Economics & Markets Research

Modelling US & Australian 10-year bond yields

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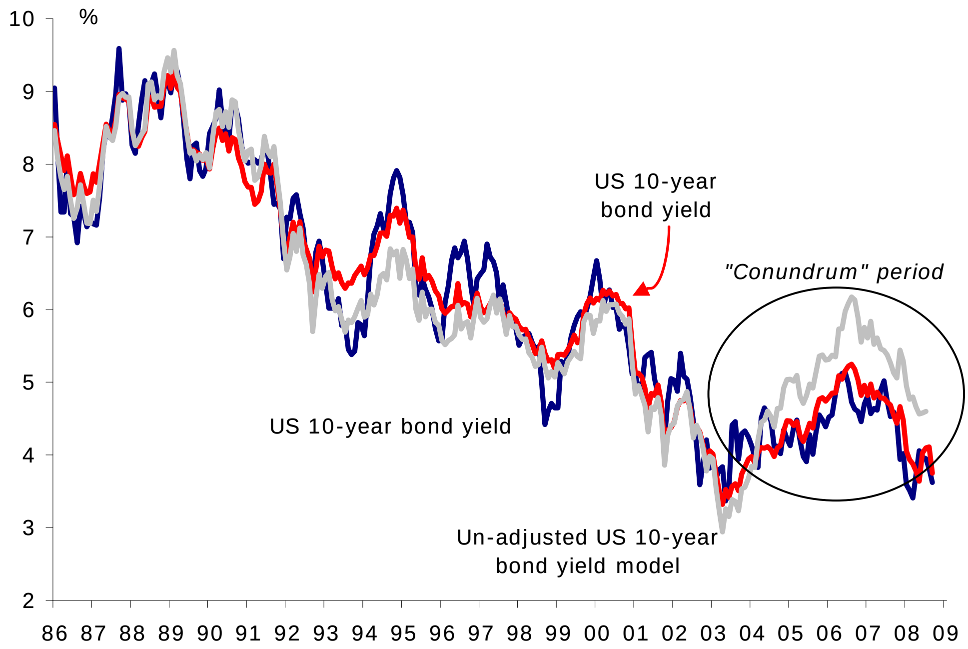
Key points

- In this note we provide an econometric analysis of US and Australian 10-year bond yields over the past two-decades.
- Firstly, it is found that the "conundrum" period of lower than expected US bond yields in recent years can be explained by taking into account the significant increased in holding of US bonds by foreign entities.
- Subsequent to this adjustment, the relationship between US macroeconomic variables and 10-year bond yields is remarkably stable over time. Using a relatively parsimonious specification, the model developed explains around 94% of the variation of US yields since 1986.
- Secondly, upon developing the model of US bond yields a similar framework is applied to modelling Australian bond yields. Despite the decoupling of the US and Australia's economic and monetary policy cycles, US bond yields remain an important driver of domestic yields. However, it is found the strength of the relationship between the respective yields has diminished significantly.
- It is clearly demonstrated that Australian macroeconomic factors and monetary policy stance have become increasingly important in explaining movements in domestic yields. Developing a model based on this framework allows us to explain around 90% of the variance of Australian bond yields over the past decade.
- The models can be used to anchor forecasts of bond yields and to undertake scenario analysis for a variety on underlying macroeconomic scenarios.

