underestimated, then empirically relevant error correction mechanisms will be omitted. If the rank is overestimated, the distributions of some statistics may be non-standard, leading to incorrect inferences;

and forecasts will be less accurate due to incorrectly retaining I(1) components (Hendry and Juselius 2004). As a rank of 4 retains the PPP term, which is I(1), it is certainly too high. With a rank of 3, the individual restrictions of PPP (1,0,0,1,-1) and the nominal interest differential (0,1,-1,0,0) are rejected. However, the joint restriction (1,-a,a,1,-1) is accepted. With a rank of 4, PPP and the interest rate differential are accepted individually (so admitting I(1) components). The estimated long run relationships of interest (relevant for the exchange rate equation) look very similar either way and are therefore unlikely to affect the error correction equations.

Table 3
Cointegration analysis (partitioned system)

	Maximum Eigenvalue Test			Trace Test		
	test statistic	adjusted	95% value	test statistic	adjusted	95% value
p==0	78.79 **	75.27 **	34.4	159.60 **	152.50 **	76.1
p<=1	37.96 **	36.27 **	28.1	80.82 **	77.21 **	53.1
p<=2	18.39	17.57	22.0	42.86 **	40.94 **	34.9
p<=3	14.70	14.04	15.7	24.47 *	23.37 *	20.0

Cointegration Restrictions:

		e	i	i*	p	p*	exchange rate response	p-value
rank=3	b1=	1	0	0	1	-1	**	0.00
rank=3	b2=	0	1	-1	0	0	**	0.00
rank=3	b1=	1	-138	138	1	-1	-0.017	
	b2	-	-	-	-	-	0	1.00
	b3	-	-	-	-	-	0	
	LR=ab'	-0.017	2.47	-2.47	-0.017	0.017		
rank=4	b1	1	0	0	1	-1	-0.015	
	b2	0	1	-1	0	0	2.44	1.00
	b3	-	-	-	-	-	0	
	b4	-	-	-	-	-	0	
	LR=ab'	-0.015	2.44	-2.44	-0.015	0.015		

Notes: Estimated for period 1986/3-2003/12.
- indicates no restriction; * indicates rejection at 5% level; ** indicates rejection at 1% level

5.2 Error correction equations

The estimated error correction equations are shown in table 4. All equations originally included an interest differential term, a PPP term, and lagged changes of all the system variables; insignificant terms were excluded and tests of reductions are shown in the final column. Panels A through E of table 4 are discussed in turn in the rest of this section.

The baseline estimate (panel A) is for the period Jan 1990-Feb 2004 and includes the four outlier dummy variables plus one lag of the dummies, where significant, to allow for subsequent reversals. Excluding the dummy variables (panel B) does not markedly alter the parameter estimates.

The autoregressive term is substantial at 0.31. While it is reasonable to expect some partial adjustment or "inertia" in the exchange rate (perhaps reflecting momentum trading), this term could be indicative of missing autocorrelated explanatory variables or risk premia.

The coefficient on the interest rate differential term is large and positive, consistent with the general rejection of perfect foresight UIP in equation (3). With a constant risk premium this would also suggest rejection of rational expectations UIP.

In the framework of random walk expectations, which gives an incentive to trade on yields, the interest differential on the right hand side implies that the interest differential continues to put upward pressure on the exchange rate until the yield differential is offset by a rise in the risk premium (eg, because of overvaluation). On its own, this term implies that in response to a 100 basis point differential (adjusted for a constant risk premium), the exchange rate would continue to appreciate by 0.36 per cent per month, or 4.35 per cent per year. However, this term is eventually offset by the mean reversion term as the deviation from PPP increases. The relative strength of the interest differential and PPP terms implies that a 100 basis point interest differential (adjusted for a constant risk premium) would lead to a 16 per cent deviation of the USD/NZD from PPP in the baseline scenario.[21]

[21] Differences in the USD/NZD and AUD/NZD are interesting in this regard. For the AUD/NZD, a 100 basis point differential implies only a 4 per cent deviation from historical PPP equilibrium in the AUD/NZD due to a combination of a slightly weaker interest rate

Table 4
Error correction equations

$$\Delta e_t \;=\; c_0 + c_1\Delta e_{t-1} \;+ c_2(i - i^* - rp)_{t-1} \;+ c_3(e + p - p^*)_{t-1} \;+ c_4\Delta p_t^{com} \;+ u_t$$

