MODELLING THE AUSTRALIAN EXCHANGE RATE, LONG BOND YIELD AND INFLATIONARY EXPECTATIONS

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Abstract

More than two decades have passed since the initial relaxation of domestic interest rate controls in Australia and just over one decade since the float of the Australian dollar. Interest rates and exchange rates now constitute two of the most important channels through which macroeconomic policy can affect the broader economy. It is widely recognized that expectations play a critical role in these mechanisms, affecting both the timing and speed with which interest and exchange rates transmit shocks through to real activity and prices. Over the longer run, the influence of these two asset prices extends to the efficient allocation of capital and resources. This paper builds on previous work undertaken at the Reserve Bank and the OECD to develop single-equation, behavioural models of these two variables. Consideration is paid to the role of inflation expectations in affecting their behaviour. In particular, a model of *ex ante* real bond yields is estimated using a measure of forward-looking inflationary expectations which has been constructed by recourse to a Markov switching technique.

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1. Introduction

More than two decades have passed since the initial relaxation of domestic interest rate controls in Australia and just over one decade since the float of the Australian dollar. Interest rates and exchange rates now constitute two of the most important channels through which macroeconomic policy can affect the broader economy. It is widely recognized that expectations play a critical role in these mechanisms, affecting both the timing and speed with which interest and exchange rates transmit shocks through to real activity and prices. Over the longer run, their influence extends to the efficient allocation of capital and resources. This paper develops empirical models of each of these variables for Australia.

Section 2 begins with a brief review of the exchange rate and bond rate equations in two of Australia's existing macroeconomic models. These large-scale models offer the convenience of an internally-consistent link between these asset price variables and the real economy and typically embody forward-looking financial sector expectations. Their exchange rate and long bond rate equations reflect orthodox theoretical relationships; they are not estimated equations. The textbook-style impulse responses obtained from the macroeconomic modelling of exchange rate and bond rate behaviour offer useful baseline profiles. But the distinctive behaviour of these asset prices, observed in the data in practice, is not fully captured by the macroeconomic model approach. Policymakers need to think more critically about the determinants of these variables since they consititute two of the most important channels of policy transmission. To this end, the remainder of the paper builds on previous work undertaken at the Reserve Bank and the OECD to develop single-equation, behavioural models of the Australian real exchange rate and long bond yield, respectively. In particular, some attention is paid to the role that inflation expectations might play in affecting these two asset prices.

Section 3 builds on the wealth of earlier applied econometric studies of the Australian real exchange rate. This previous literature identifies roles for the terms of trade, net foreign liabilities and long-term interest differentials in determining exchange rate movements. The paper adds, to these factors, direct roles for macroeconomic policy and inflation expectations, which are found to improve the performance of the model.

In contrast, very little work has been undertaken in Australia on modelling the behaviour of long bond rates. Section 4 draws on work undertaken at the OECD by Orr, Edey and Kennedy (1995). This work identifies a comprehensive list of the fundamental determinants of real long-term yields across a 17 country *panel* data set, including Australia. This paper trials these determinants in a *time-series* model of the Australian *ex ante* real long bond rate. This time-series specification suffers several inadequacies and raises the question of how best to transform nominal bond yields into real magnitudes. Because inflation expectations are largely unobservable, the paper spends some time exploring one possible methodology for their measurement.

In practice, inflationary expectations can be heavily conditioned on a country's historical inflation performance. In Australia, successful inflation reduction policies in the early 1990s appear to have been accompanied by falls in existing measured inflationary expectations series. Section 4.2 discusses some inadequacies of these existing measures and estimates an alternative, forward-looking inflationary expectations series. For this purpose, a Markov switching technique is used. This methodology endogenises shifts in the series and produces estimates of the probabilities associated with remaining in particular (high or low) inflationary regimes. A model of the long-term bond yield, deflated with this unconventional forward-looking series, performs quite well. Section 5 concludes.

2. The Macroeconomic Model Approach

This section focuses on two widely quoted macroeconomic models of the Australian economy: the Murphy model and the TRYM model.[1]. These macro models embody

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[1] The current (1995) version of the Murphy model consists of 538 equations. TRYM was developed between 1990 and 1993 and consists of 23 estimated equations, 3 financial market identities, 2 default response functions for monetary and fiscal policy and about 100 identities linking these key variables (Downes 1995).

similar philosophies, sharing many common features of design and specification. They have similar theoretical underpinnings, with Keynesian properties in the short run (prices are sticky and output is demand-determined) and neoclassical properties in the long run. Equations describing the exchange rate and the long-term bond yield are elements of the financial sectors of these models and reflect orthodox theoretical considerations; they are not estimated behavioural equations. This section briefly discusses these two financial sector equations and their implied responses to shocks.

The process of expectations formation is central to the performance of the macro-model equations. *Financial sector* expectations are typically assumed to be model-consistent. In particular, inflation expectations are constructed from some combination of the current inflation rate and the equilibrium inflation rate which is derived from the steady-state version of the model. The equilibrium inflation rate is secured in the long run by assuming that the authorities have an exogenously-determined target for some nominal variable. In TRYM, the authorities target the money growth path; in recent versions of the Murphy model, a nominal income target is specified. The equilibrium inflation rate is then that rate which is consistent with the difference between money supply (nominal income) and real output growth in the long run.

In the Murphy model, quarterly inflationary expectations are then calculated from a weighted average of current inflation and the model's one-quarter-ahead predicted long-term equilibrium inflation rate. In TRYM, inflationary expectations are evaluated as the average rate of inflation over the next ten years as implied by the difference between the current level of prices and the equilibrium price level in period t+40 quarters.

2.1 Exchange Rate Determination

Each of the macro models employs a concept of the equilibrium real exchange rate. This is defined as that rate which achieves macroeconomic (that is, simultaneous internal and external) balance; it is calculated by a calibration of the steady-state version of the model prior to any dynamic simulation. In this way, the equilibrium exchange rate reflects the specification of interactions within the individual macroeconomic model. In TRYM, for example, adjustment back to the equilibrium rate, following any shock, is assumed to be complete within 40 quarters.

After tying down the long-run real equilibrium exchange rate, current and future changes in the real exchange rate are determined by an uncovered interest parity condition – if foreign long (10-year) interest rates are above domestic rates, the current value of the exchange rate must be below its equilibrium value. In the long run, the interest differential collapses (either to zero or, alternatively, to some constant risk premium).

The macro-models' equilibrium exchange rate is akin to the concept of the so-called *fundamental equilibrium exchange rate* (FEER), popularised by Williamson in the early 1980s. It realises internal balance, interpreted in the standard way, as achieving the underlying level of potential output which is consistent with the NAIRU. External balance is more difficult to define, and In't Veld (1991), in calculating equilibrium exchange rates for each of the G3 countries, found that his results were very sensitive to changes in this definition. The concept is intended to describe an equilibrium position in the current account; in the Australian macro models this is achieved with a stable ratio of foreign liabilities to GDP (typically stabilised at around 45 per cent, a little higher than the current level).[2] As with any intertemporal analysis, the path to external balance depends on current assessments of the future values of variables. The part of the macroeconomic model that is critical in this exercise is the trade sector which consists of equations expressing the dependence of output and the balance of payments on demand and competitiveness (the real exchange rate). For example, the present discounted value of future terms of trade shocks impacts upon the current exchange rate to the extent that it moves the equilibrium exchange rate in the long run; the equilibrium exchange rate moves to offset income effects on the current account and restore external balance.

Bayoumi, Clark, Symansky and Taylor (1994) conducted sensitivity analysis on the macroeconomic models of several industrial economies. They found that the estimated range in the calculated equilibrium exchange rates varied between 10 and 30 per cent. This degree of imprecision implies that interpretation of such an equilibrium rate is perhaps better restricted to the identification of relatively large

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2 This definition recognises that the current account on external transactions is the counterpart of the capital account. The equilibrium current account represents the desired intertemporal reallocation of resources between countries and identifying the preferred path for the current account means identifying the preferred path for international debt (Clark, Bartolini, Bayoumi and Symansky 1994, p.14).

exchange rate misalignments. Furthermore, the calculation of equilibrium real exchange rates as a basis for policy depends on an analysis of whether there are predictable shifts in the real exchange rate and the extent to which different sources of these shifts can be disentangled (for example, structural changes from long-lag dynamics). This is an exercise more appropriately undertaken in the behavioural framework outlined in Section 3.

2.2 Interest Rate Determination

Consistent with traditional textbook models, the short-term interest rate in these macro models is endogenous. As discussed above, the authorities are assumed to target an exogenously-determined nominal variable. In TRYM, for example, where this target variable is the money-growth path, a simple error-correcting money demand equation describes the link between the model's financial and real sectors. TRYM goes some way towards recognising the role of the short-term interest rate as the policy instrument by inverting the long-run component of this estimated money demand equation. This produces what might be broadly interpreted as a rate-setting monetary policy rule: the current level of the short-run nominal interest rate is determined by medium-term changes in nominal demand relative to the money supply. By its nature, this policy rule is arbitrary and a highly simplified representation of the policy formation process; there is no reason to think that the parameters and dynamics of the inverted money-demand function, with exogenous money, necessarily describe those of a reasonable rate-setting policy rule.[3]

In the Murphy Model, the authorities react to a nominal income target. In both macroeconomic models, the primary function of these mechanisms is to ensure that the economy moves towards a stable growth path in the very long run. The Fisher effect is assumed complete and this delivers the real interest rate.

[3] As discussed in Edey and Romalis (1996), the exogenous money-growth path target can be compared to a target index for an appropriately weighted average of prices and output. In this way, this approach can be argued to retain some validity for policy analysis, despite the historically poor indicator value of monetary aggregates. However, inverting a money demand function to obtain the short-term interest rate is an invalid statistical process. Edey (1990) presents a general argument that policy under an interest-rate setting rule with freely chosen parameters dominates money targeting apropos the stabilisation of output and prices.

At the other end of the yield curve, determination of the long bond rate is analogous to the macro-models' treatment of the exchange rate. Over the long run, international arbitrage ensures that (typically subject to a constant risk premium) domestic and foreign long-term real interest rates are equalised. In this way, aggregate demand and supply are equilibrated by adjustments in the real exchange rate. Movements in the Australian bond yield away from the foreign rate (equilibrium) are then determined by a term structure calculation. [4]

2.3 Response to Shocks

To better illustrate the relevant properties of the macroeconomic models, responses to a domestic monetary policy shock and a terms of trade shock in the TRYM model are illustrated (Figures 1 and 2). [5]

Firstly, a permanent 1 percentage point reduction in the exogenous money supply is effected; this can be thought of as a standard textbook monetary policy tightening. Unfortunately, as described earlier, the macro model is not typically set up to deal with an explicit interest rate shock. Such a simulation in TRYM would involve successive manipulation of the money supply, producing 'bumpy' response functions.

In the manner of forward-looking monetary models, the asset price variables 'jump' instantaneously in reaction to any shock, typically exhibiting a damped

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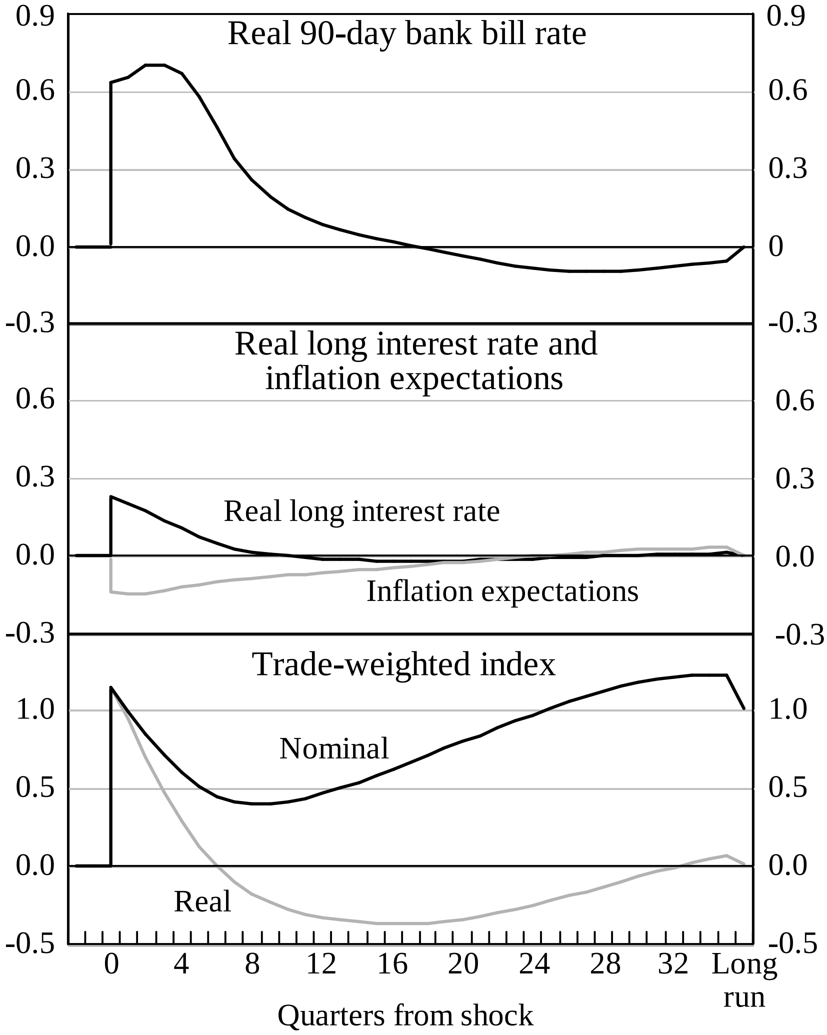
[4] The term structure calculation is macro-model dependent. In the Murphy model, for example, the yield on a 10-year security is set equal to the expected return from holding a continuous sequence of one-quarter securities over the next 10 years; the term premium is assumed to be zero. The expected returns from holding one-quarter securities are model consistent (Murphy 1988).

[5] These results from the Treasury Macroeconomic (TRYM) model should in no way be regarded as being Treasury analyses of the effect of a given policy change or as having the sanction of the Treasury, the Treasurer or the Commonwealth Government.

Figure 1: Money Supply Shock

Permanent 1% Reduction



oscillation back to their long-run paths.[6] A permanent 1 percentage point contraction of the money supply raises real short-term interest rates by 0.63 of a percentage point (Panel 1, Figure 1). This delivers a temporary fall-off in demand and a 1 percentage point reduction in the price level. The price fall is anticipated and agents immediately reduce their inflationary expectations by 0.14 of a percentage point.

The nominal 10-year bond yield jumps up by 0.08 per cent in the initial quarter of the shock; through the uncovered interest parity (UIP) condition, the nominal

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6 This long-run adjustment behaviour is largely due to the lagged adjustment processes describing the demand side of the macro models.

exchange rate must depreciate by 0.08 of a percentage point per annum for the next 10 years in order to equalise domestic and foreign returns. This requires an immediate appreciation of the exchange rate. Consistent with the imposed theoretical condition of long-run money neutrality, the 1 per cent decrease in the money supply has no effect on real variables in the long run, but leaves the nominal exchange rate appreciated by 1 percentage point.

Alternatively, consider a sustained terms of trade shock, here effected through an increase in the foreign price of exports that is maintained for ten quarters (Figure 2).[7] This shock raises domestic income. A proportion of the higher domestic income is spent on non-tradeable goods; this places upward pressure on prices and interest rates, appreciating the exchange rate via the UIP condition. The real exchange rate appreciates by around half of a percentage point.