Figure 1: Modelling US bond yields



Source: Bloomberg, ANZ

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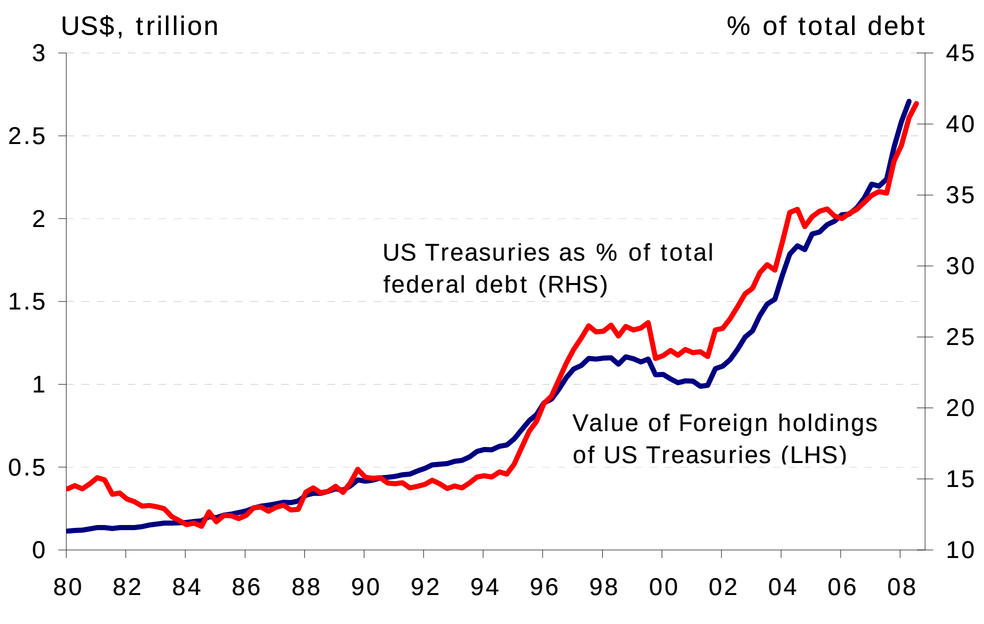
Modelling US bond yields

The "conundrum" period of lower than expected 10-year bond yields that began to occur around 2003-04 has seen most traditional econometric models break down. These models employed various staple macroeconomic and financial variables yet were consistently overestimating bond yield levels. Despite having successfully explained historical movements in yields (see the *un-adjusted model* in Figure 1). It was not until modelling began to incorporate variables that reflected the significantly increased demand for US bonds that the problem was solved.

An example of this, which is adopted in our modelling, is the work of Bandholz, Clostermann and Seitz (2007).[1] BCZ focus on 'explaining' the US bond yield conundrum econometrically by employing a structural variable that accounts for the increased demand for US treasuries by non-US entities, that has been driven by:

- The need to gain a return on huge accumulations of US dollar foreign exchange reserves, particularly by the central banks of current account surplus economies. The two largest accumulators of FX reserves, China and Japan are also the two largest holders of US treasuries.
- The investment of increasing oil revenues by OPEC nations (most likely in part via the UK and offshore financial centres) in the relatively high oil price environment beginning in late-2005.
- Strong liquidity growth driven by accommodative monetary policy. Excluding-Japan (due quantitative easing) M2 growth (in US$) in the G7 has averaged just over 9% per year for the past five years. In Asia, this rate of growth is closer to 14% per annum over the same period accelerating to close to 20% in recent years.

Figure 2: Foreign holdings of US treasuries



Source: US Federal Reserve, Datastream, ANZ

Once employed, in a modelling context, this variable acts to structurally realign bond yields over time, in this case to a lower level. BCZ present such a variable as a function of foreign demand for treasuries. However, structurally lower bonds yields generally are most likely due to a range of factors, including increased foreign demand, that have prevailed in the market over the last 20 years. Other significant factors include increased demand from US institutional investors; a reduction of risk aversion due to a less volatile global economic environment; and generally lower levels of inflation since the widespread introduction of inflation targeting by global central banks. In a modelling sense, all these factors are successfully proxied by the increase demand from foreign holders of US treasuries.

[1] *Explaining the US Bond Yield Conundrum* (2007) Bandholz, H., Clostermann, J., Seitz, F. MPRA Paper February 2007. This paper in available online: http://mpra.ub.uni-muenchen.de/2386/

This structural decrease of bond yields has had a profound impact on all asset classes. The fall in the benchmark risk-free rate has lowered the hurdle for returns in other asset classes, serving to push the prices of these assets ever higher. This was seen particularly in equities, commercial and residential property prices in the pre-credit crisis period. With other bond yields priced off US yields this effect spread throughout global financial markets.

Model estimation - US 10-year bond yields

We simplify the general approach of BCZ, who estimate a vector error correction model, to estimate an ordinary least squares model. In this way, the focus is on the medium to long term relationships between economic variables and bond yields and fitted estimates reflect a 'fair value' of bond yields over time.