	Partial Adjustment c_1	Interest Differential c_2	PPP c_3	Commodity Prices c_4	R^2	SSE	**Test of Reduction Ftest 1/**
A. Baseline							
1990/1-2004/2	**0.31**	**4.35**	**-0.022**	**0.36**	0.39	0.018	0.33
	4.65 **	*3.56* **	*-2.22* **	*4.48* **			
B. Exclude dummy variables							
	0.26	**4.01**	**-0.021**	**0.39**	0.22	0.02	0.00
	3.75 **	*2.99* **	*-1.94*	*4.35* **			
c. Different Estimation Periods							
1986/5-2004/2	**0.28**	**0.96**	**-0.012**	**0.32**	0.28	0.021	0.80
	4.45 **	*1.79*	*-1.26*	*4.29*			
1990/1-2004/2	**0.31**	**4.35**	**-0.022**	**0.36**	0.39	0.018	0.33
	4.65 **	*3.56* **	*-2.22* **	*4.48* **			
1996/12-2004/2	**0.26**	**5.95**	**-0.025**	**0.57**	0.49	0.022	0.32
	2.89 **	*3.06* **	*-1.72*	*3.63* **			
D. Risk-Adjusted Interest Differential							
1988/4-2004/2	**0.27**	**5.27**	**-0.012**	**0.38**	0.39	0.019	0.34
	4.27 **	*4.14*	*-1.26*	*5.18* **			
1990/1-2004/2	**0.29**	**5.55**	**-0.018**	**0.33**	0.40	0.018	0.25
	4.41 **	*3.87* **	*-1.88*	*4.18* **			
1996/12-2004/2	**0.27**	**5.95**	**-0.022**	**0.58**	0.48	0.022	0.34
	3.02 **	*3.06* **	*-1.53*	*3.77* **			
E. Measures of Equilibrium, 1990/7-2004/2 2/							
PPP	**0.30**	**5.67**	**-0.019**	**0.34**	0.40	0.018	0.80
	4.38 **	*3.87* **	*-1.97*	*4.00* **			
Macrobalance	**0.29**	**6.09**	**-0.027**	**0.35**	0.40	0.018	0.67
	4.38 **	*4.09* **	*-2.40* *	*4.11* **			
F. Forward Interest rate Differentials (1996/12-2004/2)							
current differential	**0.26**	**5.95**	**-0.025**	**0.57**	0.49	0.022	0.34
	2.91 **	*3.06* **	*-1.70* **	*3.06* **			
3x6 FRA	**0.22**	**6.66**	**-0.021**	**0.55**	0.51	0.021	0.49
	2.41 *	*3.61* **	*-1.51*	*3.65* **			
6x9 FRA	**0.21**	**7.81**	**-0.022**	**0.53**	0.52	0.021	0.47
	2.27 *	*3.87* **	*-1.52*	*3.46* **			
9x12 FRA	**0.23**	**7.45**	**-0.210**	**0.50**	0.51	0.021	0.47
	2.48 *	*3.57* **	*-1.47*	*3.33* **			

Notes: Equations include 4 dummy variables (2000/9, 2000/12, 2001/8 and 2002/7) and a lag, where significant except as indicated. * = significance at 5%; ** = significance at 1%; t-values in italics. '1/ Original equations included lags of all variables. 2/ Risk adjusted interest rate differential. Macrobalance measure from 1990m6.

response and substantially stronger PPP reversion. In addition interest differentials tend to be smaller. The faster equilibrium reversion may reflect the high degree of economic integration between Australia and New Zealand, and similarities in the two economies.

The PPP term measures the strength of mean reversion. This could be interpreted as goods market adjustment, or as capital market adjustment (as a currency strengthens, expected future depreciation – underpinned by real imbalances such as a current account deficit – depresses expected returns or increases the risk premium). The estimated parameter shows adjustment of 2.2 per cent per month which implies a half life of 32 months. This is slightly faster than the 3-5 years estimated by Rogoff (1996) for major US dollar exchange rates, and within the 2 to 3 years for the USD/NZD estimated by Luo and Plantier (2003).[22]

The final term shows the exchange rate response to a change in commodity prices. Recall that commodity prices were excluded from the long run multiplier matrix. The estimated response here is a short term contemporaneous impact effect. In earlier periods this term was weaker and tended to enter with a lag. This term is suggestive of rational expectations: an increase in commodity export prices increases expected returns and the effect is priced in immediately. The estimated parameter implies that the NZD/USD appreciates by 3.8 per cent in response to a 10 per cent rise in commodity prices.[23] This response potentially plays a useful buffering role: a coefficient of 1 would mean that commodity prices were stable in New Zealand dollar terms.[24] Estimation for later periods suggests that this coefficient has increased to more than 0.5.

The equation R^2 of 0.39 overestimates the explanatory power of the process being modeled as the dummy variables account for a fair part of the explanatory power (panel B of table 4). Excluding the dummy variables, the equation R^2 is 0.22. Equations in stationary data have lower explanatory power than those in levels because there is no common trend component. In stationary data, an R^2 of 0.5 to 0.6 is good. So 0.22 is not great, but it is not bad considering the dependent variable is the change in the exchange rate.

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[22] Many studies that examine PPP reversion do not include interest differentials. With this dataset, failure to account for the interest rate differential leads to estimated PPP reversion that is very slow (with a half life of about 6 years) and not significant. See Luo and Plantier (2003) for a study of mean reversion of NZD exchange rates.

[23] Chen and Rogoff (2002) estimate a USD/NZD appreciation of 0.5 to 2.3 per cent in the long run.

[24] In practice, this response may reflect expected future demand pressures, as export sector profitability flows into domestic demand, inflation and interest returns.

Misspecification tests are shown in table 5. There is still some ARCH and heteroskedasticity (while the dummies got rid of the misspecification in the unrestricted equation, it has resurfaced somewhat with the equation reduction).