If the shock had been permanent, the macro-model's equilibrium exchange rate would also have appreciated. This is because not all of the higher income arising from a permanent increase in the terms of trade is spent on imports and the current account balance improves; the macro-model's equilibrium exchange rate must then appreciate to generate a smaller trade surplus in the long run and thereby restore external balance.

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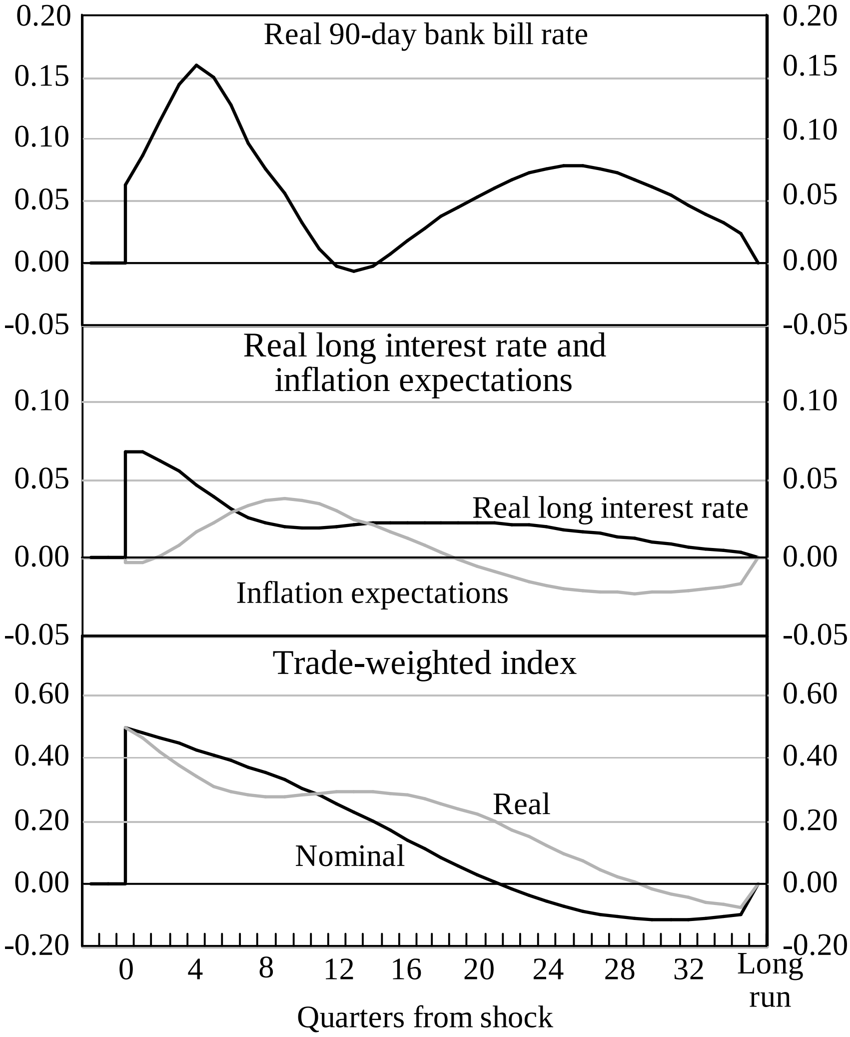
7 The shock is sustained over 10 quarters because this appears to be the average duration of terms of trade shocks historically observed in the data.

Figure 2: Terms of Trade Shock

Sustained 1% Increase in Export Prices



2.4 Assessment

The textbook-style impulse responses obtained from the macroeconomic models are driven partly by the theoretical assumptions concerning financial market behaviour outlined above. A number of critical points are worth highlighting.

- Within the macroeconomic model framework, the exchange rate and long bond yield display an instantaneous 'jump' response to shocks. This is usually followed by a damped oscillation to (partly) unwind the initial impulse. Experience suggests that such impulse responses do not accurately capture real world dynamics.

- Inflationary expectations are also characterised as a ‘jump’ variable; their instantaneous response to shocks occurs *before* any adjustment in actual inflation. This feature of the macro-model approach does not line up closely with actual experience. In many cases, a change in measured inflationary expectations has not occurred until after a change in actual inflation has occurred.

- Macro models are typically designed to produce policy simulations as responses to shocks under one particular rule – a money-growth rule, for example, in the case of TRYM. By contrast, policy simulations are more naturally examined under alternative policy rules and in terms of changes in the short-term interest rate.

- The size of the estimated exchange rate responses to terms of trade shocks cannot comfortably accommodate the long-standing observed correlation between movements in the terms of trade and the Australian dollar (first documented by Blundell-Wignall and Thomas (1987)).

- The assumption of UIP, embodying risk-neutrality (or a constant risk premium), perfect capital mobility, efficiency in the foreign exchange market, and negligible transactions costs has no empirical support (Smith and Gruen (1989) for Australia; Goodhart (1988) and Hodrick (1987) for international evidence). Quite apart from the validity of the UIP assumption, which turns on the issue of unbiasedness, predictions of future exchange rates based on UIP tend to be highly inaccurate.

With these points in mind, the remainder of this paper proceeds to develop simpler, single-equation behavioural models of the Australian exchange rate and long bond rate. This approach allows characterisation of the distinctive observed behaviour of these variables.

3. A Behavioural Model of the Australian Real Exchange Rate

3.1 What Determines the Australian Real Exchange Rate?

Previous empirical work (the most recent and comprehensive of which is Blundell-Wignall, Fahrer and Heath (1993), hereafter BW) has identified three statistically significant determinants of the Australian real exchange rate:

- the terms of trade;
- net foreign liabilities (proxied by the cumulative current account deficit); and
- real long-term interest differentials.

Each of these is addressed in turn. Firstly, while all three ‘fundamentals’ have been reported as statistically significant determinants of the real TWI exchange rate over the period since the floating of the Australian dollar, only the terms of trade has consistently retained its explanatory power over a longer sample period (1973:Q2-1992:Q3). This latter result is consistent with the cross-country study of Amano and van Norden (1992) which documents a robust relationship between the real domestic price of oil and real effective exchange rates in Germany, Japan and the United States. They interpret the real oil price as capturing exogenous terms of trade shocks and find these shocks to be the most important factor determining real exchange rates over the long run.

The relationship between the terms of trade and the Australian real exchange rate is striking, as shown in Figure 3.[8] Depreciations of the real TWI occurring in 1974-1978; 1984-1986; and 1991-1993 were all associated with falls in the terms of trade (denoted by the pale grey bars in Figure 3). Similarly, the real TWI appreciated over 1987-1989 and 1994 when the terms of trade improved (highlighted by the darker grey bars).

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8 This is the terms of trade for goods and services. It seems reasonable to take the terms of trade as exogenous because Australia’s share of world trade is small and it exports relatively few differentiated products. Dwyer, Kent and Pease (1994) present empirical evidence for Australia.

An exception can be identified in the early 1980s. This period coincides with a resources investment boom, promoted by the second OPEC oil-price shock and provides a good example of the role that expectations can play in determining movements in the exchange rate. The resources boom generated optimistic expectations about future improvements in the terms of trade and thereby, future income; the TWI appreciated despite little change in the prevailing terms of trade. Given that the anticipated improvements never eventuated, a correction in expectations contributed to the magnitude of the real TWI depreciation over 1985 and the first half of 1986.

Secondly, Australia experienced a rapid and sustained rise in net foreign liabilities over the 1980s (Figure 4).[9] Increasing net foreign liabilities, as a share of wealth, require larger balance of trade surpluses to restore equilibrium.

Similar to the macro-model mechanism of maintaining external balance, this may require a depreciation of the real exchange rate to attract resources into the tradeables sector. (Of course, if the real return on investment is high, the higher trade surpluses may be achieved without a real depreciation.)

Thirdly, the vast majority of the literature finds that the *long-term* real interest differential has the most success in obtaining significant and correctly signed estimates in exchange rate equations (Gruen and Wilkinson (1991) and BW for Australia; Isard (1988) and Shafer and Loopesko (1983) for international evidence). *Long-term* interest differentials are often justified on the grounds that shocks to the real exchange rate can persist for long periods and this slow reversion towards equilibrium is simply more appropriately matched by a correspondingly long-term interest rate.[10] This seems curious given that the

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9 Empirical work generally uses the cumulated current account deficit as a proxy for net foreign liabilities because it abstracts from valuation effects.

10 Isard (1983) supports the use of long (10-year) interest rate differentials on the grounds that they are convenient to interpret. As in the Australian macro models, he assumes that the expected real exchange rate in 10 years time is the equilibrium exchange rate; in this way, the long (10-year) real interest differential (corrected for any risk premium) can be interpreted as denoting the annual rate of real depreciation/appreciation of the dollar expected by the market over the next 10 years.

Figure 3: Real TWI and Terms of Trade

Index 1989/90 = 100

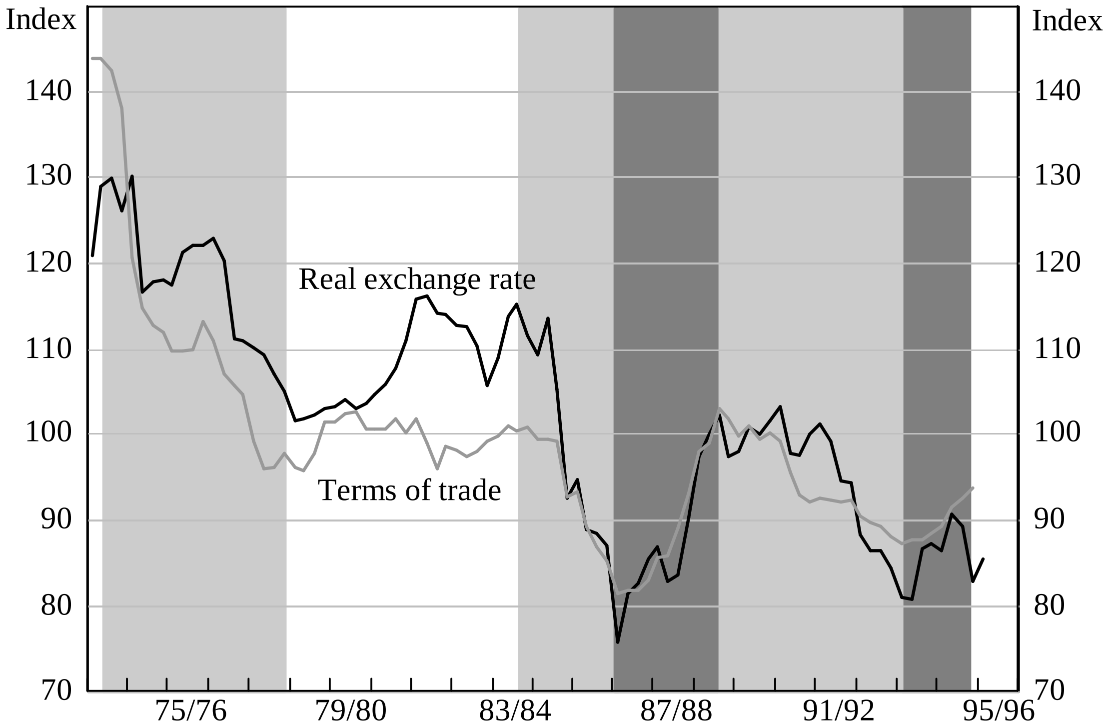
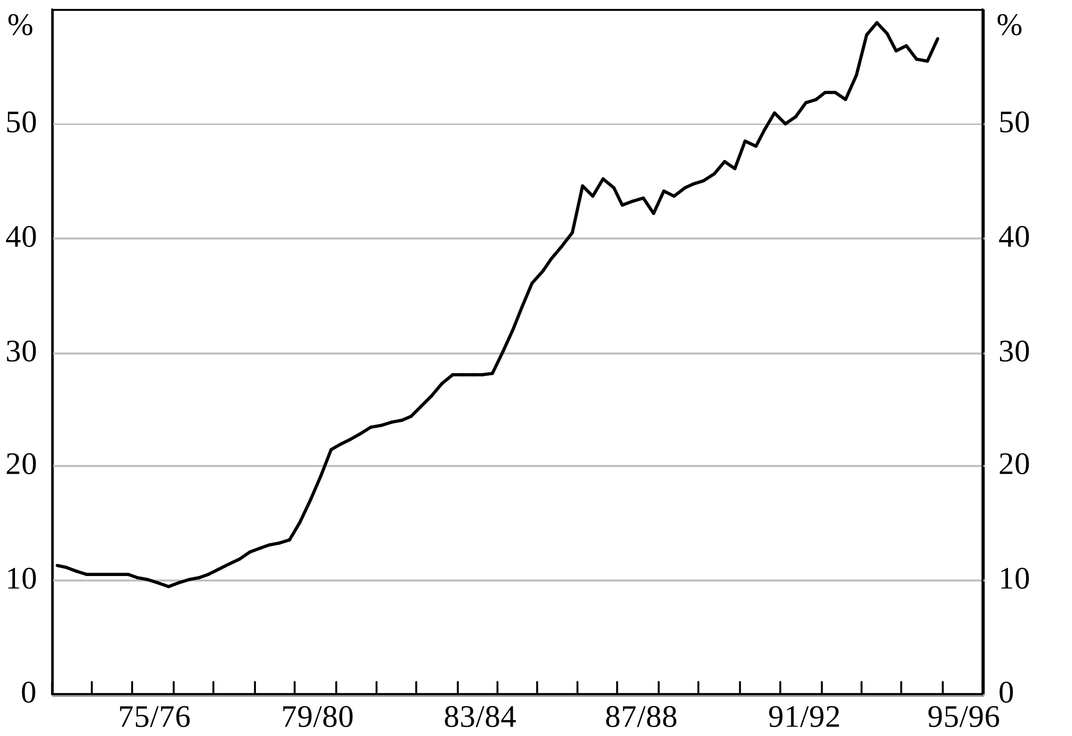


Figure 4: Australia's Net Foreign Liabilities

Per cent to GDP



exchange rate is considered to be an important channel through which changes in the policy-determined short-term interest rate feed through to the economy. De Kock and Deleire (1994) estimate that, post 1982 in the United States, the exchange rate accounts for roughly one-third of monetary policy transmission to output, compared to a near-negligible contribution earlier. Perhaps it is the case that earlier Australian studies did not have the benefit of a sufficiently long sample period, after the floating of the Australian dollar, over which to estimate their exchange rate models. At any rate, this seems to beg further investigation.

The real long-term interest differential in existing models could simply be replaced by a real *short-term* interest differential. As customarily measured – using 12-months-ended inflation rates – real short-term interest rate differentials would reflect the *prevailing* stance of domestic, relative to foreign, monetary policy; but they would fail to capture any market anticipation of the future paths of short-term interest rates, inflation and growth.

It is difficult to capture these forward-looking aspects in behavioural models. This seems unsatisfactory in models of the exchange rate since financial market behaviour is generally characterised by forward-looking expectations. Therefore, the novel approach taken here is to use a measure of the relative slopes of the domestic and foreign yield curves. Mishkin (1994) and Estrella and Mishkin (1995) provide evidence that the slope of the yield curve contains information about the current and *expected future* stance of monetary policy.[11] Inflationary expectations, and therefore expectations of the future path of short-term interest rates, are reflected in long bond yields. Although well-understood by policymakers, it is worthwhile digressing to illustrate this operational point stylistically.

