The Stability of Real Interest Rates in Australia: 1975 - 1997

by

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Abstract

This paper investigates the stability of Australian ex ante real interest rates for a range of maturities. Both ex ante real and nominal interest rate series are found to be nonstationary even after allowing for the possibility of structural breaks using techniques developed by Zivot and Andrews (1992).

The ex ante real rates investigated in this paper use survey-based expectations of inflation. The expected inflation time series is found to be stationary once a structural break (identified as September 1990) is allowed.

The implication for investors is that returns on the Australian securities considered (13 week T/N's, 2, 5, and 10 year government bonds) are volatile and therefore uncertain. In broad measure, changes in the stance of monetary policy engender volatility while inflationary expectations are comparatively stable.

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1. Introduction

This paper investigates the stability of ex ante real interest rates in Australia. The motivation for studying this issue comes from Shiller's (1979) general observation about the excessively volatile nature of returns in US financial markets. A particularly important aspect of volatility is the stability or otherwise of expected real interest rates which are such important determinants of investment and savings decisions.

The stability of real rates also determines the relevance of some of the major paradigms of finance theory for the operation of capital markets and the macroeconomy. Rose (1988), for example, shows that the central equilibrium relationship[1] of the consumption capital asset pricing model (CCAPM) holds only if the ex ante real rate of interest is stationary in the unit root sense.

The first contribution of this paper derives from the fact that it incorporates survey-based inflation expectations[2] into the ex ante real interest rate. The existence of this data enables the time series of ex ante real interest rates to be observed directly; no assumptions or models are required to construct this series.

The other main contribution of this paper derives from the utilisation of an econometric technique developed by Zivot and Andrews (1992) to test for the stability of a time series in which the presence of a structural break is allowed. An overview of this technique is provided.

[1] This equilibrium relationship links current (c_t) and future consumption (c_{t+1}) with the real return on an asset with i days to maturity $E_t\left[\beta\left(\frac{c_t}{c_{t+1}}\right)^{\alpha}\left(1+r_{it+1}\right)\right]=1$ where β is the discount factor; α a risk coefficient.

[2] The Westpac/Melbourne Institute of Applied Economics and Social Research expected inflation rate series.

The US evidence universally rejects the notion of stationarity or stability of US real rates with one notable exception. Fama (1975) found evidence of a constant real rate of interest for US Treasury bills on monthly data over the period 1953 to 1971 from which he concludes that nominal T/bill rates varied with expected inflation and that the Fisher hypothesis held. Fama's results are refuted by Shiller (1980) and Mishkin (1981) who suggest that Fama's chosen sample period is unrepresentative of twentieth century experience. Analyses[3] which follow Fama's original paper refute his main outcome, finding that US real rates are not constant.

Several of these early studies include tests for the stability of the two series comprising real rates: the nominal rate and expected inflation. These further analyses serve the useful purpose of indicating the source of any real rate instability and if inflation has any direct impact on real as distinct from nominal rates.

A recent study which offers qualified support for Fama's (1975) assertion that real rates are constant is Garcia and Perron (1996) (henceforth, GP(1996)). These authors concluded that:

> "[our] results support Fama's original characterisation of the ex ante [real] single interest rate as essentially constant with, however, the crucial difference that the mean of the series is subject to occasional shifts."
>
> Garcia and Perron (1996, p111).

Three comments about this result are warranted. First, by employing the regime-switching technique of Hamilton (1989), GP have increased the probability of finding stable ex ante real rates in subperiods. Second, like all of the other studies cited in this paper, GP did not have a data set of actual expectations available to them. In their case, ex ante real rates are *constructed* using parameters previously estimated from their regime-switching

[3] Garbade and Wachtel (1978), Nelson and Schwert (1977) and Fama and Gibbons (1982) are included among these.

model of ex post real rates. Finally, a direct comparison of their results with those found here is not feasible because the necessity to model the ex ante rate is eliminated in the case of Australia.