Table 5
Misspecification tests: error correction equations

	AR 1/ *p-value*	Normality 2/ *p-value*	ARCH 3/ *p-value*	Heteroskedasticity 4/ *p-value*
A. Baseline	0.28	0.42	0.030 *	0.09 *
B. Exclude dummies	0.30	0.20	0.000 **	0.00 **
C. Different Periods				
1986/5-2004/1	0.01 **	0.04 *	0.009 **	0.01 **
1990/1-2004/1	0.28	0.42	0.030 *	0.09 *
1996/12-2004/1	0.89	0.75	0.170	0.15
D. Risk Adjusted Interest Differentials				
1986/5-2004/2	0.56	0.16	0.030 *	0.45
1990/1-2004/2	0.49	0.20	0.030 *	0.11
1996/12-2004/2	0.87	0.72	0.170	0.23
E. Measures of Equilibrium				
PPP	0.49	0.27	0.023 *	0.14
Macrobalance	0.55	0.33	0.018 *	0.61
F. Forward Interest Differentials (1996/12-2004/2)				
current	0.87	0.72	0.170	0.23
3x6 FRA	0.85	0.85	0.130	0.13
6x9 FRA	0.82	0.91	0.140	0.20
9x12 FRA	0.78	0.96	0.140	0.17

Notes: These tests correspond to the error correction equations in panels A-E of Table 4.
1/ Autocorrelated residuals, LM test. 2/ Doornik and Hansen (1984). 3/ Engle 1982.
4/ White 1980. * indicates 5% level of significance; ** indicates 1% level of significance.

The C panels of tables 4 and 5 show results for different time periods. Including the later 1980s leads to a fall in explanatory power, a much weaker interest rate response, weaker PPP reversion and weaker misspecification test performance. To some extent, this may be the result of failure to allow for changes in the risk premium on the interest rate differential.

Restricting the sample period to the recent cycle (from end-1996), the explanatory power increases; the estimated exchange rate response to the interest differential, to deviations from equilibrium and to commodity prices are all stronger, and the equations appears better specified (table 5).

The weak exchange rate response to the interest differential and some of the misspecification when the late 1980s are included may be the result of failure to account for a falling risk premium in the interest differential. Alternatively, the weak response in the 1980s may reflect deepening of capital markets. For example, forward rate agreement (FRA) swaps markets did not develop until the 1990s. Conversely, the stronger response in recent years may reflect capital market integration and a more persistent short term interest differential over the past decade.

Implicit in the error correction equations is a constant "risk premium" equal to the mean of the short term interest rate differential. A monthly measure of currency risk[25] is not available, but the discussion of the behaviour of long term interest rates, in section 3 above, suggests a potential measure.[26] As co-movement between New Zealand and foreign long term interest rates has increased with capital market integration (see figure 3), the long term differential may provide a reasonable proxy for the currency risk premium (although its credibility as a proxy falls as we go back further than the mid-1990s).

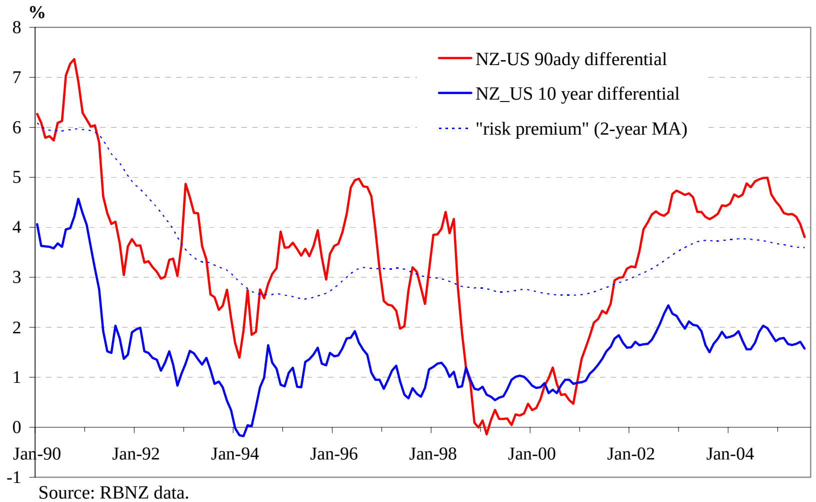
Figure 5 shows the New Zealand-US 90 day interest rate differential with a 24 period moving average of the long term NZ-US interest differential and the 90 day interest differential.[27] Allowing for such a risk premium (plus a constant implicit in the error correction equation), the coefficient on the interest differential appears more stable over time and the equation appears to be better specified, particularly for the early period (see the D panels in tables 4 and 5).

[25] See Hawkesby, Smith and Tether (2000) for a discussion of New Zealand's currency risk premium.

[26] An even better measure of the long term risk premium might be the implied forward rate, such as the implied 5 year ahead interest rate (approx 2x 10 year rate – 5 year rate).

[27] This measure of equilibrium suggests that the risk premium has generally fallen over time, but increased with the strong NZ dollar in 1996, and has increased with the rise of the New Zealand dollar since 2001.

Figure 5
New Zealand-US 10 year differential as a risk premium



Source: RBNZ data.

In theory, the equilibrium level of PPP is expected to vary with changes in relative productivity, terms of trade and savings (MacDonald, 1997). However the cointegration analysis did not support a long run role for commodity prices. Panel E of table 4 shows the estimated response to a more complete macrobalance measure of equilibrium.[28] The response to this measure of equilibrium is stronger than the simple PPP measure, as are the interest rate and commodity price responses.

