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The GIRM: A Global Interest Rate Model

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Paul Conway and Adrian Orr
Westpac Institutional Bank
PO Box 691
Wellington
New Zealand
Phone (644) 470 8250
adrian_orr@westpac.co.nz

A division of Westpac Banking Corporation ABN 33 007 457 141

www.wib.westpac.co.nz

1) Overview and Summary

In this paper we present an econometric model for explaining developments in yields on 10-year government bonds. The countries included in our Global Interest Rate Model (GIRM) are the United States, Germany, Canada, the United Kingdom, Australia, Sweden, and New Zealand. The work is the most recent in a continuum of papers that began in 1994.[1]

While we have largely adopted the estimation techniques and framework of the earlier papers, we have updated the model with five more years of quarterly data, covering the period 1986-2002. We have also narrowed the number of countries in the model from seventeen to seven. This has allowed us to account for the European monetary union and make the model more tractable for forecasting purposes.

The framework

The GIRM framework is based on the concept of efficient debt markets, whereby any arbitrage opportunity is exploited by global investors. The GIRM accounts for a series of influences on long-term interest rates including:

- Economic fundamentals that determine the ***long-run*** level of interest rates and ***cross-country*** divergences. These fundamentals include inflation credibility, persistent trends in saving-investment imbalances, and the rate of return on capital (i.e., opportunity cost) for each country. Also included is a 'beta' estimate of the variability of a country's bond yields in a portfolio of global bonds.
- ***Short-run deviations*** of bond yields from their long-run levels due to business cycle influences and economic surprises. The key cyclical influence is developments in short-term interest rates i.e., monetary policy developments. Bond rates in each country have their own ***'speed of correction'*** back to their long-run level.
- ***Global financial integration*** that imply interest rate developments in larger countries (i.e., Germany and the US) influence interest rates in all other countries simultaneously.
- The advent of the ***European currency union*** has seen bond yields in member countries converge with the disappearance of expected exchange rate changes and a reduced liquidity risk premium. To capture these developments in the GIRM we make the yield on German bonds dependent on the economic fundamentals of the European region after 1998, rather than own country fundamentals. The introduction of the euro has also created the second largest bond market in the world, offering investors greater liquidity and diversification. We have thus introduced an 'investor premium' variable that captures the benefits of creating such a large and diversified bond market.

The results

The economic 'fundamentals' in the GIRM model explain developments in long-term government yields in a statistically meaningful way. On balance, high government debt, a poor inflation track record, persistent saving-investment imbalances, and a volatile bond market all add to a country's long-term interest rate level. These factors are in addition to the minimum return required for debt to compete with equity i.e., the rate of return on capital.

The modelling technique has also been successful at capturing the short-term fluctuations in interest rates generated by the business cycle and monetary policy developments. Not surprisingly, short-term interest rates are a significant explanatory variable of long-term interest rates in all countries. In addition, the GIRM captures cross-country linkages that are important in explaining bond yields in an integrated global financial market.

We have also been able to model the implications for European bond yields of the transition to the euro. The long-run trend in euro yields is determined by the economic fundamentals of the region as a whole. There also exists an additional investor premium post-1998 for euro denominated bonds, possibly related to improved liquidity and risk diversification, and/or a growing home bias for European investors.

[1] See Orr, Edey and Kennedy (1995), and O'Donovan, Orr and Rae (1996).

Bond yield forecasts
The GIRM makes it possible to project future bond yields based on forecasts of the fundamentals and business cycle developments. Importantly, it forces a discipline on forecasters to treat each country equally, with yield projections differing purely on the back of a country's economic fundamentals and business cycle position. As such, we hope that the GIRM is a useful medium-term forecasting tool.

So what is the GIRM telling us at present? Global bond yields are at historically low levels, with the GIRM highlighting just how far some of the cyclical factors (e.g., easy monetary policy) are driving yields below their long-run values. The GIRM thus highlights how far up yields may have to go when 'normality' in monetary policy resumes.

The GIRM also highlights how bond yield differentials across countries are likely to converge once monetary policy cycles become more synchronised. For example, US yields are more likely to converge towards Australian and NZ bond yields over the coming six months or so. This yield convergence will be a consequence of either monetary policy decisions being more synchronised, or a rising risk premium in the United States pushing their yields up as their economic fundamentals get stretched.

2) Modelling Long-term Interest Rates

The GIRM separates the long-term or trend influences on interest rates from the short-term, or cyclical, influences. The *long-term* component in bond yields reflects persistent changes in savings and investment behaviour, the return on capital, and the risk characteristics of that country's bond market.

The *cyclical* component, by contrast, reflects temporary shocks that are often related to business cycle stresses. For example, a tightening of monetary policy tends to initially push up long term interest rates. This positive relationship is all the more so the lower the credibility of a country's central bank. In addition, global capital markets allow domestic borrowers to access savings in other countries. This implies that economic developments in large countries will affect the global borrowing rate and hence interest rates in smaller countries.

Overall, our empirical analysis of real long-term interest rates:

- Identifies the key fundamentals that determine trend developments in real rates;
- Allows actual real rates to deviate from their trend for considerable periods of time due to cyclical factors; and
- Captures the influence of real rate developments in large countries on smaller countries.

To do this we model the determinants of real long-term interest rates in a pooled-time-series estimation across seven OECD countries. The structure of the model is depicted in equation 1:

$$\Delta r_{i,t} = \lambda_i (r_i - r_i^*)_{t-1} + \theta_i \Delta z_i + \varepsilon_{i,t} \qquad (1)$$

i = countries: the US, Germany, Canada, UK, Australia, Sweden, and NZ.
t = time: quarterly from 1985Q3 to 2002Q1

The left-hand-side variable ($\Delta r_{i,t}$) is the one-quarter change in country *i*'s real interest rates at time *t*. Real interest rates are defined as nominal yields on 10-year government bonds minus a proxy for inflation expectations. Ten-year rates were chosen to maximise data comparability across countries, while government bonds are heavily traded (liquid) and similar in risk (low).

Measuring *ex ante* inflation expectations is a difficult issue. We follow past research and use the Hodrick-Prescott filter trend (lambda = 1600) of actual inflation as our measure of expected inflation. We use CPI inflation for all countries, although using the GDP deflator makes little difference to the overall result.[2]

The first term on the right-hand-side of equation (1) is last period's gap between the level of actual and long-term interest rates (r^*) in country *i*. Bond yields in a particular country can be shunted from their long-term value by business cycle developments and/or economic shocks. However, there exists a 'gravitational pull' back towards the long-run level. The strength of this pull (error-correction) is measured by the size of the λ coefficient. We do not impose any restrictions on λ_i, allowing bond rates in each country to return to their long-run values at their own pace.

The second term, Δz_i, represents a collection of temporary dynamics that are specific to a particular country. It may also include changes in real rates in one of the G2 countries (the US and Germany), reflecting the fact that developments in interest rates in larger countries can have a significant influence on each other, and on rates in the smaller countries. However, over time, each country's rates will tend back towards their own long-run levels.