Our purpose is to test for the stationarity of the following ex ante Australian real interest rate series: 13 week Treasury Notes (T/Ns), and two, five and ten year Australian government bonds. We test also for the stationarity of the associated nominal rate and expected inflation rate series. We have chosen rates on series across the maturity spectrum to determine if real rates are comparatively more stable at the long end of the maturity spectrum.

2. Methodology, Data and Results

The analysis is based on tests for the stationarity of the ex ante real interest rate defined in the usual fashion:

$$r_{it}^{e} = i_{it} - \Pi_{t}^{e} \qquad (1)$$

The expected value of the real rate of interest on asset i is the difference between the nominal rate (i_{it}) and the expected inflation rate (Π_{t}^{e}). In many countries Π^{e} is not observable. A common solution to this problem is to assume that agents form expectations about inflation rationally and use the expost realised inflation rate as a proxy for ex ante inflation. This rational expectations approach is not required on Australian data because a monthly expected inflation time series is available.[4] This is the median value of expected inflation calculated from the survey data.

Expected inflation in each period t is used to calculate four individual real rate series representing the full maturity spectrum. These are the expected real rates on 13 week Australian Treasury Notes and the ex ante real rate on two, five and ten year Australian

[4] The Westpac/Melbourne Institute of Applied Economics and Social Research expected inflation rate series.

government bonds. This selection of securities ensures that tests for the stability of expected returns apply across the entire maturity spectrum.

The individual nominal rate series for Australian T/Ns, two, five and ten year Australian bonds are end of month rates published by the Reserve Bank of Australia.[5] The monthly time series used in this study dates from December 1975 to December 1997 a sample comprised of 264 observations.

The first step of the analysis involves a standard ADF test for a unit root in each of the real rate time series. These tests for stationarity are based on the t ratio $\left(\hat{t}_\alpha\right)$ associated with the coefficient (α) on the lagged value of the real rate $\left(r_{t-1}\right)$ in a standard augmented Dickey-Fuller model. Estimated values of $\hat{t}_\alpha$ are shown on column (1) of Table 1. The result of this first step is that each of the four Australian real rate series is nonstationary in levels.

Zivot and Andrews (1992), among others, indicate that standard unit root tests can be misleading if time series are susceptible to structural change. They propose three tests for stationarity which accommodate separate level shifts (Model 1), trend shifts (Model 2) and a model combining both level and trend shift (Model 3)[6]. The alternative hypothesis for the ZA test is that the time series is stationary subject to a structural break. To test this alternative

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[5] These data were purchased from *Global Financial Data* and are derived from various monthly issues of the *RBA Bulletin.*

[6] Model (1)
$$r_t = a_1 + b_1 t + \omega_{11} DU_t(\lambda) + \sum_{i=1}^{m} \theta_{1i} \Delta r_{t-i} + \alpha_1 r_{t-1} + \varepsilon_t \tag{2}$$

Model (2)
$$r_t = a_2 + b_2 t + \omega_{21} DT_t(\lambda) + \sum_{i=1}^{m} \theta_{2i} \Delta r_{t-i} + \alpha_2 r_{t-1} + \varepsilon_t \tag{3}$$

Model (3)
$$r_t = a_3 + b_3 t + \omega_{12} DU_t(\lambda) + \omega_{22} DT_t + \sum_{i=1}^{m} \theta_{3i} \Delta r_{t-i} + \alpha_3 r_{t-1} + \varepsilon_t \tag{4}$$

$$\lambda = t_b / T \tag{5}$$

where λ indicates a potential breakpoint in the time series.

against the null of nonstationarity, t ratios for coefficients on the lagged value of the real interest rate in each model are calculated. These are labelled $\hat{t}_{\alpha_1}, \hat{t}_{\alpha_2}$ and $\hat{t}_{\alpha_3}$ for ZA's model (1), (2) and (3). The ZA procedure is based on a series of regressions of (2) to (4), one for each value of λ. The parameter λ represents potential breakpoints and lies in the range (0,1). Each of the three models is estimated for every λ and the t-statistics for each $\alpha_i (i = 1,....3)$ estimated. To test for a unit root subject to a structural break select the minimum value of each ADF statistic t_{α_i} in estimates of (2) to (4):

$$\inf_{l \in (0,1)} t_{a_i}(l) \quad \text{for each i, i} = 1, 2, 3. \tag{6}$$

The smallest value of $t_{\alpha_i}(\lambda)$ increases the prospect of rejecting the null hypothesis of nonstationarity subject to a structural break. It is these minimum values of t_{α_i} which appear as $\hat{t}_{\alpha_i}$ on Table 1. The estimated values of these t statistics are recorded on columns (2), (3) and (4) and rows (1) to (4) of Table 1 for the four real rates.