Since the exchange rate is thought of as an asset price determined in forward-looking markets, the equation was also estimated using 3, 6 and 9 month forward interest rate differentials, using FRA swap data (panel F of tables 4 and 5).[29] These data are available for all 3 horizons from the end

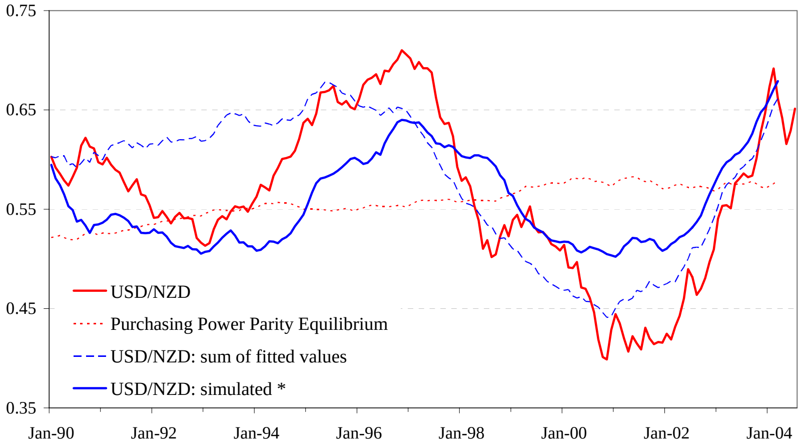
[28] Estimated equilibrium exchange rate data from Wren-Lewis (2004). This equilibrium is consistent with achieving a sustainable current account balance.

[29] The integral of the interest differential from 1 to 5 years was also constructed, using the yield curve to estimate implied 90 day rates from 3 months forward to 5 years forward. This variable was outperformed by the current 90 day interest rate. In practice implied future interest differentials tend to converge smoothly on the 10 year differential, so that the 90 day rate is roughly a linear transformation of the integral of expected differentials over time.

of 1996. The explanatory power and strength of the exchange rate response to the interest differential both peak at the 6-month horizon, suggesting that, on average, the markets are trading on 6 month ahead contracts. Beyond this horizon, uncertainty may lead to rapid discounting of future returns.

Figure 6 shows the USD/NZD exchange rate, the sum of fitted values and the simulated path implied by the reduced form equation (based on in-sample data and coefficients and excluding dummy variables). The simulated path captures a reasonable share of the exchange rate path in levels. This does not represent forecast performance as out-of-sample forecasts of interest rates, commodity prices and inflation would lead to quite different results (for example, if the main drivers, the 90 day interest differential and commodity prices, are projected to reverting toward long term trends, then the exchange rate forecast would be strongly mean reverting).

Figure 6
Exchange rate levels: actual and simulated



* Generated based on Dec 1989 exchange rate, estimated parameters and in-sample interest rate and price data. Source: ANZ, Statistics New Zealand and RBNZ data.

Parameter constancy is a problem which has important implications for forecast performance. When estimated over different time periods (see

Appendix C), the estimated PPP reversion coefficient, in particular, varies substantially over time. This could be the result of no-arbitrage bands around the “equilibrium” exchange rate, suggesting that nonlinearities might be an important part of an empirical model.

5.3 Out-of-sample forecasts

While the equation appears to capture a reasonable part of the exchange rate cycle within sample, out-of-sample tests are required to assess its usefulness for forecasting. Even if the reduced form captured the true data generating process (which is very unlikely), if all current information was already priced in then one wouldn’t expect the equation to outperform a random walk. Since Meese and Rogoff (1983) found exchange rate models to perform very poorly out-of-sample, they allowed in-sample data to separate a models’ forecast performance from the quality of the data forecasts. With the advantage of in-sample data, a model that captures the true data generating process would be expected to outperform a random walk, but only to the extent that data outcomes over the forecast horizon differ from expectations at the beginning of the horizon.

Nevertheless, to assess the forecasting performance of the model, 1 to 18 step-ahead forecasts were constructed using out-of-sample parameters and in-sample data. The error correction equation (using risk-adjusted interest differentials, equilibrium defined by PPP, and excluding dummy variables) was estimated from April 1988 (the beginning of available data) to the end of each year from 1989 and the parameters used for the subsequent year’s forecasts.

The root mean square forecast errors (RMSE) are shown in table 6. For an average of all forecasts from 1990 to 2004, a random walk outperforms the equation for forecast horizons up to 7 months after which the equation outperforms a random walk. The reduction in the RMSE increases with the forecast horizon, consistent with the generally improved performance of macroeconomic models at longer forecast horizons.