Figure 5 depicts two episodes of monetary policy action in Australia. Between April and December 1987 (top panel) and from December 1990 to March 1992

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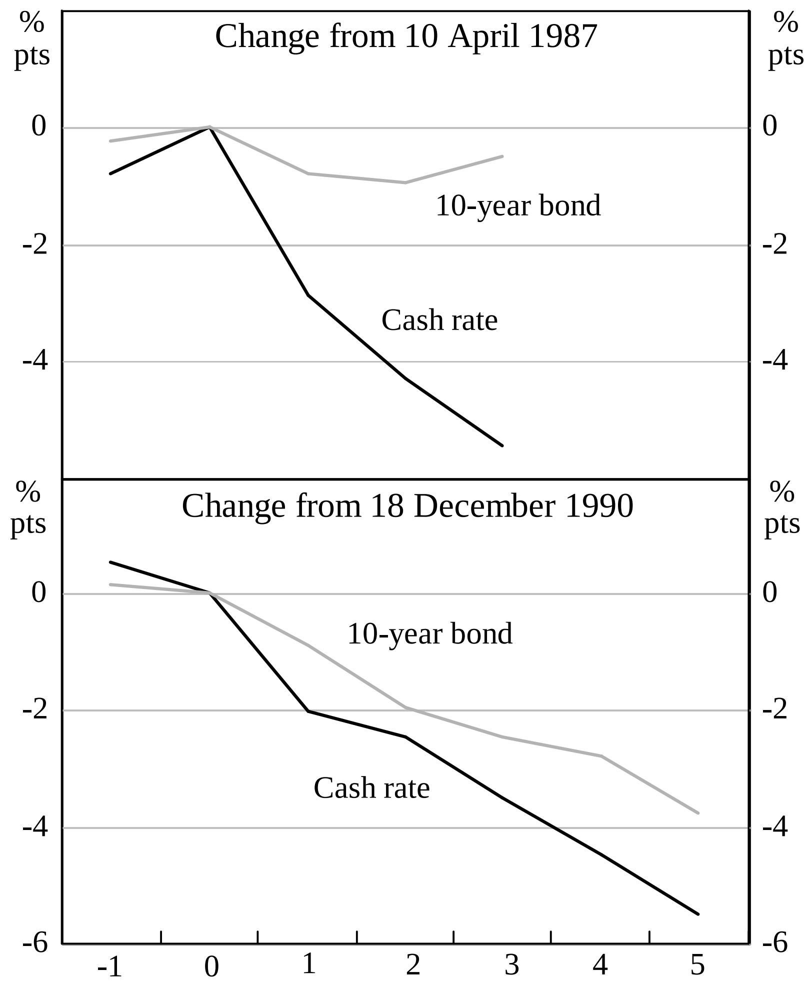
[11] See also Cook and Hahn (1990) for a survey of the literature and some support for the idea that parts of the yield curve are useful in forecasting interest rates; Lowe (1994) provides evidence for Australia.

Figure 5: Episodes of Policy Change



Quarters from policy change represented on horizontal axis

(bottom panel), the operational instrument of monetary policy in Australia – the nominal cash rate – was reduced by around 5½ percentage points.

In the first episode, in 1987, the long bond yield remained relatively unchanged (falling by a small 0.48 of a percentage point). By comparison, over the early 1990s episode, the long bond yield fell by almost 4 percentage points. At this time, some progress on inflation was already widely apparent in Australia and so market expectations for future inflation may well have moderated with the reduction in the cash rate. Of course, this discussion is simplistic and ignores a number of issues, but to the extent that inflation expectations explain some of the fall in the long end of the yield curve, agents were not expecting short-rates to have to rise very much in the future. Relative to the example in 1987, the slope of the yield curve remained fairly flat. By this measure, the stance of monetary policy was relatively tighter than over the 8 months to December 1987, despite equivalent movements in the nominal cash rate.

Also of interest to policymakers is the role of fiscal policy in determining exchange rate behaviour. Rarely mentioned in earlier work on the Australian exchange rate, the impact of fiscal policy can occur through two separate channels and is theoretically ambiguous.

- Firstly, the simplest *Mundell-Fleming* model predicts that expansionary fiscal policy causes an appreciation of the exchange rate. The intuition for this result is that increased government spending raises demand for domestic output which, in turn, induces a currency appreciation (alternatively, increased demand exerts upward pressure on interest rates which induces capital inflow and a stronger currency). The appreciated currency reduces the value of foreign demand, which restores the original level of output.

- Secondly, fiscal policy can impact upon the exchange rate through a risk premium. Fiscal expansion may be penalised by investors who perceive an increased probability of default or expect higher inflation in the future because they believe that the incentive exists for the Government to 'inflate' its debt away; in order to hold Australian dollar assets, they demand a risk premium on domestic interest rates. Furthermore, it is often argued that higher government budget deficits are associated with negative sentiment on the exchange rate because they imply lower national savings and so greater net foreign liabilities in the longer run. In this way, it is argued that the exchange rate depreciates. To the extent that the negative sentiment arises because of the overall size of net foreign liabilities, rather than their public/private composition, this effect may be partly captured, over the long run, by a cumulated current account variable.

Both the monetary and fiscal policy variables discussed above seem likely to be important, in addition to the variables identified in earlier work, for explaining movements in the Australian real exchange rate. To ascertain the empirical validity of this proposition, the BW equation, being the most recent in this literature, is tested for and appears to suffer from omitted variable bias.

Table 1: Omitted Variable Tests

Estimation period	RESET Rainbow test	Significance level	
1984:Q1-1992:Q3 (BW 1993)	3.11**	*F(18,10):*	0.035
1984:Q1-1995:Q2 (Updated BW sample)	2.61**	*F(24,16):*	0.026
1985:Q1-1995:Q2 (Tarditi 1996)	2.02*	*F(22,14):*	0.089

Notes: ** and * denote rejection of the null hypothesis of *no* omitted variables at the 5% and 10% significance level.

Table 1 summarises the results from application of the 'rainbow test', a member of the Ramsey (1969) RESET family of tests for the omission of unknown variables (Utts 1982).[12] The test is conducted over several post-float sample periods, when the exchange rate became a channel of transmission for monetary policy; the null hypothesis of no omitted variables is consistently rejected. The omitted variable(s) will be captured in the error process and as a consequence, the estimated coefficients in the BW equation will be both biased and inconsistent.

In an effort to address this bias, several modifications to the BW specification are made. Specifically, the terms of trade and cumulated current account deficit are retained. A yield gap differential replaces the long-term interest differential and takes the form:

$$YGAP = \{(i_S - i_L) - (i_S - i_L)^*\} \tag{1}$$

[12] The 'rainbow test' compares estimates of the variance of the regression disturbance obtained from estimation over the relevant full sample and a truncated sub-sample; if the null hypothesis is true, both variance estimates are unbiased. The test statistic is an F-statistic, adjusted for the appropriate degrees of freedom. See Kmenta (1990, pp.454-455) for a full description of the test. It should be noted that the consequences of omitting relevant explanatory variables are the same as those of using an incorrect functional form.

where:

$(i_s - i_L)$ measures the slope of the domestic yield curve as the difference between the domestic nominal cash rate (i_s) and the domestic nominal long (10 year) bond yield (i_L);

$(i_s - i_L)^*$ measures the slope of the foreign yield curve using equivalent foreign interest rates (see Appendix A for details on the construction of world interest rates and Table B.2 in Appendix B for statistical confirmation of the implied restrictions in (1)).

In addition, a role for fiscal policy is accommodated by including a measure of the change in the Commonwealth Government budget balance, expressed as a proportion of GDP (hereafter, the fiscal variable). While it would be preferable to use a cyclically-adjusted measure of the fiscal position, this was not available for Australia.[13]

3.2 The Empirical Results

Following the convention for time series methodology, the order of integration of the real exchange rate and its proposed explanatory variables is established (see Table B.3 in Appendix B for detailed statistics). To this end, the Augmented Dickey-Fuller (Dickey and Fuller 1981; Said and Dickey 1984) and Elliot, Rothenberg and Stock (1992) (DF-GLS) tests of a unit root null, together with the Kwiatkowski, Phillips, Schmidt and Shin (1992) (KPSS) test of a stationary (trend stationary) null, are employed.[14] Confirming the results of Bleaney (1993) and

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[13] Typically, the government budget tends to be in surplus when the economy is growing strongly and vice versa. The fiscal variable was tested against domestic and foreign growth variables and measures of the output gap to eliminate the possibility that it was just proxying the economic cycle. The fiscal variable retained its explanatory power over both the shorter post-float period (1985:Q1-1995:Q2) and the longer, historical sample period (1973:Q4-1995:Q2). These results were not qualitatively altered when the Commonwealth Government measure of the fiscal position was replaced by a measure of the change in the public sector borrowing requirement.

[14] The null hypothesis of a unit root in the ADF and DF-GLS tests may result in a type II error; series may appear to contain a unit root because the data are insufficient to provide strong

Gruen and Kortian (1996), these tests imply mean reversion of the Australian real exchange rate to a slowly declining trend.[15] Similar evidence of stationarity exists for other countries (see, for example, Phylaktis and Kassimatis (1994); Liu and He (1991) and Huizinga (1987)).[16] The integration tests also provide evidence that the terms of trade and other explanatory variables are I(0) processes.

Nevertheless, the analytical convenience of the unrestricted error correction framework is exploited to specify a behavioural model of the real Australian TWI exchange rate.[17] The model is specified with 4 lags of each explanatory variable in the dynamics; lower case denotes logarithms. Sequential F-tests are used to derive the following parsimonious representation:

$$\Delta rer_t = a + b\,rer_{t-1} + d\,tot_{t-1} + f\,cad_{t-1} + g\,YGAP_{t-1} + \sum_{i=0}^{1} j_i \left[\Delta gdef \big/ gdp \right]_{t-i} + q\Delta tot_t + e_t \qquad (2)$$

where:

evidence for rejection of that null. This is why the KPSS test, with a null of stationarity, is also applied to the data (see Appendix B for a brief description of this test).

15 From the perspective of modelling, the essential difference between the trend-stationary and integrated model specifications is the nature of the process driving the stochastic component, not whether the series is trended.

16 Phylaktis and Kassimatis (1994), in examining real exchange rates in eight Pacific Basin countries (calculated using the unofficial black market exchange rates), find evidence for mean reversion which suggests a half-life of four quarters. Using amended variance ratio tests, Liu and He (1991) offer evidence that mean reversion is quicker in the developing Asian countries relative to industrialised countries. Huizinga (1987) employs spectral methods to analyse real exchange rates for ten major currencies *vis-a-vis* the US dollar. Various real bilateral rates against the US dollar and the pound sterling were found to be mean-reverting, but against the Japanese yen, the exchange rates were indistinguishable from random walks.

17 In this way, this analysis recognises that in finite samples, any trend stationary process is nearly observationally equivalent to a unit root process where shocks are substantially reversed – that is, where the errors have a moving-average component with a root near minus one (or a fat-tailed distribution for the error process). And, irrespective of the order of integration of the variables, this modelling technique remains valid.

rer	Australian real TWI exchange rate;
tot	terms of trade;
cad	cumulated current account deficit, expressed as a proportion of GDP (defined such that a current account deficit is a positive number);
YGAP	relative slopes of domestic and foreign yield curves as described in (1) above (see Table B.2 in Appendix B for statistical confirmation of the implied interest rate restrictions);
$\Delta gdef/gdp$	fiscal variable, defined as the log change in the Commonwealth Government deficit and expressed as a proportion of GDP (defined such that a budget deficit is a positive number);
e	white noise error term;
Δ	first difference operator.

Given the time-series properties of the data, this specification is used to distinguish different types of influences on the real exchange rate and, in this way, retains one characteristic of the macroeconomic models described in Section 2 – namely, the general framework wherein the real exchange rate – affected by speculative and cyclical factors – eventually tends toward a path determined by underlying structural factors. The macroeconomic fundamentals, identified in Section 3.1 above, set the parameters within which the exchange rate should move in the medium term and provide a pertinent framework from which to assess the appropriateness of policy settings.

The model is estimated over two sample periods; three decades of data encompass two broad exchange rate regimes in which the dynamics of the real exchange rate are unlikely to be identical. With this in mind, results for equation (2) over the post-float period (1985:Q1-1995:Q2)[18] and a longer, historical sample (1973:Q4-1995:Q2) are reported in Table 2.

Table 2: Real Exchange Rate Model

Dependent variable: Change in log real TWI $\left(\Delta rer_t\right)$

Explanatory variable	1985:Q1-1995:Q2	1973:Q4-1995:Q2
ß: Real exchange rate$_{t-1}$[19]	-0.51*** (0.12)	-0.25*** (0.07)
δ: Terms of trade $_{t-1}$	0.46*** (0.14)	0.22*** (0.07)
ϕ: Cumulated current account deficit $_{t-1}$	-0.01 (0.05)	-0.04** (0.02)
γ: Yield curve differential $_{t-1}$	1.10*** (0.35)	0.08 (0.21)
$\Sigma j_i : \Sigma_{i=0}^{1} Fiscal_{t-i}$	4.87*** *{7.15}*	1.36*** *{5.43}*
θ: ΔTerms of trade $_t$	1.41*** (0.19)	0.89*** (0.16)
α: Constant	0.16 (0.31)	0.09 (0.25)
$\bar{R}^2$	0.74	0.35
DW	1.53	1.88
ARCH (4) test c_4^2	1.33 [0.86]	3.26 [0.52]
AR (4) test c_4^2	5.48 [0.24]	5.19 [0.27]
Jarque-Bera Normality test c_2^2	2.28 [0.32]	2.40 [0.30]
Rainbow test	1.08 [0.45]	0.84 [0.72]

Notes: ** and *** denote significance at the 5% and 1% levels. Standard errors are in round brackets; probability values are in square brackets; and the F-test statistic for the joint significance of the fiscal variables is in parentheses, {}.

[18] The foreign exchange market is given one year after the floating of the Australian dollar in 1983:Q4 to establish its new regime; thus, estimation over the shorter sample period begins in 1985:Q1. If the entire period since the float is included in the estimation period (ie 1984:Q1-1995:Q2) then a direct role for monetary policy is no longer significant at the 10 per cent level.

Three points are worth noting straight away.

- As expected, it is only after the floating of the Australian dollar that the exchange rate has played a role in channelling changes in real interest rates through to the broader economy.[20]
- On the other hand, the cumulated current account deficit is only significant in explaining the real exchange rate over the fuller, historical sample period; this accords with its longer-run structural nature.[21] Over this period, the level of Australia's net foreign liabilities is estimated to have exerted some downward pressure on the real exchange rate, but this has been of a relatively small order of magnitude; a one percentage point increase in net foreign liabilities to GDP, *ceteris paribus*, has an estimated long run effect of $^1/_6$ of a percentage point on the real exchange rate over this period.

- The positive coefficient on the fiscal policy variable implies a conventionally-signed Mundell-Flemming effect during the sample period.

The remainder of this section concentrates on interpretation of the results obtained from estimation of this model over the post-float period. Simple impulse response diagrams show the estimated impact of shocks to the yield curve and to the terms of trade, *ceteris paribus*, on the real exchange rate.

The first shock is defined as a one percentage point inversion of the Australian yield curve relative to the foreign yield curve, maintained for eight quarters. In response, the real exchange rate is estimated to appreciate by 2.2 percentage points; 76 per cent of the adjustment is complete after two quarters (Figure 6a). This gradual

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[19] β measures the speed of adjustment which, for the post-float regression, implies a half life of 1 quarter; this is not unreasonable given that the real exchange rate is trend stationary.