All estimated values of the indicated $\hat{t}_{\alpha_i}$ are greater (less negative) than the relevant cut off scores provided at the foot of Table 1 indicating that the null hypothesis cannot be rejected. When level shifts (Model (1)) or combined level and trend shifts (Model (2)) are allowed, real rate series remain nonstationary. The values of $\hat{t}_{\alpha_1}$ and $\hat{t}_{\alpha_3}$ exceed the relevant cut off scores. However, there is some rather weak evidence of stationarity with trend shifts in the case of the real return to 13 week T/Ns and to 5 year bonds: $\hat{t}_{\alpha_3}$ is less than the relevant cut off score at the 10 but not 5 percent levels. The T/N series breaks in August 1985 and the 5 year bond return series in November 1981. This evidence is not strong and does not alter the following general conclusion: the four selected Australian real interest rates form nonstationary time series with and without break.

Table 1: Australian Interest Rates and Expected Inflation: Unit Root Tests With and Without Structural Breaks

	Time Series r_{it}	**ADF[(1)] Without Break**	**ADF With Break** Model (1)	Model (2)	Model (3)
		(1)	(2)	(3)	(4)
		$\hat{t}_{\alpha}$	$\hat{t}_{\alpha_1}$	$\hat{t}_{\alpha_2}$	$\hat{t}_{\alpha_3}$
(1)	13 wk T/NS	-2.78	-4.45	-4.13*[(3)] 85(8)	-4.34
(2)	2 year bond	-2.08	-3.51	-3.92	-3.94
(3)	5 year bond	-1.86	-3.75	-4.24* 81(11)	-4.22
(4)	10 year bond	-1.77	-3.73	-4.03	-3.93
	Time Series i_{it}				
(5)	13 Wk T/N:	-2.62	-4.37	-2.68	-4.62
(6)	Bonds 2 Yrs:	-2.16	-3.70	-2.02	-3.76
(7)	Bonds 5 Yrs:	-1.88	-3.42	-3.47	-3.56
(8)	Bonds 10 Yrs:	-1.79	-3.65	-3.79	-3.95
(9)	**Time Series P_t^e**	-1.60	-6.22*** 90(9)	-2.38	-4.58

(1) Estimated with 12 lags suggested by Schwartz criterion

(2) Cut off scores		$\hat{t}_{\alpha}$	$\hat{t}_{\alpha_1}$	$\hat{t}_{\alpha_2}$	$\hat{t}_{\alpha_3}$
***Signif. at	0.01:	-3.96	-5.34	-4.93	-5.57
**Signif. at	0.05:	-3.41	-4.80	-4.42	-5.08
*Signif. at	0.10:	-3.13	-4.58	-4.11	-4.82

(3) Date of structural break

[+]Cut off $\hat{t}_{\alpha}$ from Davidson and Mackinnon (1993, p. 708).

Cut offs for $\hat{t}_{\alpha_i}$, Zivot and Andrews (1992)

The importance of the nonstationarity of Australia's real rates for investors and policy makers motivates a further question: is volatility in the form of nonstationarity mirrored by Australia's nominal rate structure, or is it explained by the nonstationary behaviour of inflationary expectations? The answer is derived from rows (5) to (8) of Table 1 where $\hat{t}_{\alpha}$ and $\hat{t}_{\alpha_i}$ are recorded for the nominal rate structure. From column (1) there is no evidence from the standard augmented Dickey-Fuller unit root tests to reject the null hypothesis of nonstationarity at the 10% level. In every case $\hat{t}_{\alpha}$ exceeds the 10% cutoff score of -3.13.