Table 6
Out-of-sample root mean squared forecast errors

Period	Forecast Horizon (months) 1	2	3	6	12	18
			Equation			
1990/1-2003/12	2.41	3.86	4.95	7.54	**11.67**	**14.11**
1990/1-1994/12	1.99	3.32	4.44	6.73	9.20	**10.33**
1995/1-1999/12	2.10	3.24	4.15	7.09	12.85	**16.69**
2000/1-2003/12	**3.13**	**5.05**	**6.34**	**9.01**	**13.05**	**14.78**
MCI (1997/6-1998/11)	**2.83**	4.65	6.29	10.78	**13.72**	**9.29**
OCR (1999/3-2003/12)	**2.97**	**4.80**	**6.00**	**8.86**	**15.40**	**19.44**
			Random Walk			
1990/1-2003/12	**2.27**	**3.65**	**4.67**	**7.30**	12.45	16.46
1990/1-1994/12	**1.46**	**2.39**	**3.05**	**4.74**	**7.86**	10.93
1995/1-1999/12	1.99	3.12	4.03	6.90	12.98	17.17
2000/1-2003/12	3.24	5.25	6.71	10.12	16.67	22.02
MCI (1997/6-1998/11)	2.87	**4.62**	**6.05**	**10.33**	14.26	12.54
OCR (1999/3-2003/12)	3.02	4.88	6.21	9.48	16.83	22.34
			Equation forecast error-RW forecast error			
1990/1-2003/12	0.14	0.21	0.29	0.23	**-0.78**	**-2.35**
1990/1-1994/12	0.54	0.93	1.40	1.99	1.35	-0.60
1995/1-1999/12	0.11	0.12	0.12	0.19	**-0.14**	**-0.48**
2000/1-2003/12	**-0.10**	**-0.19**	**-0.37**	**-1.11**	**-3.62**	**-7.24**
MCI (1997/6-1998/11)	**-0.04**	0.03	0.23	0.44	**-0.54**	**-3.25**
OCR (1999/3-2003/12)	**-0.05**	**-0.09**	**-0.21**	**-0.62**	**-1.43**	**-2.90**

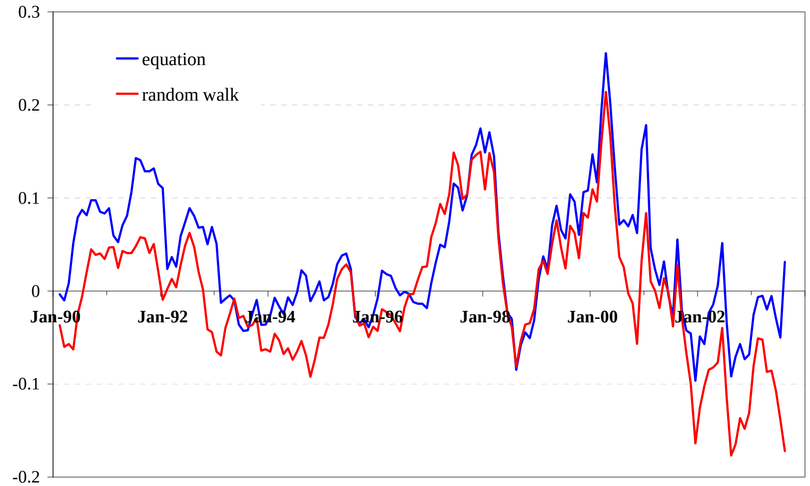
Notes: Root mean square errors of ln(e) are approximately in percentage terms. Calculated using out-of-sample coefficients and in-sample interest rates, consumer prices and commodity prices. Coefficients estimated for 1988/4 to the end of each year, and used for the subsequent 12 months.

The equation performance improves over time, particularly after the OCR was introduced in 1999. This result makes intuitive sense in view of the changes in the monetary regime and greater financial market integration discussed earlier in this paper. With less adjustment in short term interest rates, greater adjustment to deviations from UIP may be expected through the exchange rate.

As expected, the difference in forecast performance is modest, particularly at shorter horizons. The largest increase is for the period 2000-2003: at the 18 month horizon, the RMSE fell from 22 per cent to 15 per cent.

However, as shown in figure 7, the periods of large random walk errors and large equation forecast errors generally coincide.

Figure 7
6-step ahead forecast errors



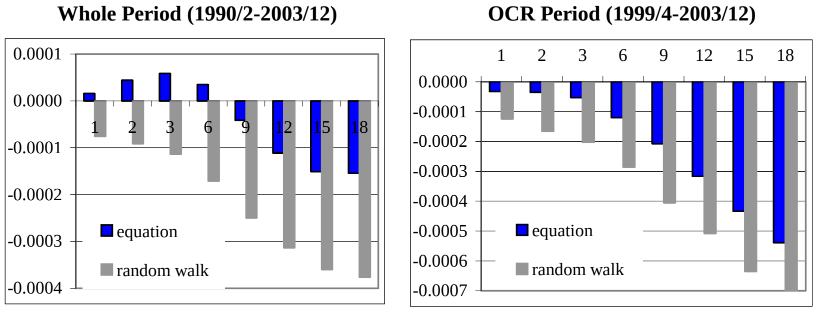
But are these significant improvements? An appealing approach to compare forecast errors here is an encompassing test. The case for encompassing is clear here since the error correction equation is estimating the innovations in a random walk process. The null hypothesis is that the equation encompasses a random walk if it captures at least a part of the data generating process. If the equation encompasses a random walk, then a combined forecast $f = \lambda(f_{eq}) + (1-\lambda)f_{rw}$ should perform no better than the equation forecast (λ=1). This can be examined by regressing the forecast errors on the error differential:

$$e_{eq} = (1-\lambda)\,(e_{eq}-e_{rw}) + \varepsilon_1 \quad (11)$$

$$e_{rw} = -\lambda\,(e_{rw}-e_{eq}) + \varepsilon_2 \quad (12)$$

where e_{eq} is the equation error, e_{rw} is the random walk error, and (e_{eq} - e_{rw}) is the error differential. If the estimated parameters are significant, then the forecast error can be reduced by using a combined forecast. Put another way, the null hypothesis is zero correlation between the forecast error and the error differential. Figure 8 shows the correlation between the forecast errors and the error differential. In all cases, the correlation of the equation error with the error differential is smaller, suggesting that the loss differential can reduce the random walk forecast error by more than the equation errors.