The variables used in the model follow what is a common specification of bond yield models in academic literature, with the addition of the variable to account for foreign holdings of bonds. The long-term bond yield is modelled as a function of the short-term interest rate, inflation and a proxy for business-cycle conditions. Specifically, the variables are: US 10-year bond yields, US 3-month LIBOR (%), the annual rate of US core inflation (%), the ISM manufacturing index and the ratio of Foreign held US Treasuries to the total amount of foreign debt outstanding (%).[2] The period of estimation is January-1986 to August-2008. The estimated equation takes the following form:

$$i_t^{US\ 10\,year} = \alpha_t + \beta i_t^{3m\,libor} + \phi \pi_t^{core} + \lambda y_t^{ism} + \psi\, treasuries_t + \varepsilon_t$$

The results of the OLS estimation of the above equation gives:

Table 1 OLS results – US 10-year bond yields

	Estimate	s.e.	t-stat	P-val.
constant (α_t)	1.365	0.409	3.332	0.00
3-month LIBOR (β_t)	0.278	0.015	18.039	0.00
Core inflation (ϕ_t)	0.517	0.046	11.137	0.00
ISM (λ_t)	0.071	0.006	12.819	0.00
Treasuries (ψ_t)	-0.086	0.005	-17.005	0.00
R^2	0.942	***S.D. dependent var***		1.62
S.E. of regression	0.391	***DW statistic*** [3]		0.50

This parsimonious specification 'explains' over 94% of the variation of US 10-year bond yields (see Figure 1). All coefficients are statistically significant and are correctly signed (having the expected economic interpretation). We find that:

- **a 100 bps increase in the 3-month LIBOR results in a 28bps increase in 10-year bond yields.** In line with the expectation that the yield curve will flatten/steepen with higher/lower yields at the short end, largely with moves in monetary policy.
- **a core inflation rate that is 1% higher will raise 10 year bond yields 52bps.** Interestingly, this estimate is slightly lower than historical studies, which may indicate inflation expectations have become better anchored in the last decade, reflecting a period of relative monetary stability.
- **a 1.0 point move in the ISM index (which is roughly equivalent to a 0.2ppt move in real GDP growth) will raise 10 year bond yields 7bps.** This indicates that yields are pro-cyclical and will rise on the expectation that the economy will enter an expansionary phase.
- **a 100 bps increase in proportion of US Treasuries held overseas results in a 9bps decrease in 10-year bond yields.** The fall in yields reflects strong foreign demand for treasuries.

[2] Financial variables are 'end-month' rather than month average, sourced from Bloomberg.
[3] First order serial correlation is inherent in models that adopt the 'fair value' approach as taken here. This can be solved by applying a lag of the dependent variable in the specification (reflected in a DW much closer to 2). Doing this does not change the ratio of the variables to each other and it is therefore concluded that the presence of serial correlation is not having a significant negative impact on the statistical quality of the parameter estimates in the fair value model.

Importantly, the inclusion of the *Treasuries*(ψ_t) variable significantly improves the explanatory power of the model in the both the conundrum period but also throughout the historical sample. The variable also significantly out performs the use of dummy variables, especially as a statistically significant structural break cannot be found.

Modelling Australian bond yields

Many developed economy bond yields can be 'priced-off' US yields and it is found in this note that this remains true for Australia. This is despite divergent economic performance and monetary policies in recent years as the Australian economy becomes ever more reliant on faster growing developing countries in the Asian region. However, it is found that the link between US and Australian bond yields has weakened significantly in the recent decade.

The modelling approach is similar to that above with the specification including short term domestic interest rates, 'core' inflation [4] as well as the US short term interest rate and US 10 year bond yield. The model is estimated from March-1986 to August-2008, taking the following form:

$$i_t^{Aust\ 10\,yr} = \alpha_t + \xi i_t^{US\ 10\,year} + \chi\pi_t^{RBAcore} + \omega i_t^{90\,dayBBSW} + \beta i_t^{3m\,libor} + \upsilon_t$$

The results of the OLS estimation of the above equation gives:

Table 2 OLS results – Australian 10-year bond yields

	Estimate	s.e.	t-stat	Prob.
constant (α_t)	-1.023	0.128	-7.973	0.00
US 10-year yield (ξ_t)	1.203	0.035	34.780	0.00
RBA core inflation (χ_t)	0.066	0.033	1.768	0.048
90 day bank bill (ω_t)	0.419	0.024	17.413	0.00
US 3-month LIBOR (β_t)	-0.336	0.027	-12.243	0.00
R^2	0.971	***S.D. dependent var***		2.95
S.E. of regression	0.491	***DW statistic***		0.47

The model successfully accounts for 97% of the variance of Australian bond yields (see Figure 3 overleaf) over the period with all variables statistically significant and correctly signed.