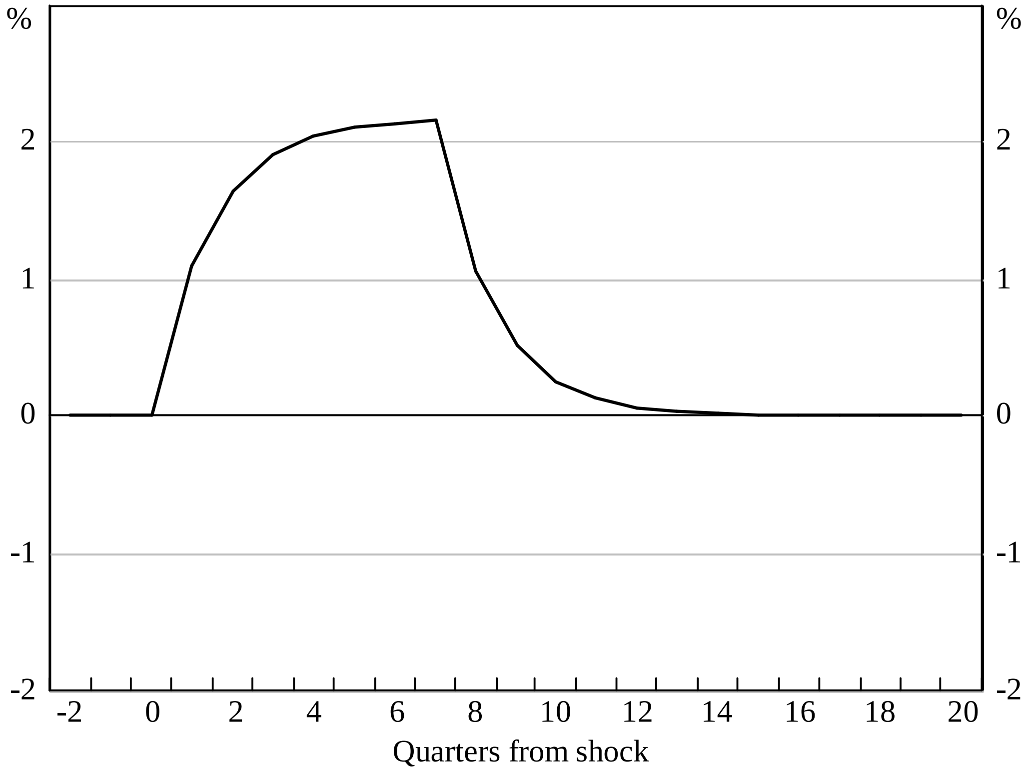
[20] It is worth noting that the relative yield gap variable outperforms (statistically) the alternative short-term real interest differential over this sample period (see Table B.4 in Appendix B for details).

[21] This is the opposite of the BW result that the cumulated current account deficit is only significant over the shorter, post-float sample period and even then, that it is outperformed by a simple trend (see Table B.1 in Appendix B).

adjustment of the real exchange rate to an interest rate shock is quite different from the ‘jump’ responses elicited in macro models.

Figure 6a: Real TWI Exchange Rate: Impulse Response

1% Inversion of Domestic Yield Curve for 8 Quarters

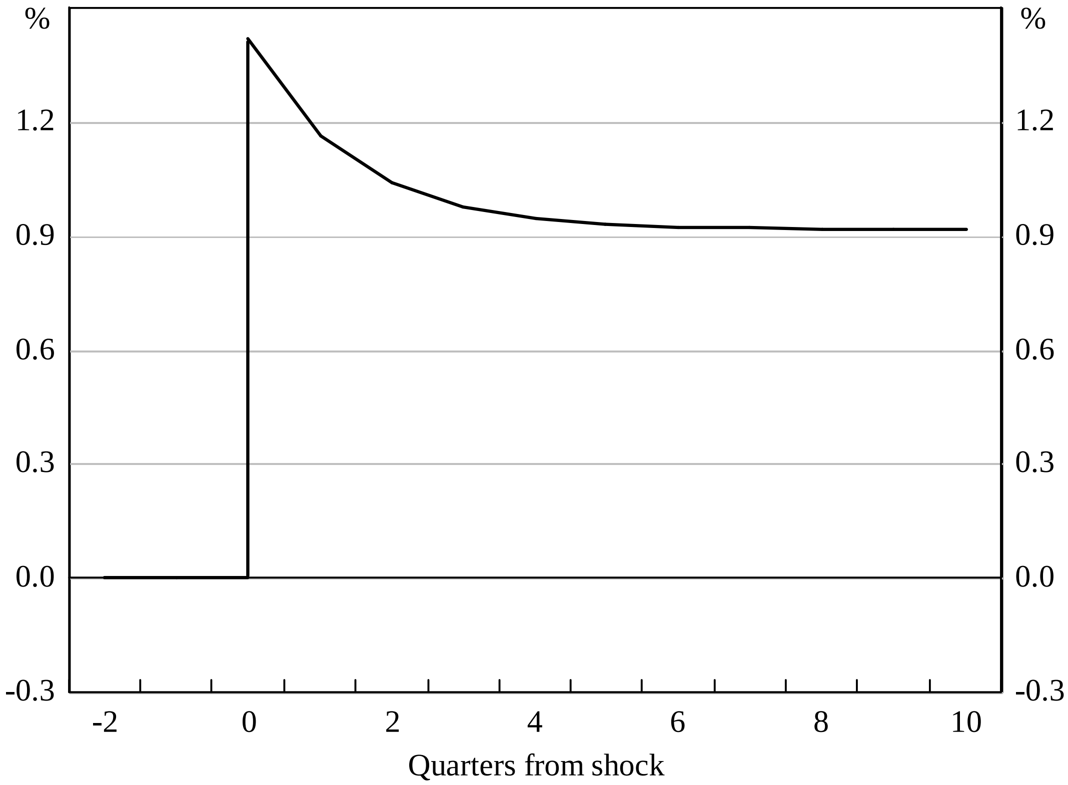


Secondly, consider a *terms of trade* shock. Similar to the results obtained by earlier work, a one percentage point increase in the *terms of trade* that is sustained for ten quarters, eventually delivers a 0.9 per cent appreciation of the real Australian exchange rate (Figure 6b). This estimated response is almost double that returned by simulation of the TRYM model discussed in Section 2. While there is some uncertainty about the operation of the short-run dynamics, a literal interpretation of the estimated model suggests an initial response of as much as 1.4 per cent.

The magnitude of the estimated real exchange rate response to terms of trade shocks is something of a puzzle. Gruen and Kortian (1996) contend that this observed historical response results from inefficiency in the foreign exchange market. They demonstrate the existence of large, variable and predictable excess returns to holding Australian assets over horizons of a year or more. This is interpreted as evidence of a relative scarcity of forward-looking foreign exchange market participants with an investment horizon of this length.

Figure 6b: Real TWI Exchange Rate: Impulse Response

Sustained 1% Terms of Trade Shock

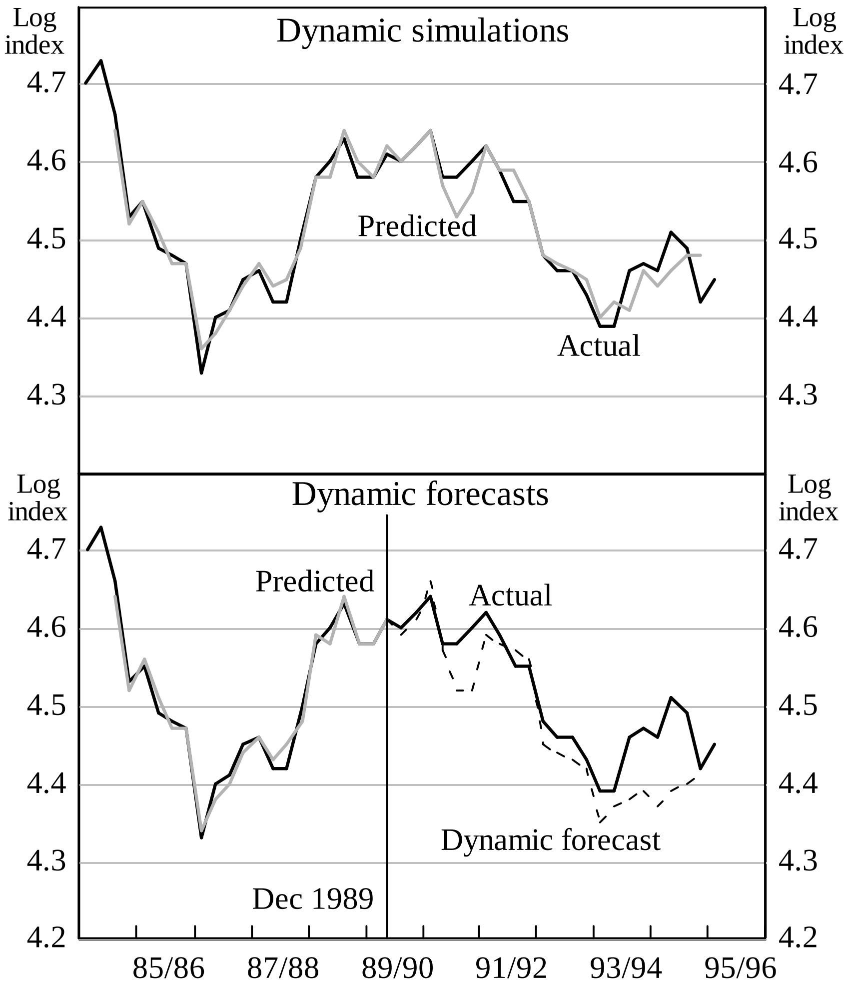


If this myopic behaviour does indeed prevail, participants in the foreign exchange market may not be adequately distinguishing between temporary, soon-to-be-reversed shocks and longer, more sustained shifts in the terms of trade. This would result in Australia's real exchange rate moving more tightly with the terms of trade than would be consistent with perfectly forward-looking investor behaviour. While the smaller responses to temporary terms of trade shocks generated by the macro models is theoretically appealing, the presence of excess returns in the foreign exchange market undermines the predictions of UIP; this condition is the central relationship determining exchange rate outcomes in the macro models.

To give some idea of the model's fit, Figure 7 compares the actual behaviour of the real Australian TWI exchange rate over the post-float period, with predicted values from this model up to the June quarter of 1995. In sample, the model fits very well.

The bottom panel of Figure 7 presents the model's out-of-sample forecasts over the same period. These are obtained by re-estimating equation (2) using data to the December quarter of 1989 (or half the sample period). Subsequently, actual values of the exogenous variables are used to obtain one-step-ahead forecasts of the real exchange rate out to the end of the sample, 1995:Q2. Out-of-sample, the equation captures most of the actual movements in the real exchange rate and picks the major turning points in the early 1990s and again around the end of 1993. The tracking ability of the equation is mainly attributable to the role of the terms of trade in explaining exchange rate movements. This result is consistent with findings of a number of earlier studies. Nevertheless, the result appears at odds with standard economic theory and, as discussed above, the assumption of market efficiency.

Figure 7: The Real Exchange Rate Model
Dynamic Simulation and Out-of-Sample Forecast



4. A Behavioural Model of the Australian Long-Term Interest Rate

In contrast to the volume of literature on determinants of the exchange rate, work on modelling the behaviour of the Australian long bond rate is scarce. This section of the paper draws on recent work undertaken at the OECD by Orr *et al.*, who identify a comprehensive list of the fundamental determinants of real long-term interest rates across a 17-country *panel* data set, including Australia. The authors also provide a succinct yet comprehensive discussion of each of these determinants. This discussion will not be repeated here. Instead, by using the 'fundamental' variables identifed by Orr *et al.*, a *time-series* equation for the Australian *ex ante* real long bond rate is trialed.

This time-series specification suffers several inadequacies and raises the question of how best to transform nominal bond yields into real magnitudes. Since inflation expectations are largely unobservable, Section 4.2 of the paper spends some time exploring one possible methodology for their measurement. Estimation of a simple model of inflation, specified to endogenise shifts between a high and a low inflation regime, is used to generate *forward-looking* expectations. This methodology seems particularly apt for Australia, where successful inflation reduction policies in the early 1990s have been accompanied by a discrete shift in existing survey measures of inflationary expectations. The explanatory performance of this unconventional forward-looking measure is compared to an existing survey measure of inflationary expectations in a time-series model of nominal long bond rates.

4.1 The Real Bond Yield Fundamentals in Brief

I begin with the principle determinants of real long bond yields. Orr *et al.* list these determinants as the domestic rate of return on capital, the world real long bond yield, and various risk premia. They note that these risk premia are likely to depend on:

- the perceived degree of each country's monetary policy commitment to price stability. Recognising that the expectations of market participants may follow some adaptive process, they use the existing level of inflationary expectations, conditioned on some longer-run historical performance (the average rate of inflation over the preceding 10 years, $\overline{p}_{10}$). In this way, movements in bond yields relative to changes in current inflationary expectations will depend on the weight that investors attribute to Australia’s relatively poorer historical inflation performance;

- the expected sustainability of government fiscal and net external debt positions. Orr *et al.* measure these with the ratios of government budget positions and cumulated current account deficits, respectively, to GDP; and

- some undiversifiable domestic portfolio risk associated with holding bonds.[22]

Following the time-series methodology outlined in Section 3, the real long bond yield, r, deflated simply, first of all, with (annualised) quarterly underlying inflation rates, is determined by an unrestricted error correction model.[23] Tests of the order of integration of each variable are presented in Table C.1 in Appendix C. Four lags of each of the differenced ‘fundamental’ variables, together with domestic growth, were included in the initial dynamic specification of the model; F-tests were then used to derive the parsimonious final model:

$$\begin{aligned} Dr_t = a r_{t-1} + b\{\bar{p}_{10} - E_t(p)\} + g_0\, RetCap_{t-1} + sDr_{t-2} + fD\, RetCap_{t-1} + \\ l_0 DE_t(p) + l_2 DE_{t-2}(p) + qDGDef_t + \sum_{i=0}^{1} g_{t-i} + e_t \end{aligned} \qquad (3)$$

where:

r_t	real Australian 10-year bond yield, deflated with annualised quarterly underlying inflation rates;
$\bar{p}_{10}$	the average rate of inflation over the preceding 10 years;
$E_t(p)$	current inflationary expectations, generated by a Hodrick-Prescott filter of the GDP deflator;
RetCap	return on capital, measured as in Orr *et al.*, as the ratio of gross operating surplus of private corporate trading enterprises to that sector’s capital stock;

---

22 It may also be the case that some degree of liquidity risk exists for Australia, due to a relatively shallow bond market. It is reasonable to expect that this risk is declining over time as the market matures and deepens.

23 Annualised quarterly inflation rates are used to avoid the introduction of autocorrelation.

GDef	Commonwealth Government Budget deficit, expressed as a proportion of GDP (a deficit is denoted as a positive number);
g	domestic GDP growth, measured with the four-quarter-ended growth rate of GDP;
e_t	white noise error term;
Δ	difference operator.

The estimation results are presented in Table 3 (see Table C.2 in Appendix C for the full dynamics). Despite the richness of the Orr *et al.* cross-sectional specification, only the return on capital and the inflation credibility risk premium were found to be significant fundamental determinants of the Australian real bond yield in this time-series model.