Figure 8
Correlation of errors and error differential



The trouble with this approach is that, with a high degree of correlation between the equation and random walk forecast errors, the results will suggest subtracting one forecast from the other to reduce forecast errors, but that doesn't help since the random walk forecast is zero.

A standard Diebold-Mariano test can be used to test the null hypothesis that the correlation between the forecast error and error differential is zero. (See Diebold and Mariano, 1985 and Harvey, Laybourne and Newbold, 1998). To correct for the correlation between the forecast errors, the variance in the denominator of the test statistic is replaced with a sum of auto-covariances. The latter can be very large for longer horizons. By this test, only the 1-step ahead equation forecast for the OCR period significantly encompasses a random walk, and then only at the 10% level.

Because of the potentially high penalties (large denominators) for forecast

horizons greater than 1-step ahead, estimating the equations for the forecast horizons of interest may be a superior approach for longer term forecasts. Forecast performance might also be improved using forward interest rates, dummy variables to exclude major outliers unrelated to the process being estimated, or nonlinearities which are found in the literature to improve forecasting performance (see Cheung, Chinn and Pascual, 2002).

6 Conclusions

The standard approach to modelling the exchange rate is based on forward-looking rational expectations, which implies that the exchange rate is a forward-looking asset price. However, this approach often does not fit the data well and the exchange rate is often the weakest aspect of open economy macroeconomic models. This paper explored reduced form descriptions of the NZ dollar-US dollar exchange rate, focusing on interest rate-exchange rate relationships. While the reduced form does not reveal the data generating process, it can be a useful way of looking at the stylized facts.

Some aspects of the estimated reduced form are consistent with forward looking rational expectations. In particular, the contemporaneous response to commodity export prices suggests that the effect of a rise in commodity prices on expected future returns is immediately priced in. In a rational expectations framework, the weak mean reversion term could be interpreted as a time-varying risk premium. Consistent with forward looking behavior in capital markets, the exchange rate appears to be most sensitive to 6-month forward interest differentials. Other aspects of the interest rate response and the autoregressive term are more difficult to reconcile with rational expectations. It is, however, difficult to draw conclusions about the interest rate response due to the inability to empirically estimate the sum of expected future returns without information about expectations and risk premia.

Two aspects of the data support the idea of some role for random walk expectations. First, the large estimated effect of the level of the interest differential on the change in the exchange rate is consistent with this form of expectations. If the expected change in the exchange rate is zero, then the expected return to uncovered interest arbitrage is the interest differential, providing an incentive to shift funds to the higher yielding currency, putting upward pressure on that currency. In this case, the change in the exchange rate should be proportional to the level of the interest differential, with appreciation eventually slowed by an increase in the risk premium as "overvaluation" affects expected returns. Second, the fact that the exchange rate lags the interest differential is consistent with random walk expectations: the level of the exchange rate (the sum of past exchange rate changes) is the sum of past interest differentials. This aspect of the data is difficult to reconcile with forward-looking rational expectations. With rational expectations, the level of the exchange rate is the sum of expected future interest differentials, which implies that the exchange rate should lead the interest differential, or at worst, be contemporaneous if shocks are not auto-correlated.

Both rational expectations and random walk expectations are strong assumptions. Forward looking rational expectations (an average forecast error of zero), suggests that agents have full knowledge of both news and how the news affects the economy. In contrast, a random walk expectation suggests that we know nothing. Ironically, in some ways, however, these may not be too far apart: if all information is already priced in, then we should not be able to beat a random walk forecast.

An appealing modelling strategy would include a process in which uncertainty drives a wedge between fundamentals and the exchange rate. A departure from pure rationality could be consistent with a framework of bounded rationality and learning or heterogeneous information.

From a monetary policy perspective, the way agents form expectations has important implications. With forward-looking rational expectations, changes in policy interest rates have no effect on the exchange rate unless they reveal information about fundamentals or about changes in central bank preferences. For a given degree of inflationary pressure, if the central bank raises interest rates more than expected, it implies a future easing of interest rates earlier than expected with little effect on the expected sum of future income returns. In contrast, if agents trade on yields, then short term interest rates potentially play a more important role in exchange rate determination.

While the reduced form equation outperforms a random walk for all forecast horizons for the OCR period, the improvements are not large

enough to be significant in the presence of highly auto-correlated and cross-correlated forecast errors. Forecast performance might be improved by longer estimation horizons for longer forecast horizons to avoid cumulating forecast errors, use of forward market interest differentials, and possibly including dummy variables to correct for exceptional events, and testing for and modelling nonlinearity.