The long run (trend) component

The long run component of real interest rates in country *i* at time *t*, $r^*_{i,t}$, is identified as a function of the economic fundamentals:

$$r^*_{i,t} = \alpha.infl_{i,t} + \phi.curr_{i,t} + \gamma.debt_{i,t} + \varphi.beta_{i,t} + constant \qquad (2)$$

- $infl_{i,t}$ is the difference between past inflation and current inflation expectations in country *i* at time *t*. Past inflation is a long term (10-year) moving average of CPI inflation. Hence, if current inflation expectations are low, a country with a history of high inflation will still pay a charge. It thus takes time to build (and destroy) inflation credibility.

- $curr_{i,t}$ is the five-year moving average of the current account balance as a proportion of GDP. A persistent current account deficit will reflect a risk that the exchange rate may depreciate and/or signal future debt problems.

- $debt_{i,t}$ is the ratio of net public debt to GDP and represents the threat of future savings imbalances and/or future inflation. Government debt may also place pressure on real rates due to a reduction in savings being available to the private sector (i.e., the government crowding out the private sector).

- $beta_{i,t}$ is a measure of the variability of country i's bonds relative to bonds in the rest of the world. It is proxied by the beta of that country's bond returns relative to a world bond portfolio, and thus represents 'undiversifiable' bond risk.

- the *constant* represents the 'baseline' return on capital, or the opportunity cost of holding bonds. We have used a constant for estimation purposes due to the paucity of reliable and comparable data for the 'return on capital' across countries. In our estimation, all countries share the same constant except for the United States, which has its own (lower) constant.

Our assumption of 'equal treatment for all' implies that the coefficients in equation (1) should be the same in all countries. In other words, the long-run impact of the economic fundamentals on bond prices in different countries is the same. If this is not the case in a globally integrated financial market, then arbitrage opportunities would exist which would quickly be exploited by thousands of fleet footed bond traders.

To impose this assumption on the model we estimate all seven equations as one, imposing the constraint that all countries share the same long run coefficients. As well as being theoretically sensible, this approach means that the long-run coefficients in equation 1 are estimated using a large number of data observations.

[2] We also include an additional inflation credibility term (explained below) on the right-hand side of the equation. The inflation credibility term is designed to capture any mis-measurement of inflation expectations and/or to capture a country's inflation credibility (i.e., history).

The time-series for each country is quarterly spanning from 1986Q4 to 2002Q1 (or 61 observations for each variable). However, with the cross-country aspect the total observations used in the regression analysis for each coefficient in the long-run trend component is 61 x 7 = 427. Hence the estimation technique provides considerable scope for efficient estimation.

Figure 1 show a stylised representation of the long-run relationships estimated by the model for one of the 61 quarters. In effect, the model is calculating the slope of the trend lines drawn in the graphs across all of the sample period. These figures are not the exact explanatory variables in the regression. Instead they highlight the 'spirit' of the estimation technique. Also, note the non-linear relationship between net government debt and the interest rate differential. This captures the notion that rising government debt has an increasing impact on bond yields.

Figure 1a: Real Interest Rate Differentials and Past Inflation

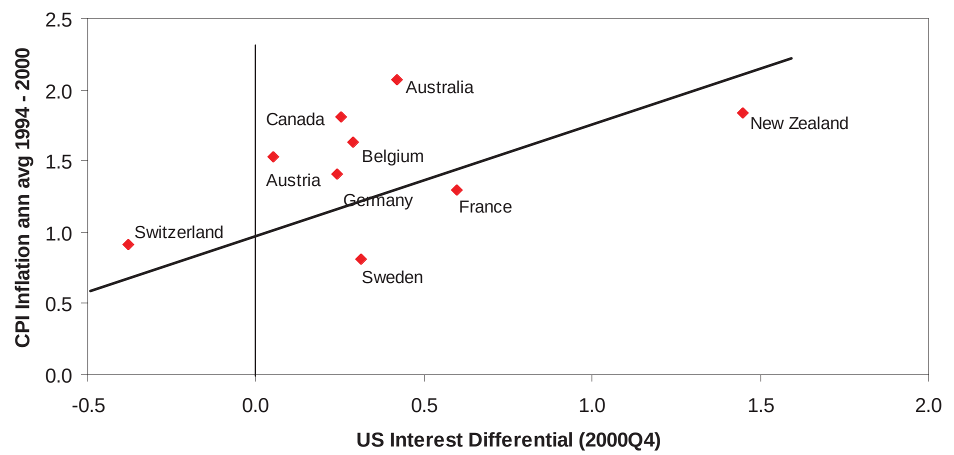
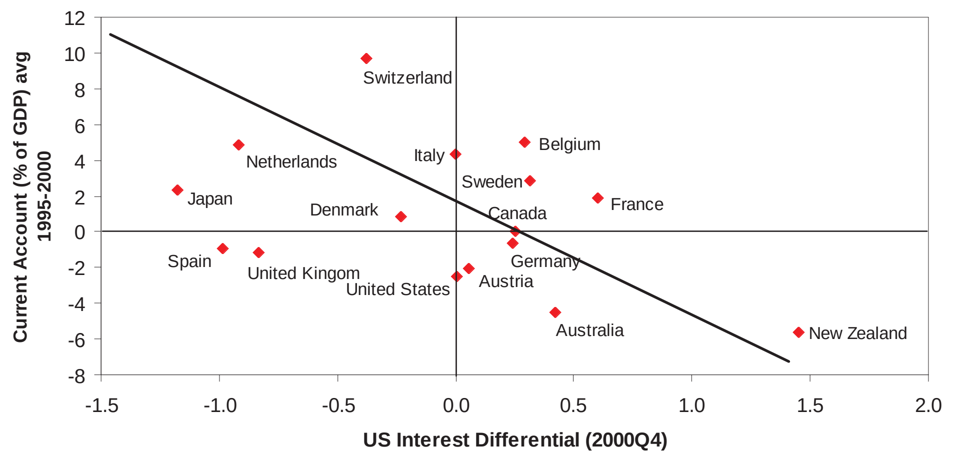
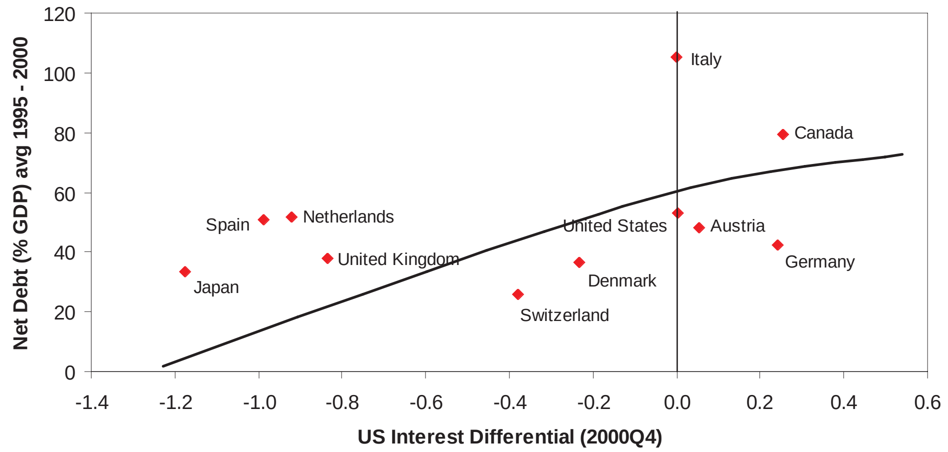