Table 3: Real Long Interest Rate Model

Dependent variable: Δr

Explanatory variable		Coefficient (Standard error)	
Speed of adjustment parameter		-0.513***	(0.10)
Return on capital		0.164***	(0.04)
Inflation term : $(\bar{p}_{10} - E_t(p))$		0.256***	(0.08)
$\bar{R}^2$		0.60	
DW		1.76	
ARCH test	c_1^2	0.882	[0.347]
AR (4) test	c_4^2	3.28	[0.512]
Jarque-Bera Normality test	c_1^2	0.96	[0.618]

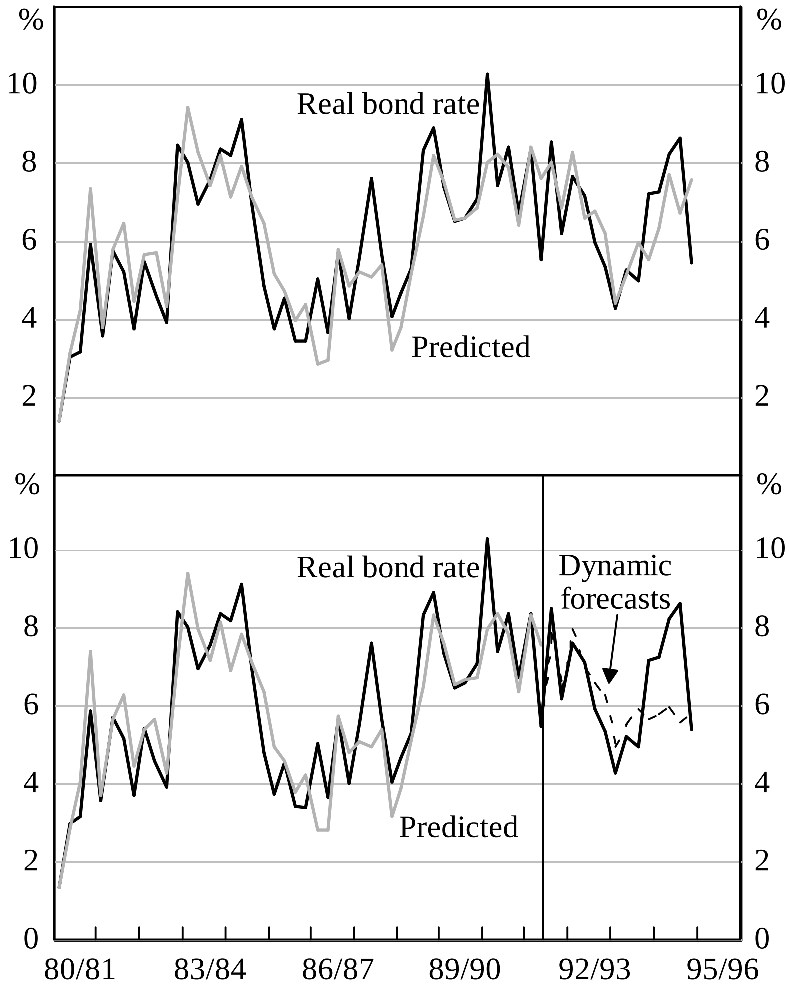
Notes: *** denotes significance at the 1% level. Standard errors are reported in round brackets; probability values are in square brackets.

A one percentage point rise in the domestic return on capital in this model implies an eventual increase in the real long bond yield of about $1/3$ of a percentage point; this compares to around $1/4$ per cent in the Orr *et al.* estimation.

While the inflation differential variable, $(\bar{p}_{10} - E_t(p))$, has some appeal for estimation with panel data, its appropriateness within this time-series framework is difficult to justify. This is because, by construction, the real bond yield will often be relatively high in periods when the current (expected) rate of inflation is low; this will also be true of the inflation variable. That is, the existence of some mean reversion in inflation would generate this positive, significant coefficient on the inflation differential variable.

The fit of the model is represented in the top panel of Figure 8. Out-of-sample forecasts are obtained by estimating the model to December 1991; actual values of the exogenous variables are then used to forecast the real long bond yield forward through time. The results are presented in the lower panel of Figure 8.

Figure 8: Real Long Bond Yield Model Simulation and Out-of-Sample Forecast



The model predicts the fall in the real long bond yield over the early 1990s and its trough in 1993. However, it fails to anticipate the extent of the rise in the real bond yield over the course of 1994, suggesting, perhaps, that the world-wide bond market sell-off was not completely consistent with fundamentals. Despite the fact that a similar pattern was documented in most OECD countries over 1994, the panel estimation in Orr *et al.* also fails to predict bond yield behaviour over this period.

Given the reservations with the model's (likely spurious) dependence on the inflation differential term, $(\bar{p}_{10} - E_t(p))$, it may be the case that the dependent variable, measured as it is, with backward-looking inflationary expectations, is not an adequate measure of the *ex ante* real long bond yield. The remainder of this section concentrates on one alternative method of constructing a forward-looking measure of inflation expectations for inclusion in a model of Australian long bond yields.

4.2 Measuring Inflationary Expectations

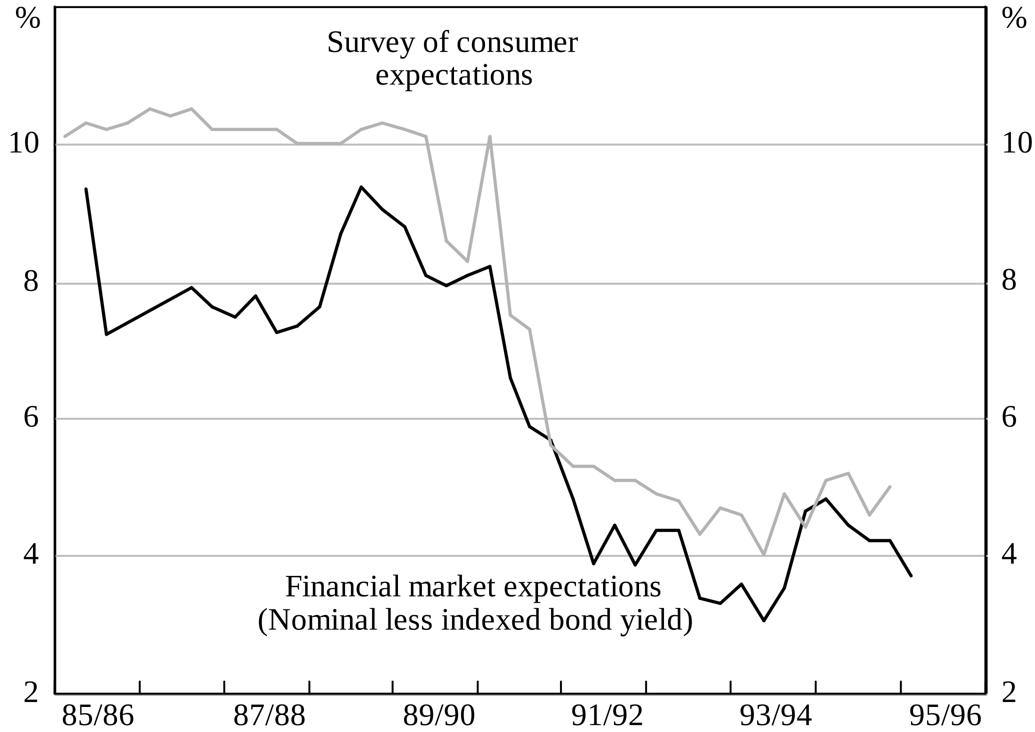
The gap between nominal and indexed 10-year bond yields is often used to estimate *financial market* expectations of the average rate of inflation over the next 10 years. However, in Australia's case, the indexed bond market has only very recently become liquid; historically, indexed bonds were held in concentrated parcels and were not actively traded in a secondary market at all until 1993. An alternative measure of inflationary expectations is available from the Westpac Bank and the Melbourne Institute. A random selection of 1,200 adults aged 18 and above, sampled Australia-wide, are asked to respond to a question about how much they expect prices to rise over the next twelve months; their responses are weighted to reflect population distribution. The disadvantage of this *consumer* survey series for models of the long bond rate is that it asks about inflationary expectations over the next 12 months – not over the next 10 years. Perhaps more importantly, the expectations of consumers might differ from those of financial market participants (Figure 9).

This paper proposes a different approach to measuring expectations which exploits the Markov-switching technique and endogenises shifts in the inflation process through time.[24] In brief, this methodology allows the process of inflation to be

[24] Initial work with Markov-switching models was done by Hamilton (1989,1990) with applications to business cycles. Recent work by Evans and Wachtel (1993) and Laxton, Ricketts and Rose (1994) (and Simon (1996) for Australia) has applied the technique to

characterised by two different regimes, the first identified by relatively high inflation; the second, by relatively low inflation. Switches between these states are based on a probabilistic process.[25] Maximum likelihood estimation of the two-state model returns a probability that inflation is in one or other of these regimes. This is used to construct a probability-weighted *n*-period-ahead inflationary expectations series which is, by its nature, forward looking. Thus constructed, this series is found to be superior to its survey alternative in a model of the nominal bond yield (Section 4.3).

Figure 9: Measures of Inflationary Expectations



inflation with a view to examining the issue of central bank credibility. The Gauss programme used for estimation of the Markov switching model is an adaption of that used by Hamilton (1989) and Goodwin (1993) and I thank Thomas Goodwin for generously providing me with the computor code.

25 A Markov process is one where the (fixed) probability of being in a particular state is only dependent upon what the state was last period.

More specifically, inflation is specified to depend on its own past values and forward-looking measures of the output gap (itself measured by a Hodrick-Prescott filter on GDP(A)). Three forecasting methods are tried.

- Firstly, agents are assumed to have perfect foresight so that they know the output gap existing in the period over which their inflationary forecast is relevant. In this case, the probability-weighted inflationary expectations series is a function of lagged inflation and the actual future output gap; this 'perfect-foresight Markov measure' is denoted $E_{PF_t}(p_{t+n})$:

$$E_{PF_t}(p_{t+n}) = f\{p_{t-1}, GAP_{t+i}\}; \qquad i = 0,1,2,\ldots,n-1. \tag{4}$$

  In this way, inflationary expectations over the next year (n=four quarters) would be $E_{PF_t}(\pi_{t+4})$; over the next 10 years, $E_{PF_t}(\pi_{t+40})$.

- Alternatively, the assumption of perfect foresight can be relaxed so that inflationary expectations are a function of lagged inflation and a *mean-reverting* output gap; this 'mean-reverting Markov measure' is denoted $E_{MR_t}(p_{t+n})$:

$$E_{MR_t}(p_{t+n}) = g\{p_{t-1}, GAP_{t+i}\}; \qquad i = 0,1,2,\ldots,n-1. \tag{5}$$

  where: $$GAP_{t+i} = GAP_{t-1}\left(1 - {}^{(i+1)}\!/_{n}\right)$$

  In this way, n=four quarters is roughly consistent with a four to five year business cycle; at any point in time, t, the output gap is not known (although GAP_{t-1} is known), but is expected to close within five quarters.

- Finally, since similar analysis in the literature has commonly been univariate, the output gap is excluded altogether (this worsens the fit of the model but leaves the general dynamics relatively unchanged).

Quarterly data from the past 35 years (1959:Q4-1995:Q2) are used to estimate the model parameters with maximum likelihood techniques. For convenience, only the results from estimation of the first specification, $E_{PF_t}(p_{t+n})$, which assumes perfect foresight of the output gap, are presented below. State 0 identifies the 1970s and 1980s as episodes of relatively high inflation in Australia and the estimated model describes underlying inflation as a persistent (but not integrated) process around a mean of 8.7 per cent. State 1 identifies the 1960s and 1990s as low inflation regimes where shocks are less persistent and inflation reverts to a mean of 3.3 per cent.

State 0: High inflation regime*

$$p_t^0 = \underset{(0.17)}{0.40} + \underset{(0.07)}{0.81} p_{t-1} + \underset{(0.03)}{0.09} GAP_{t-1} + e_t^0$$

$$e_t^0 = z \cdot \underset{(0.14)}{1.04} \sqrt{s_t^2}$$

$$p(s_t = 0 \mid s_{t-1} = 0) = 0.989$$

State 1: Low inflation regime

$$p_t^1 = \underset{(0.12)}{0.54} + \underset{(0.14)}{0.34} p_{t-1} + \underset{(0.03)}{0.11} GAP_{t-1} + e_t^1$$

$$e_t^1 = z \sqrt{s_t^2}$$

$$p(s_t = 1 \mid s_{t-1} = 1) = 0.980$$

$$z \sim N(0,1) \quad s_t^2 = \underset{(0.03)}{0.14} + \underset{(0.20)}{0.47} e_{t-1}^2$$

* Figures in parenthesis below the parameter estimates are standard errors. The notation follows the standard for ARCH and s_t denotes the state (either 0 or 1) in period t .

Figure 10 illustrates the probability of being in the high inflation state, 0, at each point in time. It is this series which is used to appropriately weight one-step-ahead forecasts from the inflation models of state 0 and state 1 to construct what will be referred to as the ‘Markov inflationary expectations series’.

This approach has two advantages. It explicitly incorporates the forward-looking behaviour customarily associated with financial market participants and assumed in the macro-model approach. Furthermore, this method can deliver a longer-horizon measure of inflationary expectations, n periods ahead, as per (4) or (5). These n-step-ahead estimates embody more realistic, behavioural processes than the simple log linear interpolated values used in the macro models. Expectations two-years-ahead, as well as one-year-ahead, are calculated.

Figure 10: Underlying Inflation and the Probability of Being in the High Inflation Regime

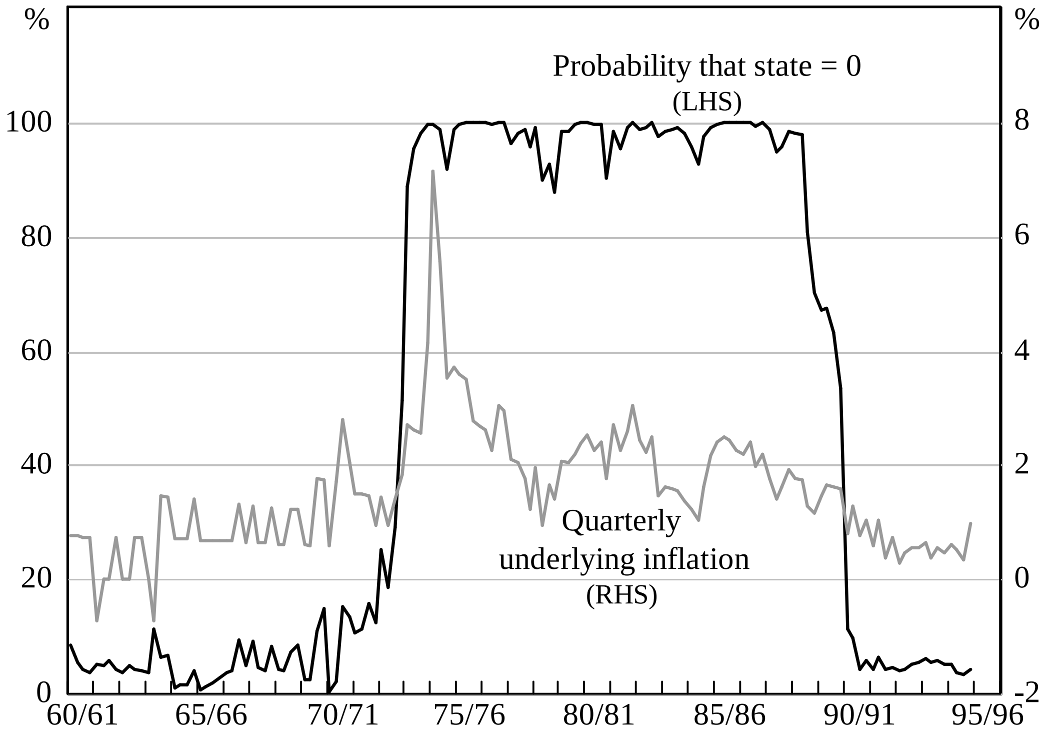
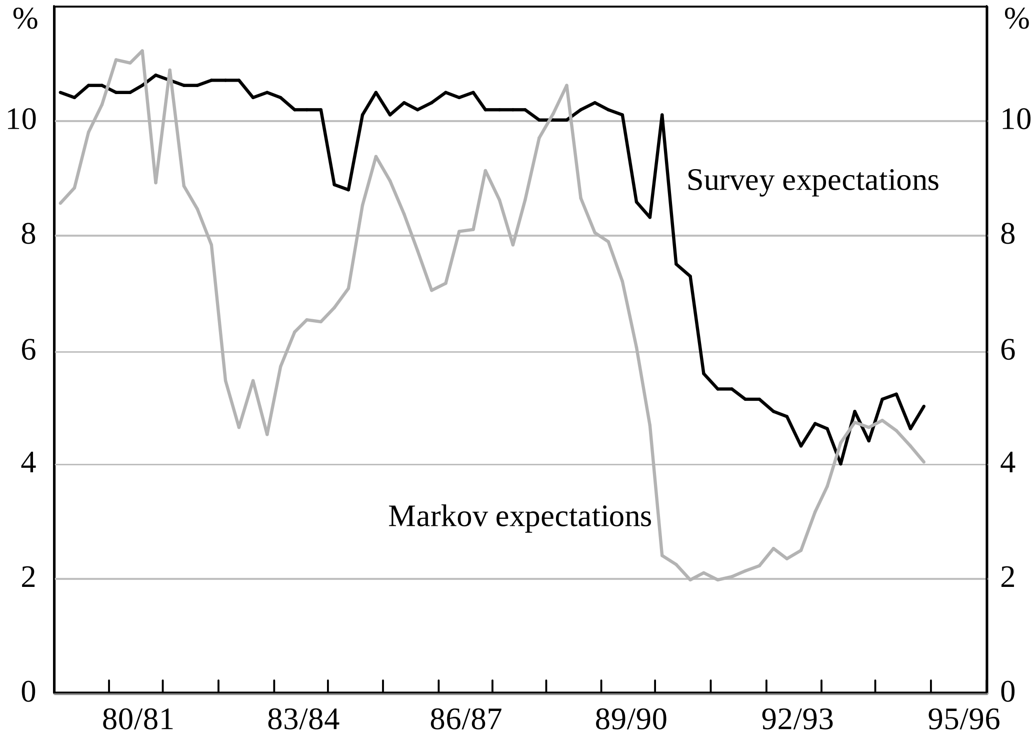