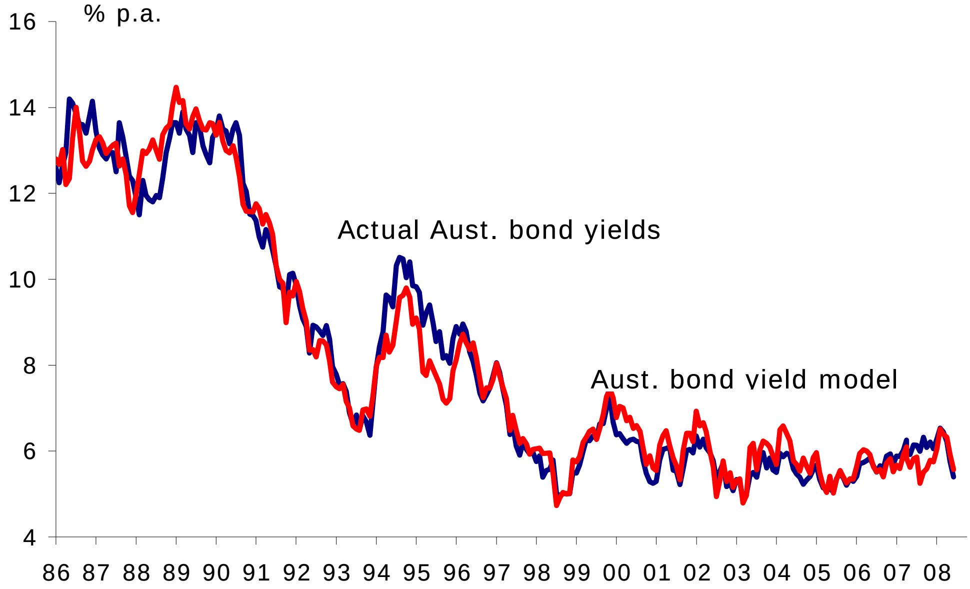
- **a 100 bps increase in the US 10-year bond yield results in a 120bps increase in Australian 10-year bond yields.** This reflects both the reliance of domestic yields on the US, as well as the risk premium attached to Australian bonds over the period.
- Although modelled as separate variables, the US LIBOR and 90-day bill rate are interpreted as the difference in monetary policy stance. As such, **a widening of this differential results in a 9bps increase in domestic bond yields.**
- **a core inflation rate that is 1% higher will raise 10 year bond yields 7bps.** This estimate seems quite low and may be explained by much of the domestic expected inflationary impact on yields being explained by nominal US yields which are a function of US inflation.

Interestingly, domestic business cycle conditions (as proxied by real GDP growth amongst other variables tested) were found to be non-significant to Australian bond yields over the period. Similar to inflation, given the high correlation between the US and Australian economies, especially over the first half of the sample, the US bond yield co-efficient is most likely masking domestic economic factors.

[4] Core inflation is defined as the average of the Reserve Bank's statistical measures of inflation. Quarterly observations are extrapolated to construct a monthly series.

In the same vein, trends in the holding of Australian Treasuries has followed what has taken place in the US with a significant increase in the proportion of foreign ownership. In the late 1980's around 20% of domestic Treasuries were held offshore. As of the end of late-2007, this proportion had jumped to 65%. However, this impact of this demand in the model is captured the structural shift downwards of US bond yields.

Figure 3: Modelling Australian bond yields 1986-2008



Source: Bloomberg, ANZ

Despite the presence of heteroscedasticity (non-constant variance of residuals) not being detected statistically in the model, an ocular examination of the actual and fitted values in Figure 3 does raise some concerns. The fitted value consistently over- or under-shoots the actual value in the second-half of the estimation period. This occurs due to the variance of yields in the second-half of the period being considerably less than in the first. This decrease in variance has taken place in many macroeconomic variables and is a consequence of well-anchored inflation expectations in the inflation targeting period of Australian monetary policy. In this case, this invites the use of an alternate methodology to take account of non-constant variance or to more simply re-estimate the model over a shorter period, which is what is done here.

The sample period is bisected, to begin in 1998 around five years into the Reserve Bank of Australia's formal inflation targeting period. The standard deviation of yields is 270bps in the period 1986 to 1997, but only 45bps from 1998 onwards confirming that a re-estimation of the model should be able to provide improved results. Table 3 demonstrates this improved performance of the model.