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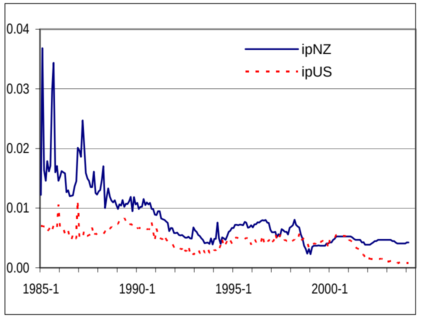
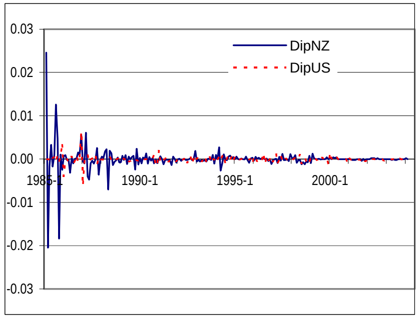
Appendix A
Data

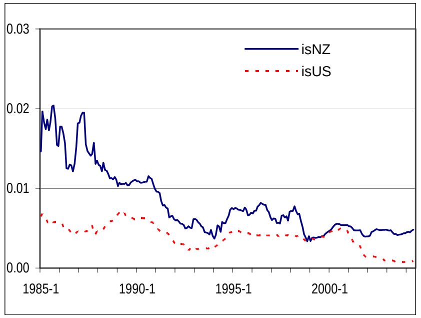
Levels | First Differences

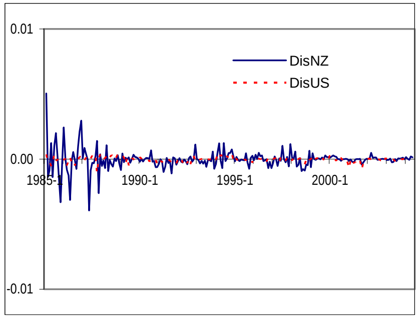
Overnight Interest Rates



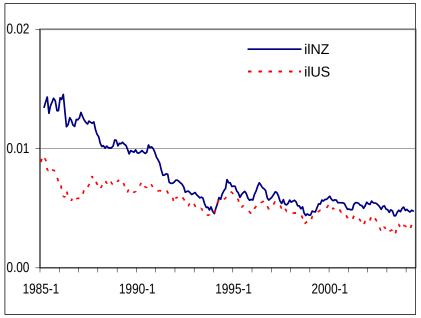


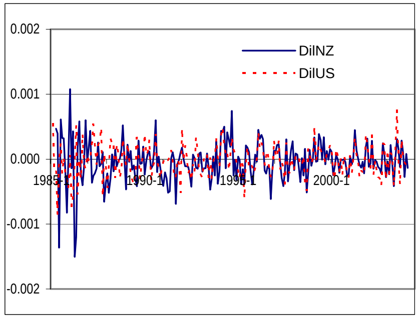
90 Day Interest Rates





10-Year Interest Rates

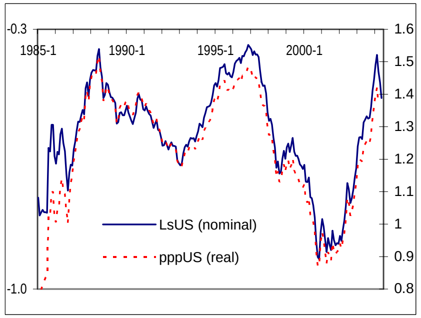


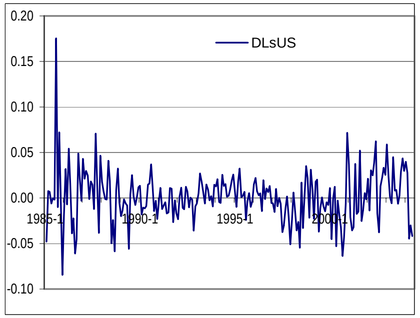


Log Levels

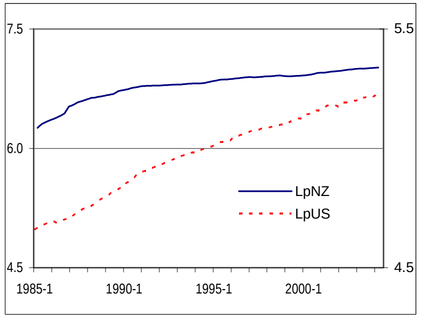
First Differences

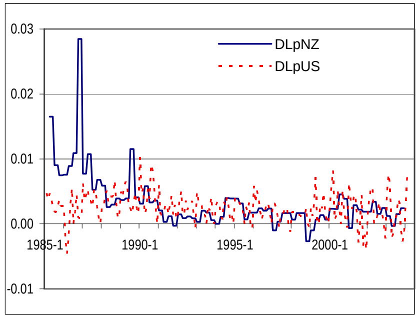
Exchange Rates



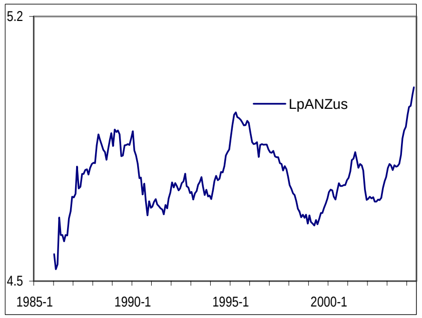


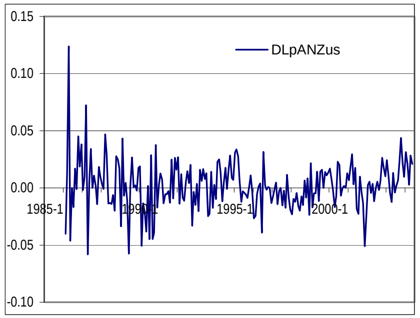
Consumer Prices





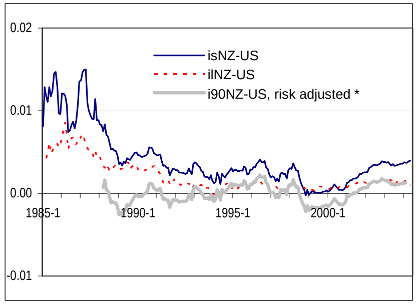
ANZ Commodity Price Index





Levels

Interest Rate Differentials



* Risk premium proxied by moving average of long term interest differential, plus a constant (implicit in the error correction equation so the mean is zero).

Appendix B
Unit root tests

Variable	Levels: Philips & Perron	Levels: ERS	First Differences: Philips & Perron	First Differences: ERS
Nominal Exchange Rate (log)	-1.38	6.56	-11.37 ***	0.55 ***
Real Exchange Rate (ppp)	-1.69	14.41	-11.02 ***	0.76 ***
New Zealand Interest Rates				
overnight	-2.34	24.02	-18.25 ***	0.38 ***
90 day	-2.65 *	70.80	-13.19 ***	0.23 ***
10 year	-2.78 *	159.23	-12.19 ***	0.26 ***
US Interest Rates				
overnight	-2.28		-29.18 ***	
90 day	-0.94	29.12	-12.20 ***	0.26 ***
10 year	-1.50	15.49	-13.40 ***	2.05 **
Nominal Interest Rate Differentials				
90 day	-2.91 **	41.52	-14.26 ***	8.79
10 year	-3.23 **	149.17	-14.53 ***	0.59 ***
90 day diff-10year diff	-3.58 ***	18.76	-14.22 ***	1.04 ***
Consumer Prices (log)				
New Zealand 1/	1.09	312.80	-4.22 ***	1.95 **
US	-2.87 *	4,648.0	-10.41 ***	0.36 ***