Figure 1b: Real Interest Rate Differentials and Current Account Balance





European monetary union

The introduction of the euro has been the single most important event for international financial markets since the collapse of the Bretton-Woods system of fixed exchange rates in 1972. It has also introduced some additional challenges for the modelling of global bond yields.

In 1995 the European monetary union (EMU) member governments decided that as of January 1999 all new fungible public debt would be issued in euros. Then, in May 1998, the EMU member countries announced irrevocable fixed exchange rates between one another. In addition, the EMU governments opted to redenominate their outstanding debt into euros and harmonise bond conventions.

What does this imply for the behaviour of EMU member countries' bond yields? Equation (3) is a modified version of the uncovered interest parity condition and is a useful starting point for considering the implications of the euro for bond markets:

$$i_t^* + \text{currency risk premium} + \text{liquidity premium} + \text{default premium} = i_t + \Delta s_{t+1}^e \quad (3)$$

This equation stipulates four principle reasons for differences between domestic (i_t) and foreign (i_t^*) interest rates:

1. *Currency risk premium*, which reflects uncertainty about the future value of the currency;
2. *Liquidity premium*, which reflects the risk that investors may need to sell an asset at a discount because the market cannot easily absorb their trade;
3. *Default premium*, which reflects the risk that the government that issued the debt might not be able to pay it back; and
4. *Expected change in the exchange rate* (Δs_{t+1}^e)

The introduction of the euro in January 1999 means that currency risk premium and expected exchange rate changes are no longer causes of cross-country interest rate differentials within the euro zone. In addition, euro-denominated government bonds are more substitutable. To the extent that this has expanded the euro region debt market and increased trading, the adoption of a single currency has also reduced liquidity risk. This leaves the risk of government default as the only significant remaining cause of cross-country interest rate differentials amongst the EMU.[3]

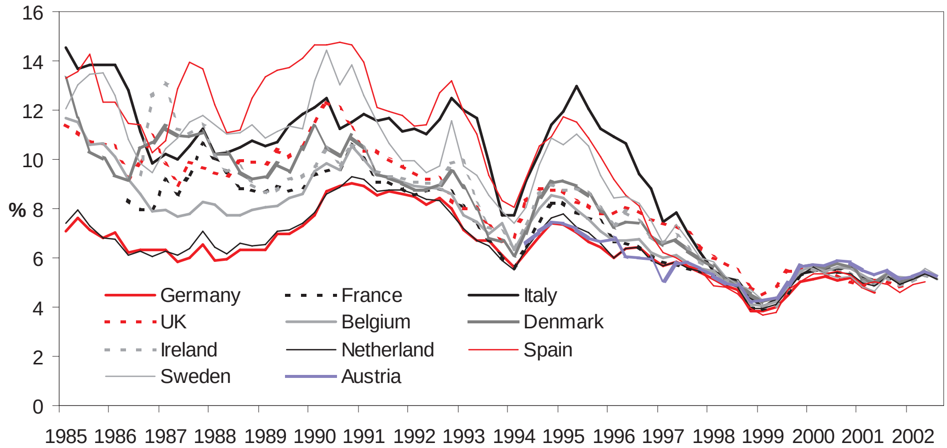
[3] This is especially so given the "no-bail-out" clause of the Maastrict Treaty, which rules out any liability of EMU member governments for each other's debt.

Accordingly, it is no surprise that nominal bond rates have broadly converged in the EMU group of countries. This can be seen in figure 2, which plots bond yields from 1985 until present across the various euro zone countries. Clearly from 1997 onward very little difference exists in bond yields across the region. Of course, the factors identified in equation (3) are still relevant in explaining differences in interest rates between the euro-zone and the other countries in the GIRM.

To capture these differences we have deflated German nominal 10-year bond rates by expected euro-zone inflation from 1998 onward. We have also spliced the euro-zone economic fundamentals onto the relevant German fundamentals from the same date. In both cases we allow a linear convergence over four quarters from 1997q1. In sum, from 1998 onward, the equation for German real bond yields effectively becomes a euro real interest rate equation and captures the bond-market implications of the introduction of the euro.

As well as accounting for convergence to euro-zone fundamentals, we also include another variable to capture any additional investor premium associated with the introduction of the euro. This is a 'dummy variable' that is zero until 1997Q4 and one thereafter, and aims to capture the impact on yields of the additional depth and breadth of the European bond market, and any increase in investor 'home bias' post the introduction of the euro.

Figure 2: Nominal 10-Year Government Bond Yields



The short-run dynamics

The short-run dynamics in the GIRM – Δz_i in equation (1) above – captures the cyclical movements of actual bond yields around their long-run trends. The variables included in the model are:

- Movements in *short rates* (i.e., 90-day rates). This measures the influence of monetary policy on bond rates, with the immediate impact of a policy tightening being a rise in bond rates.
- Changes in the *inflation rate*. It will take time for the financial market to decipher a temporary from a permanent inflation surprise, and hence long-rates will be impacted.
- A country's own *history* (i.e., the lagged dependent variable). This captures the persistence that is evident in most bond markets; although they are fast-moving, bond prices often do not adjust instantly implying that large bond rallies and sell-offs carry a degree of momentum with them.
- Movements in the *US and/or German long-term interest rates*. This recognises that large country developments can temporarily influence developments in smaller countries in a global capital market. However, bond rates in each country eventually return to their own country's fundamentals.
- Changes in the *long run variables* discussed above (apart from the inflation credibility term). This allows for the fact that markets adjust to different variables at different rates.

Estimation
Although it is conceptually helpful to separate the *long run* from the *cyclical* factors for discussion purposes, in practice both parts of the model are estimated together. The model is estimated using quarterly data from 1986Q4 to 2002Q1.

Developments in the US and Germany (i.e., euro-zone after 1998) are modelled as simultaneously influencing interest rates in smaller countries. Because of this simultaneity we have used an instrumental variables estimation technique (non-linear three-stage least squares). Meanwhile, the deviation of a country's actual long-term bond yield from its estimated 'long run' level is captured using an error-correction approach.