Figure 11: Alternative Measures of Inflationary Expectations



It is clear from Figure 11 that the behaviour of the Markov expectations series is quite distinct from that of the consumer survey measure. For exposition, only the Markov one-year-ahead inflationary expectations, generated by agents with perfect foresight of the output gap, $E_{PF_t}(p_{t+4})$, are illustrated in Figure 11. The alternative, mean-reverting output gap specification and the two-year-ahead forecasts of Markov expectations exhibit similar patterns and timing.

4.3 Empirical Results for the Long Bond Yield Equation With Forward-Looking Inflationary Expectations

The relevance of the various forward-looking Markov expectations series, in contrast to the survey measure of consumer expectations, is examined for explaining movements in the nominal bond yield. This is achieved by estimating an unrestricted ECM of the form:

$$i_t = ai_{t-1} + b\hat{E}_t(p_{t+40}) + gZ + q\Delta X + e_t \tag{6}$$

where:

i_t	nominal 10-year bond yield;
$\hat{E}_t(p_{t+40})$	estimated average rate of inflation expected over the next 10 years proxied either by one of the Markov measures of inflation expectations or the consumer survey measure;
Z	vector of explanatory variables for the real 10-year bond yield as described by Orr *et al.* and discussed in Section 4.1 above; of all the variables listed in Orr *et al.*, only the return on capital and, in one case, the foreign real long bond yield were found to be statistically significant Z variables.
X	vector of dynamics;
e_t	white noise error term.

Four lags of each of the differenced explanatory variables were initially included in the dynamic specification of the model; F-tests were then used to derive the parsimonious final model. Table 4 summarises the results from estimation of (6) using the competing measures of $\hat{E}_t(p_{t+40})$.

Table 4: Australian Nominal Long Bond Yield Equation

Dependent variable: Δi

(1981:Q1-1995:Q2)

$\hat{E}_t(p_{t+n})$				Z			
Model No.	Measure of $\hat{E}_t(p_{t+40})$	ß (t-statistic)	α Speed of adjustment (t-stat)	γ_0 Return on capital (t-stat)	γ_1 r* (t-stat)	$\bar{R}^2$	$H_0: a = -b$ (p-value)
1	$E_{PF_t}(p_{t+4})$	0.204 (4.80)	-0.241 (4.36)	0.079 (2.68)	0.13 (1.90)	0.332	0.61
2	$E_{MR_t}(p_{t+4})$	0.223 (4.10)	-0.226 (4.38)	0.083 (2.97)	—	0.284	0.93
3	Survey	0.262 (3.09)	-0.299 (3.47)	0.083 (2.31)	—	0.271	0.33
4	$E_{PF_t}(p_{t+8})$	0.091 (2.05)	-0.065 (2.95)	—	—	0.216	0.32
5	$E_{MR_t}(p_{t+8})$	0.245 (3.21)	-0.210 (3.61)	0.066 (2.33)	—	0.214	0.44

The Markov one-year-ahead inflationary expectations measure, calculated using the assumption of perfect foresight for the output gap, $E_{PF_t}(p_{t+4})$, was found to have the greatest explanatory power for movements in the nominal long bond yield (Model No. 1); it clearly outperforms the survey measure (Model No. 3).

The alternative Markov measure – which is based on an assumption of mean-reversion in the output gap rather than perfect foresight – but calculated with an equivalent one-year forecast horizon, $E_{MR_t}(p_{t+4})$, also performed better than the survey measure; this is Model No. 2. However, in this specification, the real long foreign bond yield became insignificant.

Two-year-ahead Markov expectations, $E_{PF_t}(p_{t+8})$ and $E_{MR_t}(p_{t+8})$, in Models No. 3 and 4, respectively, were slightly less significant; the foreign long bond yield was insignificant in these equations as well.

The remainder of this section concentrates on the results obtained from Model No. 1’s specification (see Table C.3 in Appendix C for the full estimated dynamics):

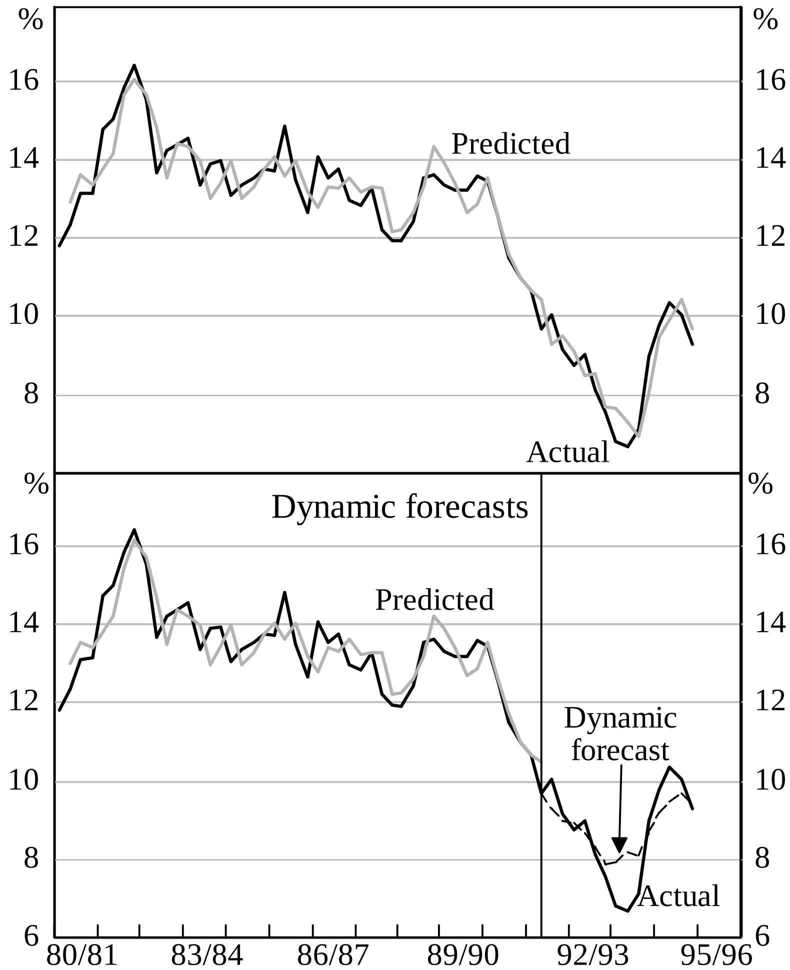
$$Di_t = a i_{t-1} + b\Big[E_{PF_t}(p_{t+4})\Big]_{t-1} + g_0 \, RetCap_{t-1} + g_1 r^*_{t-1} + \sum_{i=0}^{2} q_{0_i} Dr_{t-i} + q_1 D\Big[E_{PF_t}(p_{t+4})\Big]_{t-1} + q_2 g_{t-3} + e_t \qquad (7)$$

where:

i_t	nominal Australian 10-year bond yield;
$E_{PF_t}(p_{t+4})$	Markov model estimates of inflationary expectations as defined in (4) above or consumer survey measure;
RetCap	return on capital;
r^*	US real 10-year bond rate;
g	domestic GDP growth;
e_t	white noise error term;
Δ	difference operator.

Full-sample predictions from this very simple nominal long bond yield equation fit the actual data very well (Figure 12).

Figure 12: Nominal 10-year Bond Yield Dynamic Simulation and Out-of-Sample Forecasts



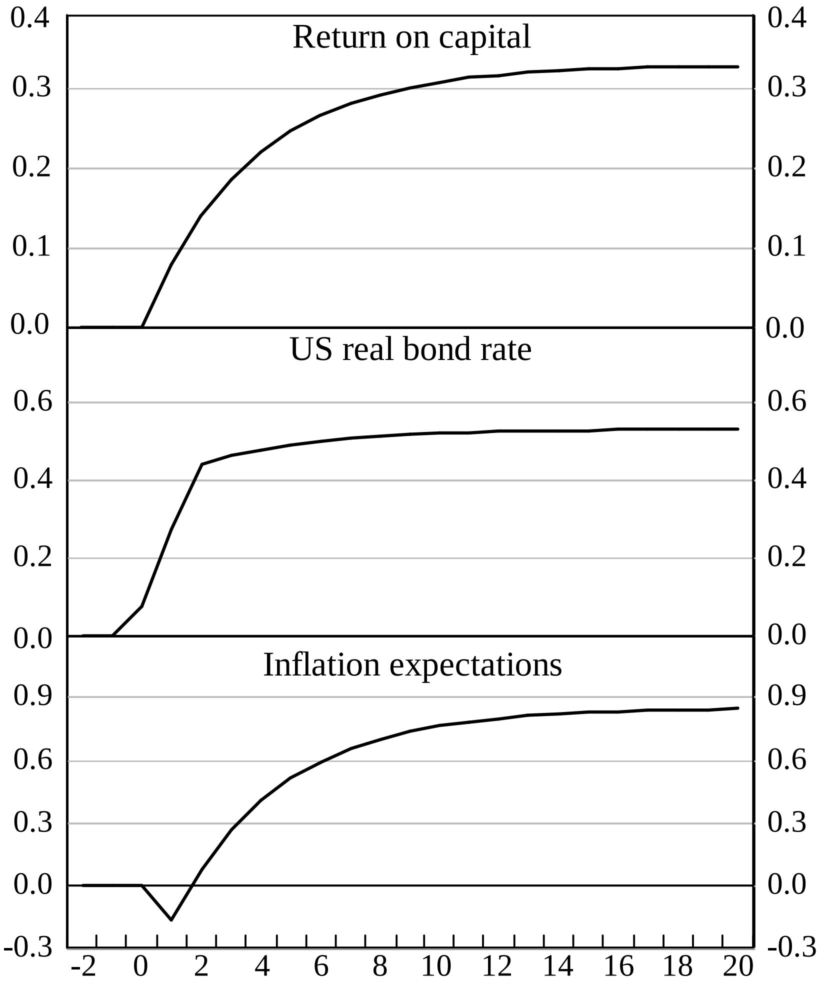
As in Section 4.1, out-of-sample forecasts were obtained by estimating the model to December 1991; actual values of the exogeneous variables were then used to forecast the nominal long bond yield forward in time. The model anticipates the turning point in bond yields in late 1993 as well as their subsequent pick-up over 1994, presumably because it contains the foreign bond yield (r^*); the other models did not.

The null hypothesis in the final column of Table 4 tests that the Fisher Hypothesis holds, such that movements in inflationary expectations are matched one-for-one by movements in the nominal interest rate. This restriction is necessary for valid reparameterisation of Model No. 1 (equation (7)) as a real bond yield equation; the null hypothesis could not be rejected. Trivially, additional restrictions are also accepted such that this model, re-estimated as a real bond yield equation, delivers the same parameter estimates on the *Z* variables.

In this way, while equation (3) in Section 4.1, presented a model of the real 10-year bond yield, deflated with *backward-looking* expectations, equation (7) provides an alternative model wherein real yields are constructed using a *forward-looking* Markov measure of expectations. The main features of this latter model are listed below.

The Australian nominal long bond yield reacts to a change in inflationary expectations with a lag (bottom panel of Figure 13). In contrast, a permanent 1 percentage point rise in the US real long bond rate, *ceteris paribus*, causes the

Figure 13: Bond Yield Responses to Permanent 1% Shocks to Explanatory Variables



Australian real long bond yield to react instantaneously; by the second quarter after the shock, the domestic long bond yield would be around 0.54 of a percentage point higher (panel 2, Figure 13; this is larger than the 0.30 of a percentage point implied by the Orr *et al.* cross-section estimates for Australia).

Consistent with the result obtained from estimation of equation (3), a permanent 1 percentage point improvement in the return on Australian capital raises the domestic real yield by around ⅓ of a percentage point; this response occurs more slowly than that estimated for a change in the US real rate (panel 1, Figure 13).

5. Conclusion

There is no single, simple conclusion to be drawn from this research, but, rather, a series of points can be made.

Interest rates and exchange rates now form part of the transmission mechanism by which policy changes feed through to the broader economy. Expectations play a critical role in this mechanism, affecting both the timing and speed of transmission. Theoretical discussions of interest and exchange rate markets typically characterise expectations as forward looking. However, it has been difficult to model this type of behaviour within an empirical framework.

One approach has been to rely on the relevant components of full-scale, intertemporal macroeconomic models. These models typically embody theoretically consistent, long-run properties and rational, forward-looking expectations in the financial sector. In Australian macroeconomic models, such exchange rate and bond yield equations are not estimated; they reflect orthodox theoretical considerations including uncovered interest parity and the term-structure hypothesis. But the textbook-style results produced by these macro models have limited relevance for practical policymaking.

Alternatively, single-equation, behavioural models can be used to document the observed historical relationships in the data. These have typically assumed that expectations are formed adaptively, that is, are backward looking. The research in this paper concentrates on introducing forward-looking, policy elements into behavioural models of the Australian real exchange rate and long bond yield.

Given that expectations play a central role in determining the responses to various shocks, the macroeconomic and behavioural model approaches are probably best distinguished by a comparison of impulse response functions. In particular, these two methodologies provide different characterisations of the behaviour of the real exchange rate. In the macro-model framework, monetary policy shocks elicit an instantaneous change in the real exchange rate which is subsequently and gradually unwound. In contrast, the behavioural model developed in this paper does not return this instantaneous 'jump' response. Instead, the real exchange rate only gradually transmits a change in monetary policy through to the broader economy so that the full impact of the policy change through this channel is felt with a lag. Despite very different adjustment paths, both models produce final responses of a similar order of magnitude.