Table 3 OLS results – Australian 10-year bond yields – short sample

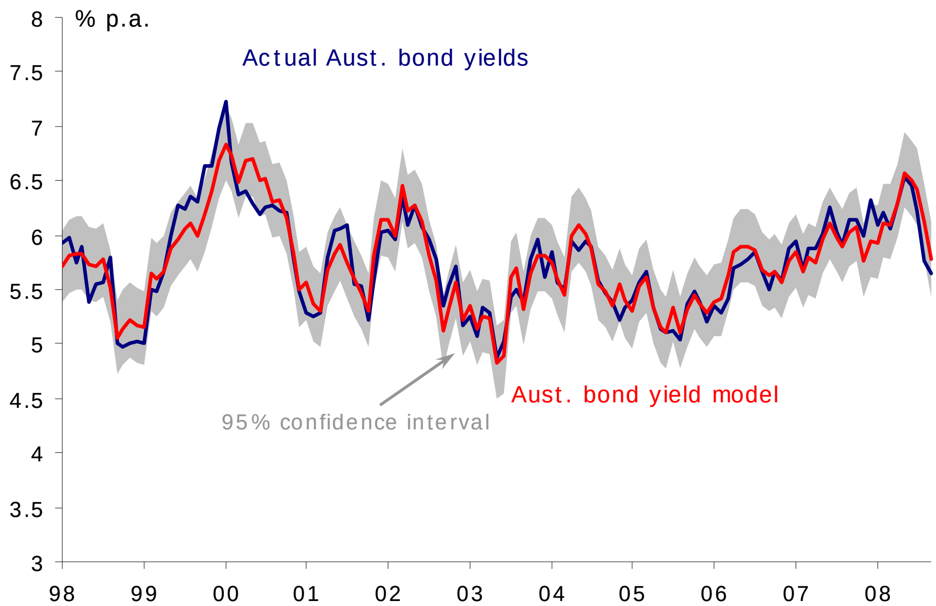
	Estimate	s.e.	t-stat	Prob.
constant (α_t)	-0.140	0.209	-0.67	0.504
US 10-year yield (ξ_t)	0.774	0.033	23.3	0.00
RBA core inflation (χ_t)	0.327	0.047	6.98	0.00
90 day bank bill (ω_t)	0.297	0.032	9.39	0.00
US 3-month LIBOR (β_t)	-0.153	0.017	-9.10	0.00
Real GDP growth (λ_t)	0.082	0.014	5.73	0.00
R^2	0.895	***S.D. dependent var***		0.455
S.E. of regression	0.165	***DW statistic***		0.841

The variables used 'explain' 89% of the variance in yields which is slightly less than the longer sample model. However, the standard error of the regression is only 17bps as opposed to the 49 bps of the previous model. This provides a significant improvement in the certainty around, and robustness of, the point estimates which also is beneficial for producing projections with the model.

Another significant change in the model estimates is the diminished influence of US bond yields on Australian yields in favour of domestic macroeconomic variables. The detail of this occurrence is as follows:

- **a 100 bps increase in the US 10-year bond yield results in a 77bps increase in Australian 10-year bond yields.** This estimate is much lower than the 120bps found in the longer sample model, reflecting less reliance of domestic yields on US yields. That being said, the historical pricing behaviour remains the key driver Australian yields (having the largest coefficient estimate).
- Similarly, the difference in monetary policy stance has become more important with **a widening of short end yields resulting in a 15bps increase in domestic bond yields.**
- Domestic inflation has become significantly more important in explaining movements in yields due to the increased transparency of monetary policy over the last decade. **A core inflation rate that is 1% higher will raise 10 year bond yields 33bps, more than four times the previous estimate.**
- Domestic business cycle conditions are also now included in this framework, after being found to be statistically non-significant in the previous model**. A rate of real GDP growth that is 1% higher adds 8bps to yields.** This is around the same impact as the US business cycle has, as proxied by the ISM index, has on US yields.

Figure 4: Modelling Australian bond yields 1998- Sept 2008



Source: Bloomberg, ANZ

Conclusion

The econometric models developed here take a relatively simple approach to producing ‘fair value’ estimates for US and Australian 10-year bond yields. The central conclusion of this exercise has been that the historical, and empirically proven, relationship between Australian and US yields remains relevant despite the decoupling of monetary policy and macroeconomic cycles. It is clearly demonstrated that although the relationship remains important, Australian macroeconomic factors and monetary policy stance have become increasingly important in explaining movements in domestic yields.

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