The advantages of estimating the model as a system is that it:

- Enables us to restrict the coefficients in the long-run component of the model to be equal for all countries;
- Improves the efficiency of the estimation method; and
- Makes use of the correlation in interest rates across countries.

3) The Results

The Long Run Parameters
Estimates of the long-run coefficients in the model (from equation 2) are shown in Table 1. Each of the variables has the expected sign and is economically sensible in magnitude, as well as appearing to be statistically significant.

Table 1: Long-run Coefficients

Variable	Coefficient	t-statistic
Past minus expected inflation	0.20	3.15
Current Account	-0.19	3.82
Government Debt	0.16	2.51
Risk: Domestic vs World Bonds	0.76	3.44
Constant: US	2.03	6.72
Constant: the rest	2.96	9.69
Euro dummy: Germany	-1.36	2.49
Euro dummy: UK	-1.13	4.50

Past minus expected inflation. This variable indicates that countries with a track record of high inflation are penalised by a risk premium on their real 10-year bond rates. Approximately 20 basis points (bps) is added to the risk premium for a particular country's bonds for every percentage point that past inflation (10-year moving average) exceeds current inflation expectations (HP trend). This implies that inflation credibility is slow to build but that there is (eventually) a significant pay-off in terms of lower real interest rates.

Current account balance. Each percentage point increase in the current account deficit as a proportion of GDP will increase real rates by 19bps. This variable is a five-year moving average of the current account position, and thus is a measure of saving – investment imbalances. We tested whether the annual current account balance influenced real rates in the long-run and found that it did not, indicating that markets take more notice of medium term trends and discount short run business-cycle related movements in the current account.

Net government debt. As with earlier versions of this model the level of government debt relative to GDP is found to have a significant influence on real rates. We model the link between government debt and interest rates as non-linear and find that low levels of debt have only a small impact on the risk premium for bonds. However, the impact of debt on long-term interest rates increases as the level of debt rises.

Table 2 shows the marginal and total impact of government debt on real bond rates. Moving from a net debt level of 10% of GDP to 20% of GDP adds only 3bps to real rates and the total contribution of debt to the risk premium is only 6.5bps. However, moving from net government debt of 50% to 60% of GDP adds 6.7bps for a total effect of 28bps.

Note also that these figures may understate the impact of government debt on interest rates. The evidence shows that rising fiscal deficits spill over to rising current account deficits ('twin deficits'), and so government spending will have a double effect in our model – once via the government debt variable and again via the current account balance.

Table 2: Government Debt Risk Premium

Net Government Debt (% of GDP)	Marginal Basis Points Premium	Total Basis Point Premium
0-10	2.92	2.92
10-20	3.45	6.37
20-30	4.08	10.44
30-40	4.81	15.26
40-50	5.69	20.95
50-60	6.72	27.66
60-70	7.94	35.60
70-80	9.38	44.98
80-90	11.08	56.06
90-100	13.09	69.14

Beta. Bonds that have a high beta relative to the world bond portfolio will face a higher risk premium. A high beta signals that the real return on a country's bonds co-move with the real return on world bonds and hence do not offer global investors a means of diversifying away from global bond risk.

Constants. In the very long-run, real interest rates should converge on the real growth rate of an economy once all cyclical variables have stabilised and any saving-investment imbalances have been resolved. The GIRM thus needs an anchor that mirrors this long-run growth rate i.e., the 'opportunity cost' of investing in debt. Over the relatively short period that the GIRM is estimated we have assumed that this 'opportunity cost' has remained constant.

Why use a constant instead of country specific rates of return on capital? The answer to this question is primarily that there is no comparable and/or reliable data for returns on capital for the entire estimation period.

We test the assumption that each country's constant is equal. In each case, the restriction is accepted at the 95% confidence level. However, there is one important exception: the constant term in the US equation is significantly lower than in the rest of the world, averaging 92bps below the other countries' constant. The lower US constant indicates both 'home bias' amongst US investors, as well as the unique role the US financial system plays in world capital markets (i.e., safe haven and currency of invoice).

The Euro

The introduction of the euro has enabled us to proxy real long-term interest rate in the region using German bond yields and subtracting euro-zone inflation expectations from 1998 onward. Hence, in order to explain these developments we have spliced euro zone economic fundamentals onto the German economic fundamentals from 1998.

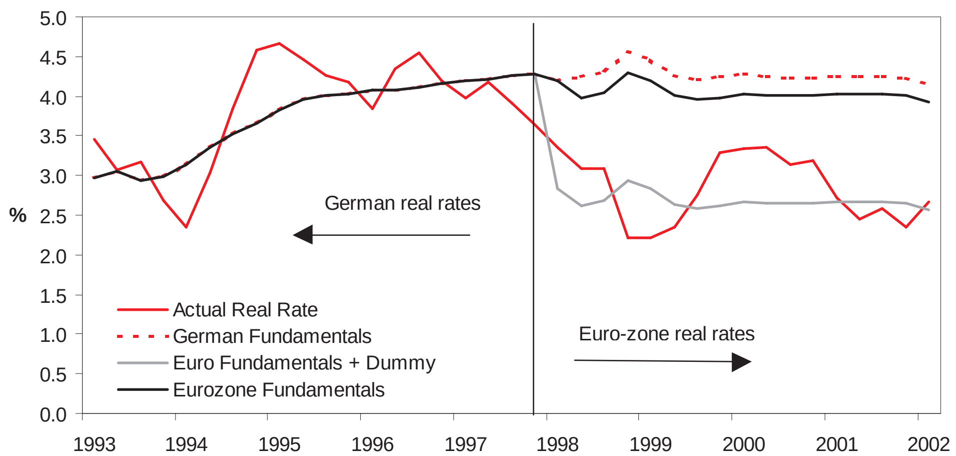
The impact of the introduction of the euro on real 10-year interest rates is shown in figure 3. We calculate three different measures of the long-run real rate using the coefficients from table 1. These are based on:

- The economic fundamentals of Germany;
- The economic fundamentals of the euro zone post-1997; and
- The economic fundamentals of the euro zone post-1997, plus a dummy variable to capture any additional investor premium for improved liquidity, diversity, and/or home bias.

As can be seen from figure 3, the long-run real rate based on euro-zone fundamentals is only 20 to 25 basis points below the estimated German long run. This means that the direct benefit for Germany from having government bonds priced on the basis of euro zone economic fundamentals is relatively small. This isn't altogether unexpected given that the economic fundamentals of Germany and the euro zone are broadly similar.[4]

Despite the similar economic fundamentals, the GIRM suggests the creation of a euro-zone bond market has resulted in real 10-year interest rates in Germany being on average 130bps less than they otherwise would have been. Such a result can be put down to improved liquidity and risk diversification, and/or a growing home bias of European investors.

Figure 3: German/Euro-zone Real 10-Year Interest Rates



The United Kingdom

The sharp-eyed reader will also notice from Table 1 that we have included a 'euro' dummy variable into the UK long-term interest rate equation (i.e., having the value of zero up to 1997 and one thereafter). This variable is included despite the UK not yet being a member of the currency union. Why?