On the other hand, about half of a sustained terms of trade shock is finally passed through to the real exchange rate in the macro models; this occurs through an initial jump in the exchange rate, followed by gradual adjustment towards the long run. While this result is theoretically appealing, it does not describe the actual behaviour of the Australian real exchange rate. The behavioural model estimates that the real exchange rate moves much more closely with terms of trade shocks, regardless of whether the shocks are temporary or sustained over very long periods. Some overshooting is estimated to occur immediately. This result is puzzling, but it is consistent with the idea that agents in the foreign exchange market look forward over only a relatively short horizon. The inherent difficulty of incorporating inefficient mechanisms into the macro-model framework may be one source of the disparity between the macro-model results and those recorded by the behavioural models.

Incorporating forward-looking behaviour into a bond yield equation is less straightforward. In this paper, it is achieved by explicitly modelling the formation of inflation expectations. Expectations are generated from a series of assessments about the probability of shifting between a high and a low inflation regime. This is particularly apt in Australia, since a discrete shift in inflationary expectations occurred in the early 1990s. The superior performance of the shorter-horizon measures of inflation expectations suggests that some myopia may exist in this market as well. Further work in this area might consider whether there are roles for both forward and backward-looking elements within the long bond rate model.

Appendix A: Data Sources

The data for Section 3 of the paper were collected for the period from September 1973 to June 1995. The data for Section 4 were collected for the period from December 1979 to June 1995. All indexes are based to 1989/90 = 100. This Appendix lists each of the variables used in the paper together with their method of construction and original data source(s).

Real exchange rate

Index.

Reserve Bank of Australia.

Terms of trade

Index; Seasonally adjusted; Goods and services measure.

The terms of trade was spliced to the goods and services trend measure at September 1974.

Australian Bureau of Statistics, Cat. No. 5302.0, Table 9.

Nominal Gross Domestic Product (GDP)

\$m; Seasonally adjusted; Income measure.

Australian Bureau of Statistics, Cat. No. 5206.0.

Real Gross Domestic Product

Average measure; The growth variable is the quarterly growth of real GDP.

Australian Bureau of Statistics, Cat. No. 5206.0.

Cumulated current account

Current account balance; \$m; Seasonally adjusted.

The cumulated current account for each quarter is calculated as the cumulative sum of quarterly current account balances from September 1959 and taken as a proportion of annualised GDP:

$$\left(ie\ S_{j=1}^{t} current\ account_j / \left(GDP_t \times 4 \right) \right)$$

Australian Bureau of Statistics, Cat. No. 5302.0, Table 3.

Net foreign liabilities

Net International Investment Position at end of period.

$m.

Annual data for the period June 1974 – June 1985, quarterly data thereafter.

Expressed as a proportion of annual GDP.

June 1974-June 1978: Reserve Bank of Australia Occasional Paper No. 8.

June 1979-June 1995: Australian Bureau of Statistics, Cat. No. 5306.0, Table 1.

Fiscal

Commonwealth Government Budget Balance;

The fiscal variable for the four quarters of each fiscal year is measured as the change in the annual Commonwealth Government Budget Balance as a proportion of GDP, calculated on a quarterly basis.

1995/96 Commonwealth Budget Paper No. 1.

Cash rate

Reserve Bank of Australia *Bulletin*, Table F.1, and internal sources.

90-day bank bill

Reserve Bank of Australia *Bulletin*, Table F.1, and internal sources.

10-year bond rate

Reserve Bank of Australia *Bulletin*, Table F.2, and internal sources.

GDP in US dollars

Annual GDP for United States, Canada and the United Kingdom, measured in millions of US dollars, are applied as weights in the construction of world variables. The UK measure of GDP is quarterly and is converted into an annual measure.

World short interest rates

The world short interest rate is calculated as the weighted arithmetic average of short interest rates (3-month Treasury Bills) from the United States, Canada and the United Kingdom. The weights are each country's GDP, measured in US dollars.

World long interest rates

The world long interest rate is calculated as the weighted arithmetic average of long interest rates for the above countries, with GDP in US dollars used as weights.

Real interest rates

Real interest rates for the exchange rate section are calculated by deflating the interest rate by a corresponding measure of four-quarter-ended inflation $\left(ie\,(1 + i_t^i / 1 + p_t^i) - 1\right)$. For the bond yield equation, US long bond yields are deflated by quarter-ended core inflation.

Australia:	Treasury underlying price index; Commonwealth Treasury.
United States:	Underlying price index; Datastream code: *uscpxfdef*.
Canada:	Underlying price index; Datastream code: *cnd20833*. Consumption deflator; Datastream code: *cnipdcone*. The underlying price index is spliced to the consumption deflator at March 1986.
United Kingdom:	Underlying price index; Datastream code: *ukrpiy..f*. Consumption deflator; Datastream code: *ukipdcone*. The underlying price index is spliced to the consumption deflator at March 1987.

Yield differential

The yield differential is calculated as the difference between the Australian and world yield curves. The yield curve for Australia is measured as the difference between the cash rate and the 10-year bond rate. The world yield curve is measured as the difference between short and long nominal world interest rates.

Inflation

Treasury underlying rate.

Commonwealth Treasury.

Return on capital

The return on capital is measured as corporate GOS divided by gross capital stock.

Australian Bureau of Statistics, Cat. Nos 5206.0 and 5221.0.

Markov Inflation Expectations

Constructed from a Markov switching model using underlying inflation and an output gap. The output gap is calculated as the percentage deviation of GDP(A) from a Hodrick-Prescott trend.

Survey of Consumer Inflation Expectations

The survey variable is the Westpac/Melbourne Institute survey of consumer inflation expectations over the next four quarters.

Financial Market Inflation Expectations

Constructed as the simple difference between yields on the nominal 10-year Government Bond and the indexed security of equivalent maturity.

Appendix B: The Behavioural Model of the Australian Real Exchange Rate – Integration Tests and Diagnostics

Table B.1: Testing the Blundell-Wignall *et al.* (1993) Equation – Cumulative Current Account Deficit (CCAD) or Trend?

Model	Estimated coefficient[(a)]			
1985:Q1-1995:Q2	CCAD		Trend	
Original specification – CCAD	-0.281	(-2.60*)		
Adding a trend term	0.626	(1.49)	-0.012	(-2.15*)
Replacing CCAD with a trend term			-0.004	(-3.11**)

Notes: (a) Estimates are taken from the Bewley Transformation of an unrestricted error correction model. Figures in parenthesis denote *t-statistics*; * and ** denote significance at the 10% and 5% levels respectively.

Table B.2: Yield Gap Variable – Testing the Null of the Validity of the Implied Restrictions

$$YGAP = g\left\{(i_S - i_L) - (i_S - i_L)^*\right\}$$

Sample period	Test-statistic	Significance level	
1985:Q1-1995:Q2	1.06	F(3,31)	0.38
1973:Q4-1995:Q2	0.77	F(3,76)	0.51

Table B.3a: Integration Tests (1973:Q4-1995:Q2)

	H$_0$: Non-stationarity					H$_0$: Stationarity	
	Φ_3	t_t	t_m	DF-GLS$_t$	DF-GLS$_m$	KPSS$_t$	KPSS$_m$
Real exchange rate	5.48*	-3.31*	-1.77	-2.92*	-2.03**	0.05	0.78***
Terms of trade	10.06***	-4.07***	-2.86*	-5.67***	-6.22***	0.14*	0.72**
Prices	8.33**	-2.32	-3.80***	0.62	1.68	0.25***	0.17
Current account	7.44**	-3.86**	-2.10	-4.13***	-3.29***	0.13*	0.58**
Debt	1.76	-1.87	-0.26	-3.18**	0.03	0.09	1.06***
Government deficit	6.97**	-3.71**	-3.31**	-1.99	-2.12**	0.08	0.23
Yield gap	5.00	-3.15*	-3.17**	-4.48***	-4.11***	0.13*	0.14
Yield gap*	5.01	-3.16*	-2.78*	-8.43***	-8.83***	0.05	0.26

Notes: *, ** and *** denote significance at the 10%, 5% and 1% levels respectively. Φ_3 refers to the likelihood ratio test of $(a, b, r) = (a, 0, 1)$ in $Y_t = a + bt + rY_{t-1} + e_t$. The critical values are from Dickey and Fuller (1981). t refers to the Augmented Dickey-Fuller (ADF) 't-tests'; t_t includes a constant and trend and t_m includes a constant only. The critical values are from Fuller (1976). DF-GLS$_t$ and DF-GLS$_m$ are a modified trend and constant version, respectively, of the ADF tests proposed by Elliot *et al.* (1992). *KPSS* is a test proposed by Kwiatkowski *et al.* (1992) which tests the null hypothesis of stationarity. A truncation lag of 8 is used for the calculation of the estimate of the error variance.

Table B.3b: Integration Tests (1984:Q1-1995:Q2)

	H$_0$: Non-stationarity					H$_0$: Stationarity	
	Φ_3	t_t	t_m	DF-GLS$_t$	DF-GLS$_m$	KPSS$_t$	KPSS$_m$
Real exchange rate	3.03	-2.36	-2.26	-4.93***	-2.22**	0.08	0.16
Terms of trade	8.96**	-4.17***	-4.24***	-3.63**	-3.43***	0.07	0.08
Prices	6.67*	-1.99	-3.60***	-1.14	1.12	0.17**	0.61**
Current account	6.13*	-3.43*	-3.37**	-4.78***	-5.56***	0.07	0.12
Debt	11.35***	-4.74***	-0.07	-3.39**	0.76	0.06	0.63**
Government deficit	6.61**	-3.31*	-3.23**	-1.27	-1.55	0.15**	0.15
Yield gap	6.78**	-3.63**	-2.46	-5.48***	-6.14***	0.13*	0.32
Yield gap*	2.78	-2.29	-2.37	-4.08***	-5.02***	0.13*	0.13

Notes: *, ** and *** denote significance at the 10%, 5% and 1% levels respectively. Φ_3 refers to the likelihood ratio test of $(a, b, r) = (a, 0, 1)$ in $Y_t = a + bt + rY_{t-1} + e_t$. The critical values are from Dickey and Fuller (1981). t refers to the Augmented Dickey-Fuller (ADF) 't-tests'; t_t includes a constant and trend and t_m includes a constant only. The critical values are from Fuller (1976). DF-GLS$_t$ and DF-GLS$_m$ are a modified trend and constant version, respectively, of the ADF tests proposed by Elliot *et al.* (1992). *KPSS* is a test proposed by Kwiatkowski *et al.* (1992) which tests the null hypothesis of stationarity. A truncation lag of 8 is used for the calculation of the estimate of the error variance.

The DF-GLS test (Elliot *et al.* 1992) is a modified version of the Augmented Dickey-Fuller (ADF) t-test, having the advantages that it exhibits superior power properties and suffers from only small size distortions in finite samples. The testing procedure involves firstly demeaning or detrending the series using Generalised Least Squares and then running the ADF test regression using that series. The constant and time trend terms are omitted from the test regression. The t-statistic on (ρ-1) is then used to test for significance against the appropriate critical value. The demeaned case (DF-GLS$^{\mu}$) is comparable to including a constant term in the ADF test; the critical values are taken from Fuller (1976) and the no-constant variant of the MacKinnon (1991) table. The detrended case (DF-GLS$^{\tau}$) is comparable to including a constant and a time trend in the ADF test; the critical values have been tabulated by Elliot *et al.*

The KPSS (1992) test is applied in the following way. All series can be written as the sum of a trend (ξ_t), a random walk (r_t), and a stationary component (ε_t) such that:

$$y_t = x_t + r_t + e_t$$

where: $r_t = r_{t-1} + u_t.$

If the series is stationary (that is, there is no random walk component), the variance of u_t will be zero. The test statistic for the null hypothesis of no unit root is an LM statistic which is a function of estimated residuals and an estimate of the long-run error variance. These residuals are either the demeaned series (h_m) or the demeaned and detrended series (h_t). The critical values for these tests are detailed in Kwiatkowski *et al.* (1992, p.166).

These tests provide evidence over the full sample period (1973:Q4-1995:Q2) that the real exchange rate; terms of trade; interest differentials; yield gaps; current account deficit; government budget balance; and relative productivity differentials are I(0), with the first two series exhibiting this stationarity around a trend. These conclusions are also supportable over the shorter sample period (1984:Q1-1995:Q2).

Table B.4: A Comparison of the Statistical Significance of Competing Measures of Interest Rates in the Real Exchange Rate Equation(a) (1985:Q1-1995:Q2)

Interest differential term	Estimated coefficient	t-statistic	(p-value)
$\left\{(i_S - i_L) - (i_S - i_L)^*\right\}$	1.10	3.10	(0.00)
$\left(r_S - r_S^*\right)$	0.90	2.62	(0.01)
$\left(r_L - r_L^*\right)$ as per the BW equation.	1.11	1.82	(0.08)
$\left(r_L - r_L^*\right)^{(b)}$	1.81	2.47	(0.02)

Notes: (a) The real TWI exchange rate model is specified as a function of the terms of trade; the cumulated current account deficit; an interest differential term; and a fiscal policy variable.

(b) The real long interest differential is here tested in the BW specification which expresses the real TWI as a function of the terms of trade; the cumulated current account deficit as a proportion of GDP; and the real long interest rate differential.