A similar conclusion applies to the ZA tests for stationarity of nominal rates allowing for the presence of structural breaks. This conclusion is based on an examination of the values $\hat{t}_{\alpha}$ and $\hat{t}_{\alpha_i}$ in rows (5) to (8) of Table 1. Without exception, $\hat{t}_{\alpha}$ and $\hat{t}_{\alpha_i}$ are greater than the relevant cut off score. Rejection of nonstationarity, even after allowing for structural breaks, is inappropriate.

The expected inflation time series is examined next. It is found to behave differently. This is evident on row (9) of Table 1. Although the standard Dickey-Fuller test for unit roots leads to the conclusion of non stationarity, the story is a different one if structural breaks are allowed. The value of $\hat{t}_{\alpha_1}$ (-6.22) is significant at the 0.01 level indicating stationarity after allowing a shift in levels in September 1990.

Investors and policy makers appear to be more often concerned with the behaviour of interest rate levels through time and observe less often first differences of nominal interest rate series. For this reason, no detailed[7] analysis of stationarity tests for the first difference of interest rates are detailed. However, a general result emerges from differencing: the null of nonstationarity of nominal, real rates and expected inflation can be rejected at the 1% level in all cases considered. All of the series examined are found to be I(1).

3. Conclusions

The general inference drawn from this study is that the level of Australian ex ante real interest rates are volatile in the sense of forming nonstationary time series. This applies to interest rate levels across the maturity spectrum. There is some weak evidence for the stationarity of the real rates on 13 week T/Ns and 5 year bonds subject to trend shifts occurring in August 1985 and November 1981 respectively. These dates coincide with major

[7] Results are available from the authors.

policy changes and movements in liquidity. The Australian economy was experiencing a growth boom in August 1985 based on the upswing in the world economy and the breaking of a long drought which produced an export led recovery. This growth phase forced the Australian monetary authorities to tighten liquidity rapidly forcing nominal and real rates up sharply. These policy effects are more evident in the 13 week T/N series because these securities provide a major source of liquidity to the Australian public sector. Liquidity shortages force short term T/N rates up more rapidly than bond rates. The 5 year bond rate series displays some limited evidence of a trend shift in November 1981 in the midst of a severe recession in Australia. The monetary authorities responded by cutting nominal rates sharply leading to a sudden fall in real rates in late 1981.

The evidence for stationarity in these cases is weak (10% level of significance only) and does not warrant the general conclusion that the ex ante real rate series analysed here form stationary time series. Rather, the weight of the evidence is to the contrary: these Australian ex ante real rates are nonstationary even allowing for the possibility of structural breaks. However, first differences of these four ex ante real rate series are found to be stationary.

The consequences of nonstationary real rate structures for Australian investors are substantial. Potential investors in the T/N or bond markets are confronted with considerable uncertainty in relation to the real return on these investments. Further, this perception of non constant real returns on government securities means that the predictions of some well known finance models may not apply to the Australian market, for example, CCAPM.

Turning to the volatility of the components of the real rate, we find that the expected inflation rate series does exhibit the properties of a stationary time series provided we allow for a level shift in this time series. Expectations appear to be revised in September 1990 in the early stages of the 1990-92 recession in Australia. Agents in the economy may have anticipated a rapid reduction of inflation as the recession worsened. Inflation had reached 12 percent for the 12 months to June 1990 but had fallen to less than 2 percent in the twelve months ended June 1992. The evidence adduced in this analysis suggests that inflationary expectations are comparatively stable and that we must look elsewhere to find the cause of instability of Australian ex ante real rates. The evidence indicates that this must be the nominal rate structure. The short term 13 week T/N rate and the return on 2, 5, and 10 year bonds is stationary in first differences but not in levels mirroring the outcomes for corresponding real rates.

The overriding conclusion of this analysis is that our sample of Australian ex ante real rates of interest are volatile making investments in T/Ns and Australian government bonds less certain for investors. On the face of it monetary policy effects are responsible for some of this instability while expected inflation is stable by comparison.

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