Nominal long-term interest rates declined in the UK post-1997, in line with the euro rates. This decline is more than can be explained by the economic fundamentals in the UK. Some of the decline must be related to the probability that the UK will eventually join the European currency union. This probability has been far from constant since 1997, however it has been significant and worthy of a reduction in investor risk premium.

The coefficient on the UK dummy variable is unrestricted and found to be smaller than that estimated for Germany. This may reflect the fact that UK entry into the EMU is still only a possibility, not a certainty.

[4] Note that this is not always the case. Estimating a fuller 17-country version of the GIRM – which separates the euro countries – highlights that the transition to euro zone fundamentals makes a significant difference for some countries

Speed of Adjustment

Table 3 shows the error-correction coefficients – λ in equation (1) – which measures the speed at which real rates snap back to their long run levels. All of the coefficients have the expected sign and are highly statistically significant. This indicates that if actual real bond rates are pushed away from their equilibrium values a 'gravitational pull' tends to drag them back over time.

The size of the error correction coefficient tells us how responsive real bond rates are to deviations from their equilibrium levels. The associated 'half-life' is the number of quarters required for the deviation from equilibrium to be reduced by one half. These range from 1.47 to 3.32 quarters for the countries in the GIRM. In New Zealand for example, half the gap between the actual and equilibrium real bond rate will be closed after 2 quarters. These are plausible and indicate that the deviation from equilibrium is an important determinant of quarterly changes in real bond rates.

Table 3: Error Correction Coefficients

	Error Correction Coefficient	t-statistic	Implied "Half Life"
United States	-0.21	4.33	2.25
Germany	-0.10	3.70	3.32
United Kingdom	-0.36	5.65	1.47
Canada	-0.20	4.08	2.32
Australia	-0.12	3.32	3.06
New Zealand	-0.25	3.95	2.00
Sweden	-0.11	3.12	3.18

Short Run Influences

The short-run influences outlined are unconstrained and country specific. In other words, they can vary across the different country equations in the model. If one of the short-run influences is found to be insignificant, or have the 'wrong' sign according to economic intuition, then it is excluded from that equation.

The coefficients on the short-run influences are not reported. However, changes in real 90-day rates are the most consistently important short-run variables and are included in every equation. On average across the GIRM, a one percent increase in real short-rates leads to around a 20bps increase in real ten-year yields.

In terms of the debt-market linkages between countries, changes in US rates have a statistically significant influence on real bond rates in Australia, Germany, and most strongly in Canada. Changes in euro long-term rates also influence UK rates in the short run.

Equation Performance

The long-run coefficients in the GIRM are similar in size to earlier papers that have modelled real 10-year bonds using the same framework over shorter time periods.[5] We have also estimated two larger seventeen-country models, which use different techniques to account for the introduction of the euro, over the full sample period and find that the long-run coefficients are also similar.

The stable long-run coefficients on the variables in equation 1, despite varied sample periods and country pools, indicates that we have identified some stable structural parameters and have not lost a lot of information by excluding some countries with the euro convergence. It would appear that the long-run coefficients in the seven-country GIRM are well anchored in terms of explanatory power and stable in economic magnitude.

The accuracy of each equation is summarised in Table 4 and Figure 4. There is a strong tendency for rates in most countries to revert to their long-run levels. However, they can stay away from these long-run levels for a considerable time. With the introduction of the short-run variables however, the GIRM captures the motivation for these temporary deviations and fits the data well.

[5] See Orr et al (1995) and O'Donovan et al (1996)

The equations fit the data reasonably accurately, with low standard errors and high R^2 statistics for equations in quarterly changes. The concordance statistics indicate that the model is reasonably apt at picking the sign of quarter-on-quarter changes in real bond rates. The New Zealand equation, for example, correctly picks the direction of quarterly changes in real bond rates 78% of the time.

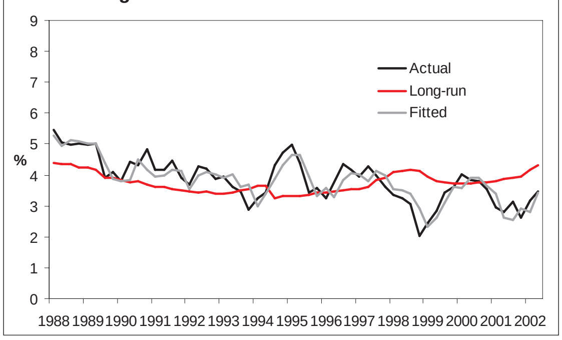
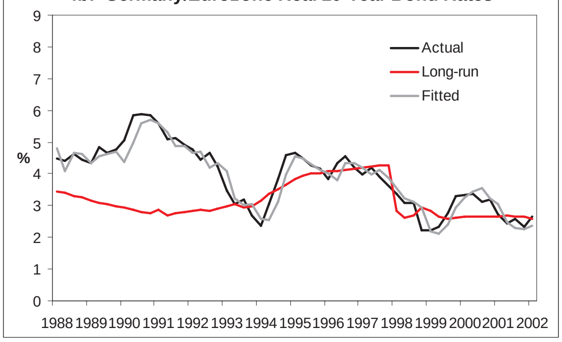