Figure B.1: Diagnostics
Real Exchange Rate Model – Equation (2)

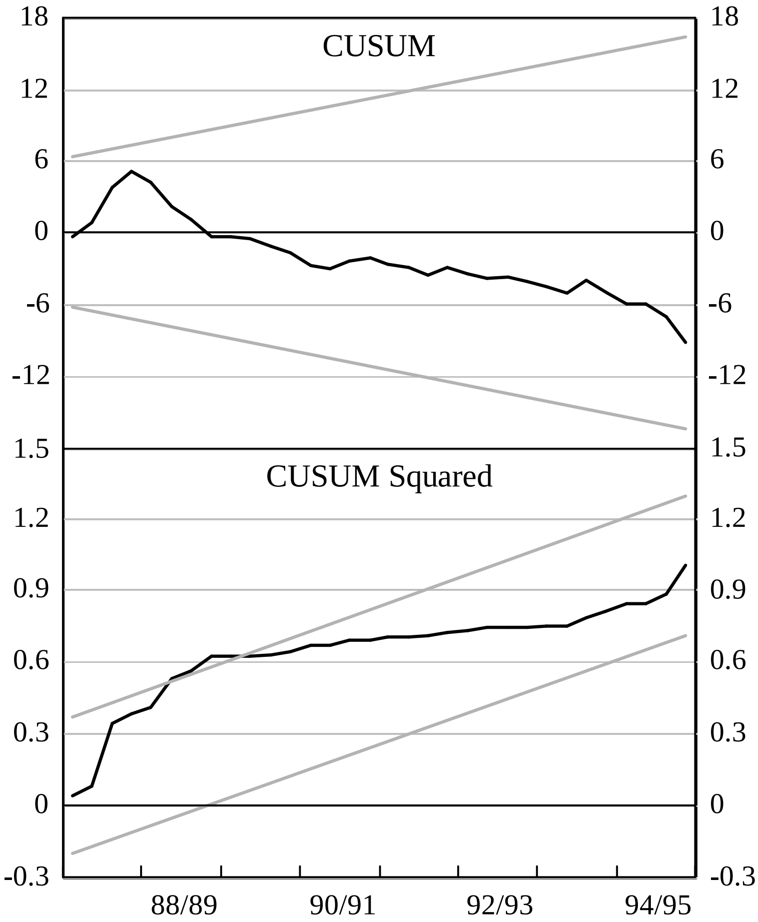


Figure B.2a: Parameter Stability Tests

Yield differential

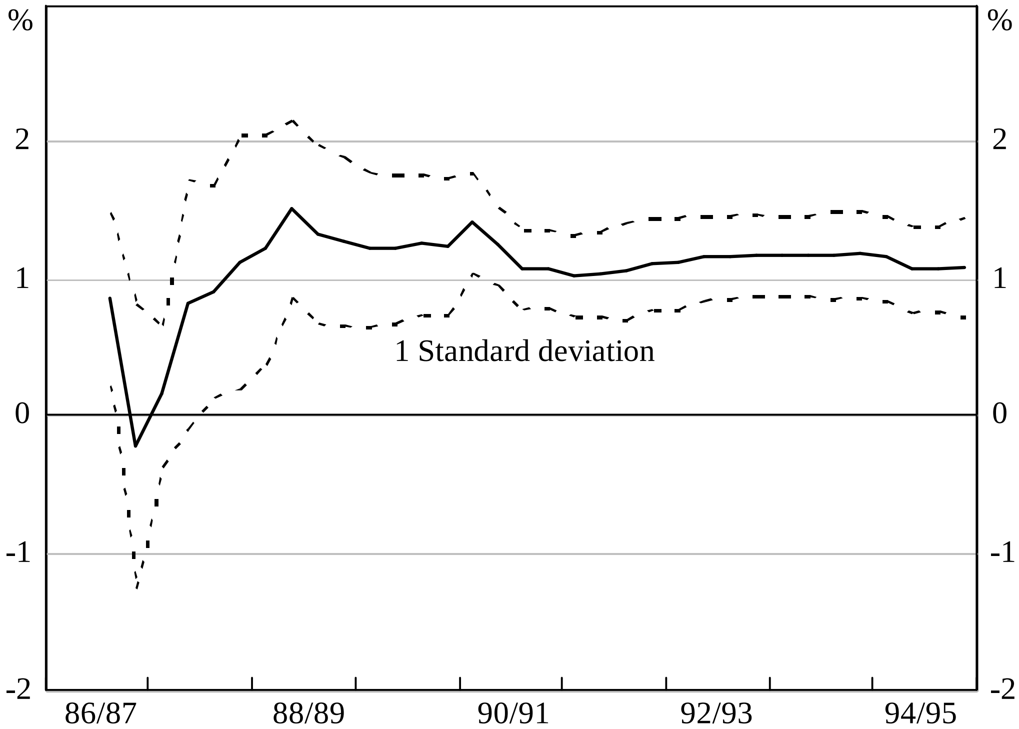
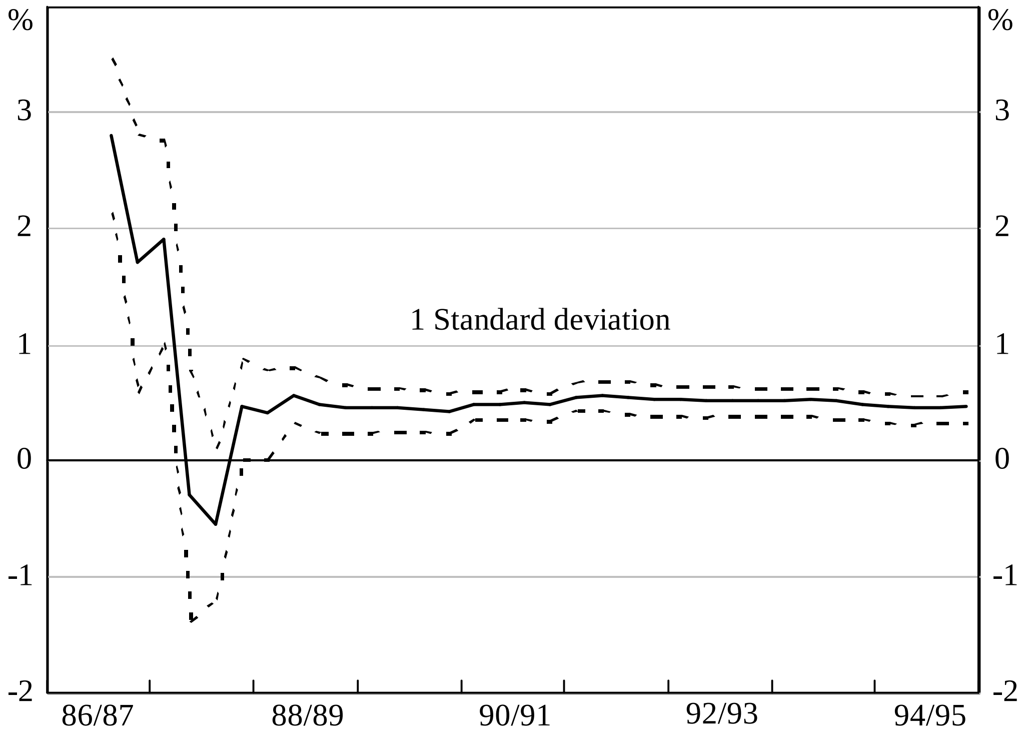


Figure B.2b: Parameter Stability Tests

Terms of trade



Appendix C: The Behavioural Model of Australian Long Bond Yields – Integration Tests and Diagnostics

Table C.1: Integration Tests (1979:Q4-1995:Q2)

	H_0: Non-stationarity					H_0: Stationarity	
	Φ_3	t_t	t_m	DF-GLS$_t$	DF-GLS$_m$	KPSS$_t$	KPSS$_m$
Real 10-yr bond	10.51***	-4.37***	-4.31***	-11.24***	-11.94***	0.08	0.43*
Real US 10-yr bond	4.38	-2.94	-2.63	-1.21	-1.46	0.12*	0.12
Return on capital	6.29**	-3.53**	-3.49**	-3.56**	-3.60***	0.10	0.19
Cash rate	2.47	-1.96	-1.42	-5.29***	-5.90***	0.16**	0.28
Government deficit	5.14	-3.18*	-3.19**	-2.64	-2.56**	0.11	0.11
Undiversifiable risk	1.36	-1.60	-1.52	-6.52***	-7.46***	0.12*	0.13
Current account	3.54	-2.21	-2.68	-3.39**	-5.54***	0.21**	0.51**
Inflation expectations	12.03***	-4.89***	-2.80	-3.68**	-2.15**	0.07	0.39*
Δ Inflation	58.8***	-10.80***	-10.84***	-1.79	-0.77	0.08	0.11

Notes: *, ** and *** denote significance at the 10%, 5% and 1% levels respectively. Φ_3 refers to the likelihood ratio test of $(a, b, r) = (a, 0, 1)$ in $Y_t = a + bt + rY_{t-1} + e_t$. The critical values are from Dickey and Fuller (1981). t refers to the Augmented Dickey-Fuller (ADF) 't-tests'; t_t includes a constant and trend and t_m includes a constant only. The critical values are from Fuller (1976). DF-GLS_t and DF-GLS_m are a modified trend and constant version, respectively, of the ADF tests proposed by Elliot *et al.* (1992). $KPSS$ is a test proposed by Kwiatkowski *et al.* (1992) which tests the null hypothesis of stationarity. A truncation lag of 8 is used for the calculation of the estimate of the error variance.

All three tests support the stationarity of the Australian real 10-year bond rate around a constant or a trend. On the other hand, evidence for the US real long bond rate is mixed; the ADF and DF-GLS tests fail to reject their null of a unit root, but the KPSS test fails to reject the null hypothesis that the US real long bond rate is stationary around either a mean or a trend. The return on domestic capital and inflationary expectations are both clearly stationary; the ratio of the Commonwealth government budget balance to GDP is mean stationary; the evidence for the undiversifiable risk term, 'beta', is mixed.

Table C.2: Real Long Bond Equation (3)
Dependent variable: Change in real bond
(1981:Q1-1995:Q2)

Explanatory variable		Coefficient (Standard error)
Speed of adjustment parameter		-0.513*** (0.10)
Return on capital		0.164*** (0.04)
Inflation term : $(\overline{p}_{10} - E_t(p))$		0.256*** (0.08)
Δ Real bond$_{t-2}$		0.369*** (0.12)
Δ Return on capital$_{t-1}$		0.431* (0.23)
Δ $E_t(\pi)$		-1.22*** (0.22)
Δ $E_{t-2}(\pi)$		0.93*** (0.29)
Δ Government deficit$_t$		0.89* (0.52)
Growth$_t$		0.40* (0.21)
Growth$_{t-1}$		-0.39* (0.20)
$\overline{R}^2$		0.60
DW		1.76
ARCH test	c_1^2	0.882 [0.347]
AR (4) test	c_4^2	3.28 [0.512]
Jarque-Bera Normality test	c_1^2	0.96 [0.618]

Notes: *, ** and *** denote significance at the 10%, 5% and 1% respectively. Standard errors are in parentheses; probability values are in square brackets.

Figure C.1: Real Long Bond Equation (3)

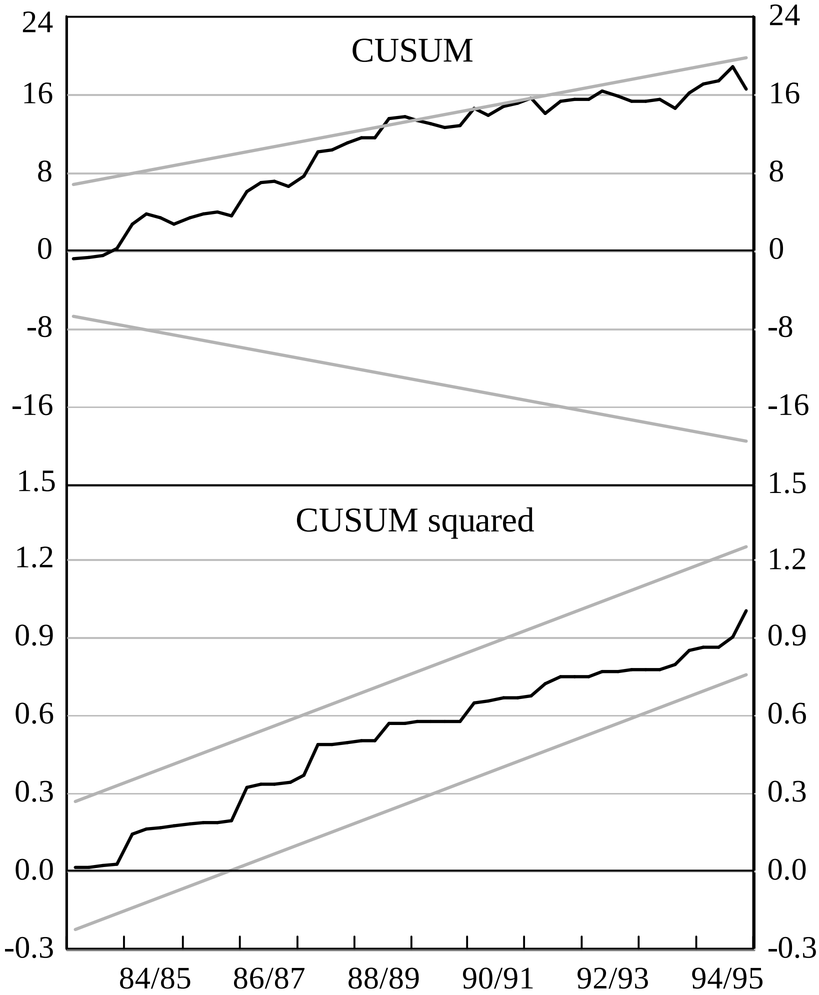


Figure C.2: Nominal Bond Equation (7)

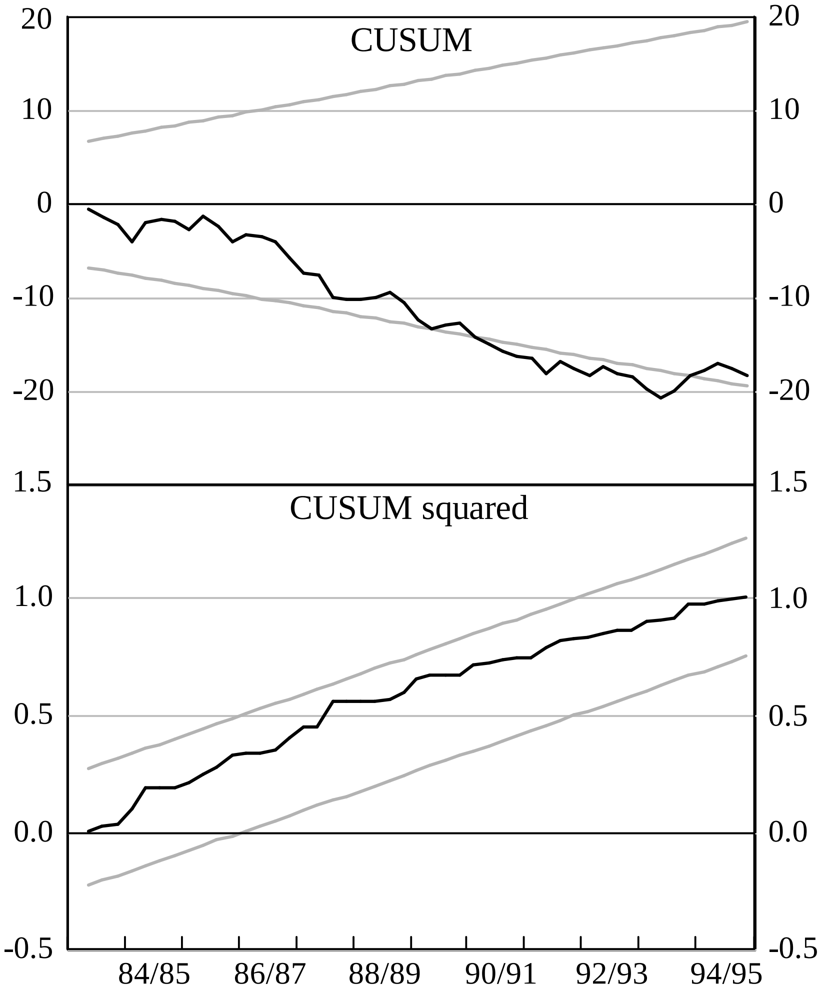


Table C.3: Nominal Bond Equation (7) Specification

Dependent variable: Change in nominal bond

(1981:Q1-1995:Q2)

Nominal Bond$_{t\text{-}1}$	-0.241***
	(0.055)
Return on Capital $_{t\text{-}1}$	0.079***
	(0.029)
US Real Rate$_{t\text{-}1}$	0.127*
	(0.67)
Perfect Foresight 1-year-ahead Markov Expectations$_{t\text{-}1}$	0.204***
	(0.042)
$\underset{i=0}{\overset{2}{S}}\left(D\,Real\,Rate\right)_{t-i}$	0.268*
	{0.084}
D Markov Expectations $_{t\text{-}1}$	-0.375***
	(0.136)
D GDP$_{t\text{-}3}$	-0.304***
	(0.111)
$\bar{R}^2$	0.332
DW	2.07
ARCH test c_1^2	0.416
	[0.519]
AR (4) test c_4^2	3.0846
	[0.544]
Jarque-Bera Normality test c_2^2	1.408
	[0.495]

Notes: *, ** and *** denote significance at the 10%, 5% and 1% respectively. Standard errors are in brackets (), probability values are in square brackets and the F-test for the joint significance of the US real rate dynamics are in parenthesis.

The small negative coefficient on the third lag of growth in the dynamics of equation (7) corresponds with the (roughly) three-year cycle in bond yields in Australia.

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