Commodity Export Prices (US$)	-2.45	35.16	-14.79 ***	1.02 ***
Critical Levels				
1%	-3.46	1.92	-3.46	1.92
5%	-2.87	3.18	-2.87	3.18
10%	-2.57	4.34	-2.57	4.34

Notes: For period 1986/5-2004/2 except commodity prices from 1987/3.
*, ** and *** indicate rejection of a unit root at the 10% level, 5% level and 1% level respectively.
1/ Quarterly data, so critical levels are not as indicated below.

Appendix C
Estimated equations for out of sample forecasts

period	constant	Partial Adjustment de(t-1)	Interest Differential (i-i*-rp)t-1	PPP (e+p-p*) t-1	Commodity Prices dlpANZ(t)	Equation Rsq
1988/4-2004/1	*0.01*	*0.23*	*4.73*	*-0.015*	*0.40*	
			periods beginning in 1988			
1988/4-1990/1	0.34	0.22	13.06	-0.025	0.48	0.56
1988/4-1991/1	0.27	0.33	7.54	-0.200	0.44	0.48
1988/4-1992/1	0.10	0.26	6.36	-0.079	0.35	0.30
1988/4-1993/1	0.04	0.21	5.55	-0.032	0.35	0.25
1988/4-1994/1	0.05	0.22	5.64	-0.041	0.33	0.29
1988/4-1995/1	0.05	0.21	5.53	-0.044	0.30	0.30
1988/4-1996/1	0.06	0.20	5.62	-0.048	0.27	0.28
1988/4-1997/1	0.06	0.20	5.60	-0.047	0.27	0.28
1988/4-1998/1	0.06	0.26	5.30	-0.048	0.31	0.31
1988/4-1999/1	0.04	0.27	3.57	-0.036	0.37	0.25
1988/4-2000/1	0.04	0.25	3.91	-0.031	0.37	0.23
1988/4-2001/1	0.02	0.28	3.95	-0.018	0.39	0.21
1988/4-2002/1	0.01	0.21	3.78	-0.010	0.36	0.16
1988/4-2003/1	0.01	0.22	4.53	-0.016	0.38	0.20
1988/4-2004/1						
			periods beginning in 1990			
1990/1-1998/12	0.04	0.33	3.62	-0.030	0.283	0.22
1990/1-1999/12	0.03	0.28	3.69	-0.029	0.305	0.19
1990/1-2000/12	0.01	0.29	3.68	-0.015	0.324	0.16
1990/1-2001/12	0.00	0.22	3.13 (11%)	-0.006	0.302	0.12
1990/1-2002/12	0.01	0.23	4.17	-0.015	0.302	0.16
1990/1-2003/12	0.02	0.24	4.78	-0.016 (11%)	0.351	0.20

Numbers in bold are not significant at the 10% level.
Interest differential adjusted for risk premium proxied by a 2-year moving average of the long term interest differential, plus a constant.