Figure 4a: US Real 10-Year Bond Rates



4b: Germany/Eurozone Real 10-Year Bond Rates

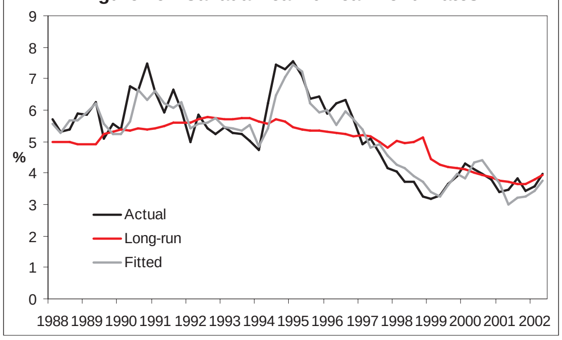


Figure 4c: Canada Real 10-Year Bond Rates

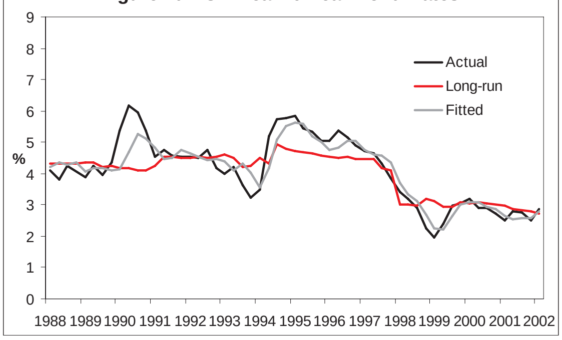


Figure 4d: UK Real 10-Year Bond Rates

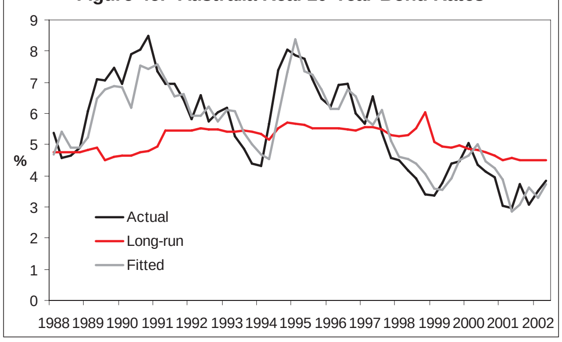


Figure 4e: Australia Real 10-Year Bond Rates

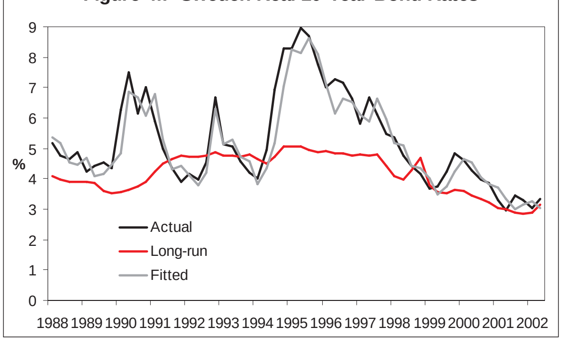


Figure 4f: Sweden Real 10-Year Bond Rates

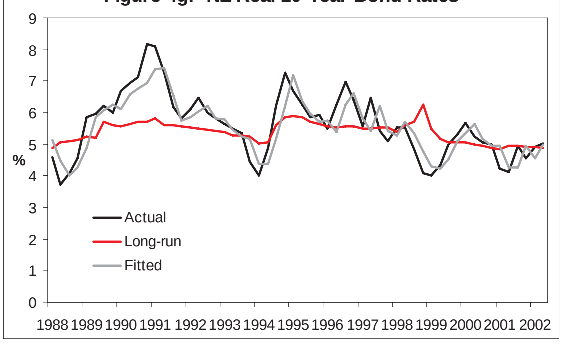


Figure 4g: NZ Real 10-Year Bond Rates

Table 4: Individual Equation Summary Statistics

	Standard Error (Basis Points)	DW	R^2 (%)	Concordance Statistic (%)
United States	13.2	1.67	39.0	67
Germany	9.7	1.41	28.1	68
United Kingdom	15.1	0.98	32.0	70
Canada	18.8	1.56	47.3	66
Australia	30.3	1.60	23.4	62
New Zealand	25.3	1.63	33.4	78
Sweden	29.8	1.49	47.1	79

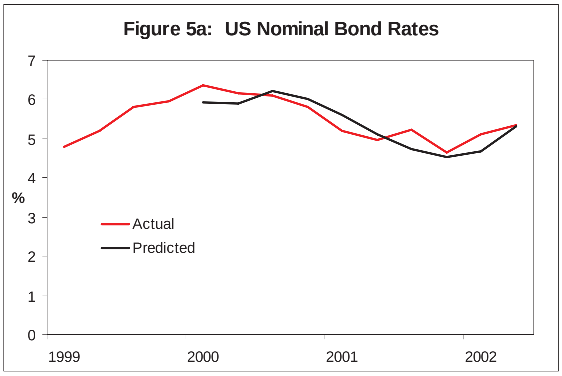
DW is the Durbin-Watson autocorrelation statistic.
R^2 measures the goodness-of-fit for the first difference of real interest rates.
Concordance statistic measures the percentage of quarters that the model correctly picks the direction of real bond rate changes.

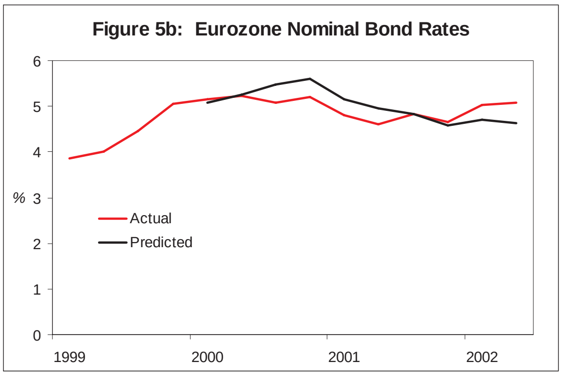
Forecasting accuracy

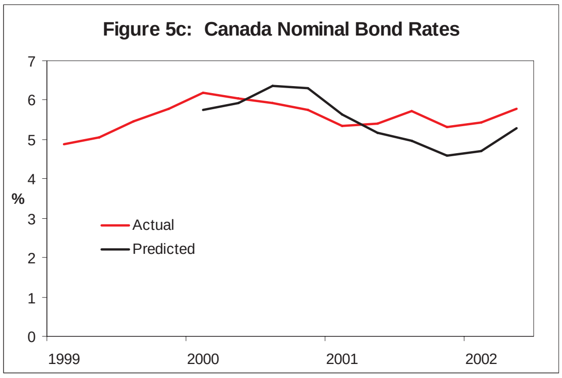
In order to test the GIRM's forecasting accuracy we have fed into the model historical data from 2000Q3 to 2002Q2 and assessed whether it accurately predicted the interest rate outcomes over that two-year period. The importance of this test is that it will accumulate any forecasting errors over the two-year period.

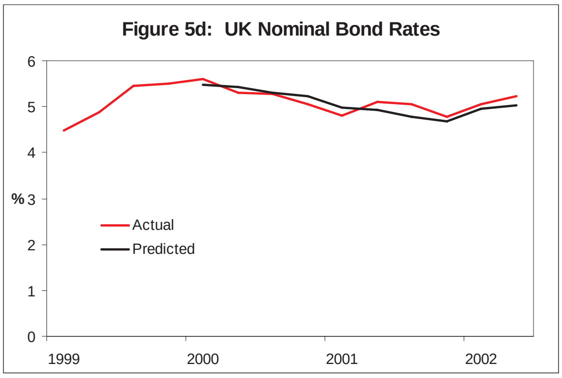
Figure 5 captures the outcomes, comparing actual with forecast long-term bond yields across the seven countries. Table 5 compares the difference between actual and predicted bond yields two years, having had 'perfect foresight' of the explanatory variables.

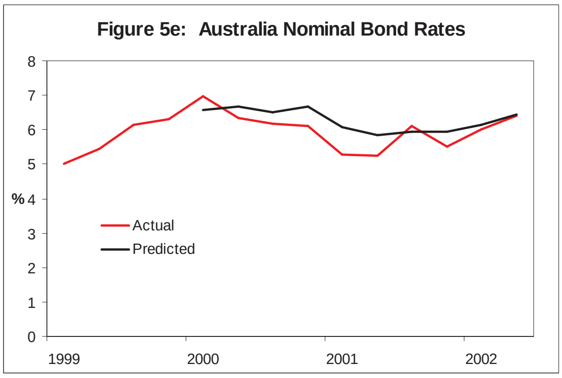
The results are encouraging. The average absolute error at the end of the period was an impressive 17 basis points. The most accurate forecast is an error of a mere 2 basis points for the US and the least accurate is a 34 basis point error in Canada. The GIRM would have clearly added value to a fund manager's decision making – for both outright level trades as well as investing in cross-country interest rate spreads.

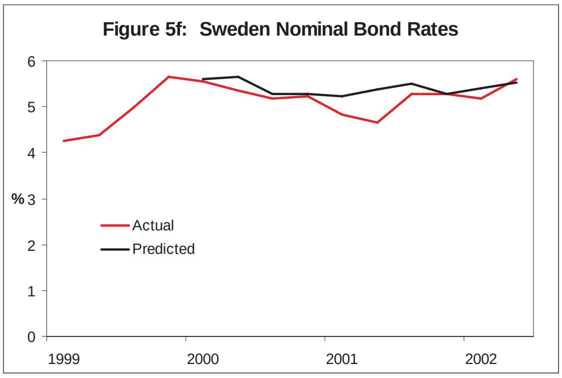












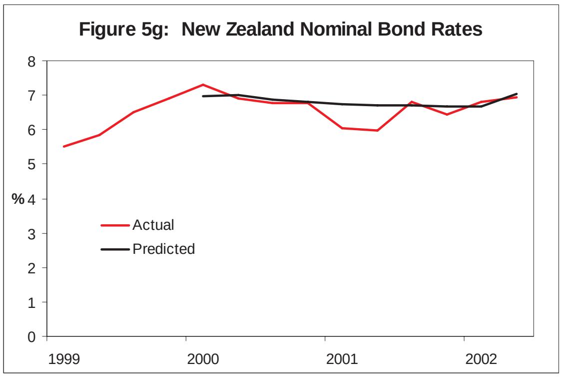


Table 5: Actual and Predicted Nominal 10-year Rates

	Actual (2002Q2)	Predicted[1]	Actual - Predicted
United States	5.34	5.36	-0.02
Germany	5.07	4.82	0.25
United Kingdom	5.22	5.03	0.19
Canada	5.79	5.45	0.34
Australia	6.42	6.68	-0.26
New Zealand	6.94	7.03	-0.09
Sweden	5.59	5.55	0.04

[1] The 2002Q2 nominal 10-year bond rate predicted by the GIRM in 2000Q3 assuming 'perfect foresight' of the explanatory variables

The outlook ahead

What does the GIRM suggest for the future path for long-term interest rates? Figure 6 highlights some illustrative forecast results that arise from inputting the OECD's June 2002 forecasts for all of the explanatory variables, except short-term interest rates where we input the implied future 90-day rate track from current market prices (see Table 6).

The results for the US show the extent to which 10-year bond yields are below their long-run level and suggest that the next big move in US bond yields is upward (see Table 7). This result occurs in part because we have input a rising US short-term interest rate profile, but also because of the error correction term and deteriorating US economic fundamentals (especially the growing 'twin deficit').

Figure 7 highlights US yields are projected to rise even if we keep US short-rates stable until end-2003. Interestingly, if US monetary policy does remain on hold at this level - or further easing occurs - then it is also likely that the US current account deficit and government fiscal position will deteriorate beyond the OECD forecasts. It is hard to avoid rising US bond yields.

Meanwhile, across all countries, in varying degrees, bond yields are forecast to converge on US rates (see Table 7). This appears sensible given that it is US yields that are furthest from their long-run (or 'fair value') level, with temporary cyclical factors holding down long-term rates. In New Zealand, for example, short-rates are already near their neutral level and no particular external or internal imbalance is apparent. Bond yields are thus forecast to be relatively stable and to converge towards US long rates.

Table 6: Forecast Explanatory Variables (Quarterly Year-end)

Consumer Price Inflation

	US	Eurozone	Canada	UK	Australia	Sweden	NZ
2002	1.8	2.0	1.9	2.3	2.8	2.6	2.5
2003	2.4	1.9	2.2	2.3	2.6	2.8	2.0

Short-term interest rates

	US	Eurozone	Canada	UK	Australia	Sweden	NZ
2002	1.7	3.2	3.1	3.8	4.8	4.4	5.8
2003	2.7	3.6	3.7	4.5	5.3	4.7	6.1

Current account balance (%GDP)

	US	Eurozone	Canada	UK	Australia	Sweden	NZ
2002	-4.4	0.9	1.9	-1.9	-3.8	3.9	-4.0
2003	-4.9	1.0	2.0	-2.1	-3.9	4.7	-4.0

Net financial liabilities (%GDP)

	US	Eurozone	Canada	UK	Australia	Sweden	NZ
2002	41.3	53.9	50.6	30.1	10.7	-1.2	19.0
2003	40.0	52.9	46.6	29.9	9.9	-3.5	17.9

Figure 6a: US Nominal Bond Rates

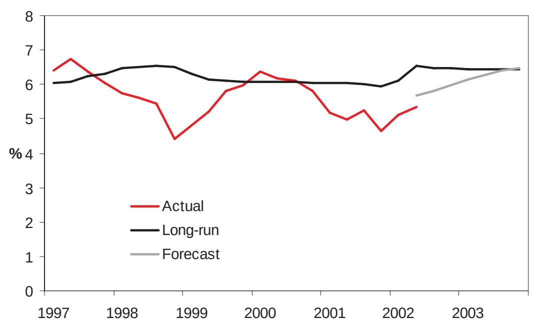


Figure 6b: Eurozone Nominal Bond Rates

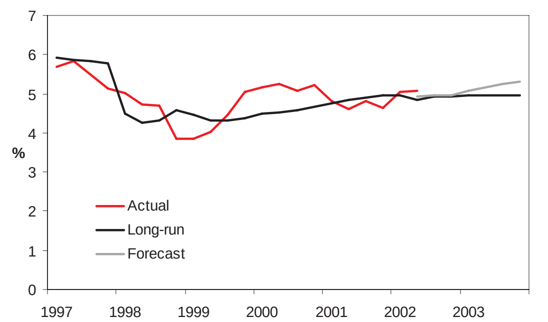


Figure 6c: Canada Nominal Bond Rates

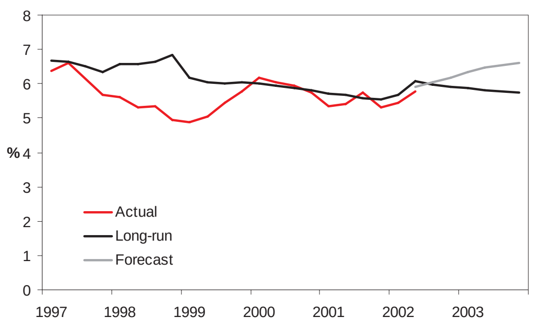
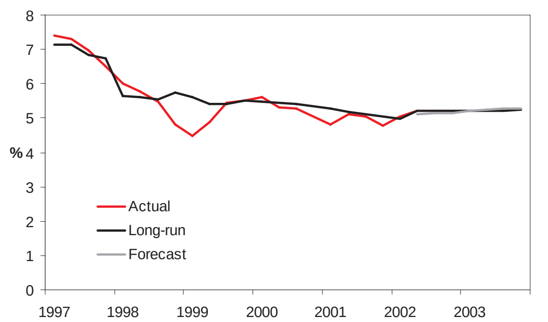
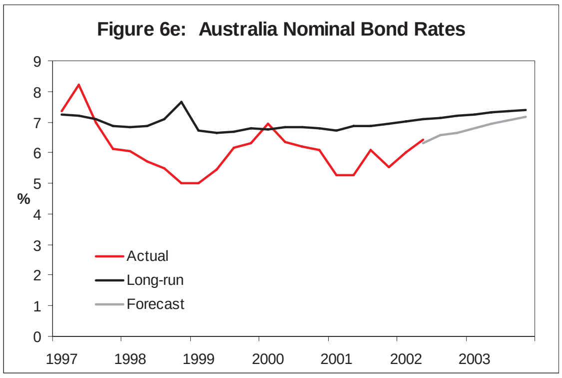
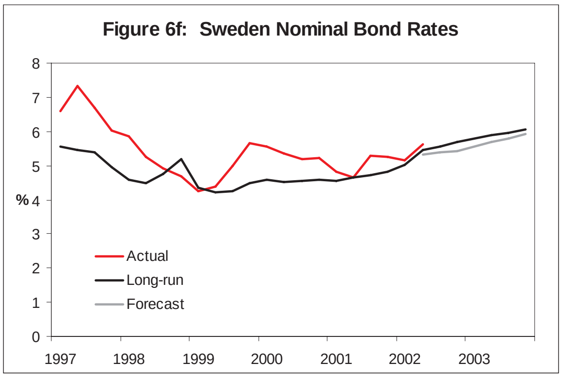


Figure 6d: UK Nominal Bond Rates







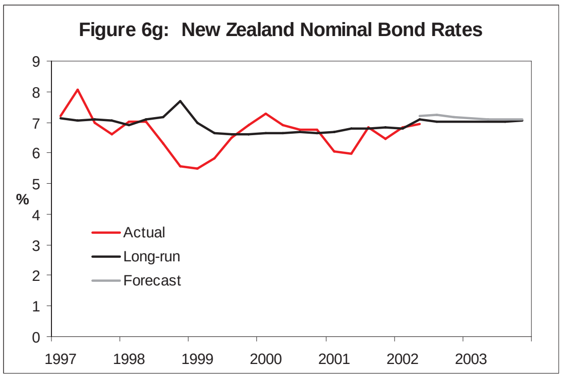
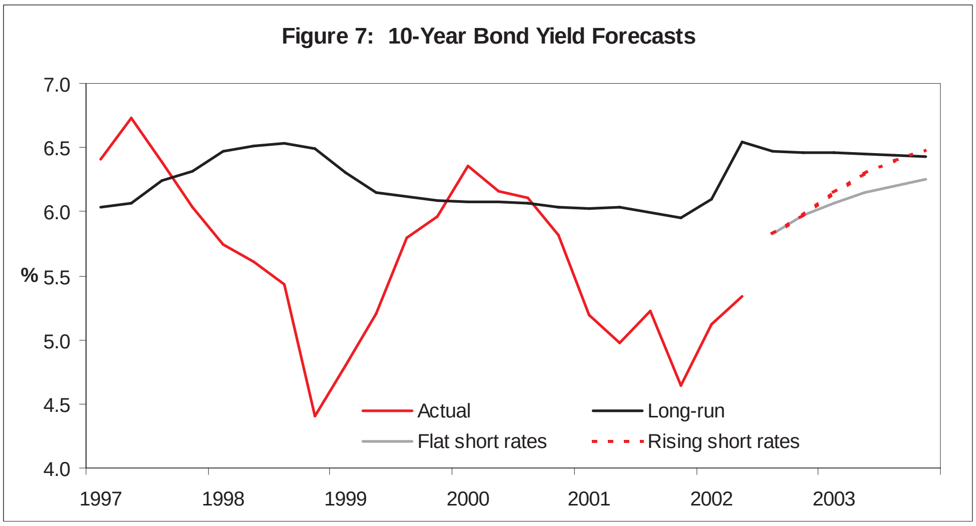


Table 7: Nominal 10-year Bond Forecasts

	Current	Predicted: 2002Q4	Predicted: 2003Q4
United States	4.13	5.97	6.49
Germany	4.51	4.95	5.32
United Kingdom	4.53	5.15	5.29
Canada	5.08	6.17	6.60
Australia	5.70	6.63	7.17
New Zealand	6.27	7.16	7.08
Sweden	5.13	5.43	5.92



Bibliography

Danthine, J., Giavazzi, F., and von Thadden, E (2000) "European Financial Markets After EMU" *Working Paper 8044*, National Bureau of Economic Research, Cambridge MA.

O'Donovan, B., Orr, Adrian., and Rae, D (1996) "A World Interest Rate Model" F*inancial Research Paper No. 7*, National Bank of New Zealand Ltd

Orr, Adrian., Edey, Malcolm., and Kennedy., Mike (1995) "Real Long-term Interest Rates: The Evidence from Pooled-Time-Series" *OECD Economic Studies, No.25 II*

Data Sources and Definitions

Nominal long-term interest rates: yield on benchmark public sector 10 year bonds. *Source:* Datastream.

Nominal short-term interest rates: benchmark 3-month yields. *Source:* Datastream.

Inflation: annual percentage change in consumer price inflation. *Source:* Datastream, Statistics NZ, Australian Bureau of Statistics.

Inflation expectations: takes the low-frequency component of the annual percentage change in CPI inflation using a Hodrick-Prescott filter (lambda = 1600).

Past Inflation: 10 year moving average of inflation.

Real long-term interest rates: nominal long-term interest rate minus expected inflation.

Real short term interest rates: benchmark 3-month yields minus expected inflation.

Current account balance: the 5-year moving average of the current account balance as a proportion of GDP.
Source: Datastream.

Net Government Debt: net government debt as a proportion of GDP, interpolated from annual data.
Source: Datastream.

Beta bond risk: is the beta coefficient measured as the 3 year moving average of the covariance between the domestic real bond yield and the real return on a benchmark portfolio of OECD bonds, divided by the variance of the real return on the benchmark OECD bond portfolio.

The OECD real bond portfolio is constructed using JP Morgan bond index weights. *Source:* Datastream.