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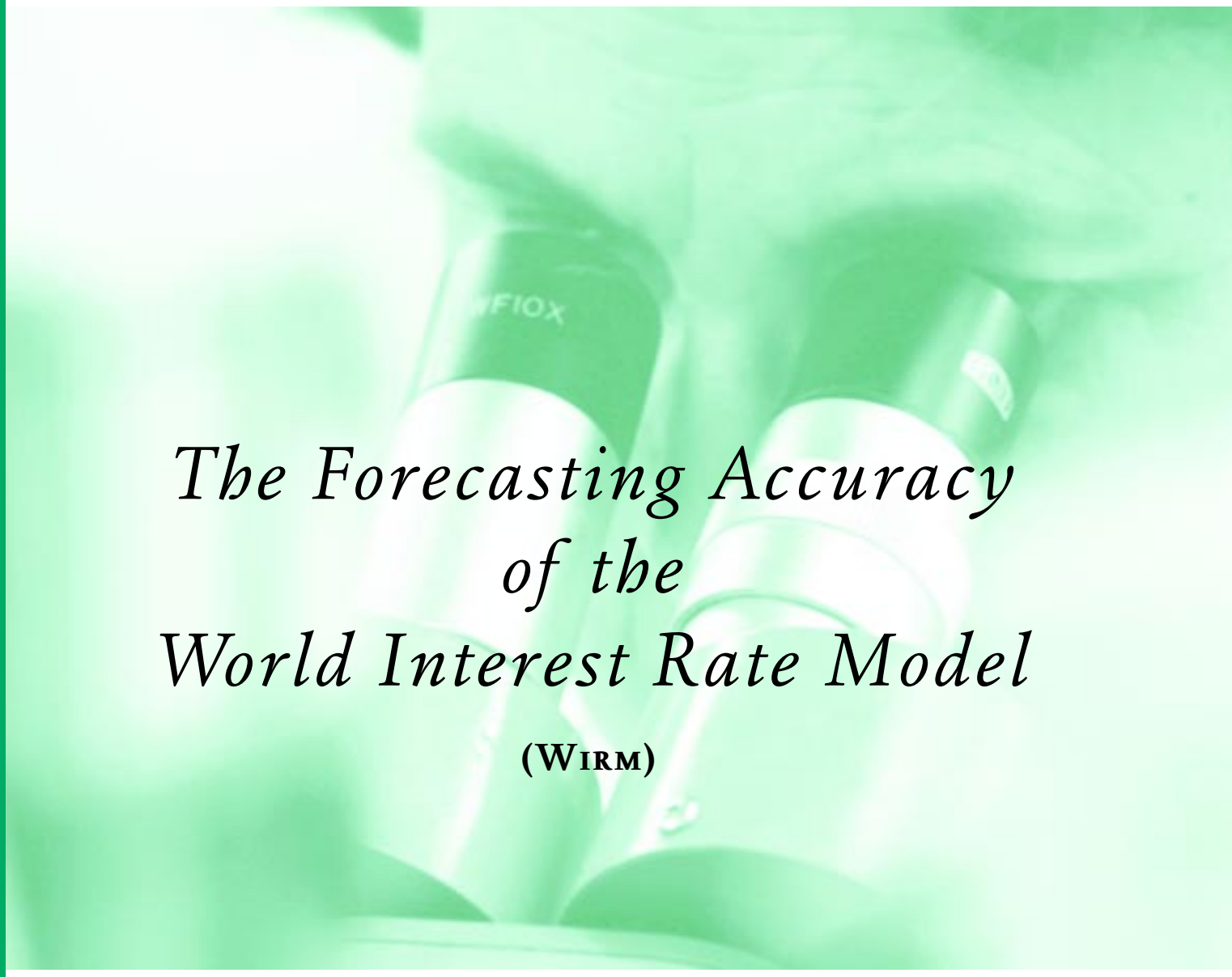

The Forecasting Accuracy of the World Interest Rate Model

(WIRM)

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EXECUTIVE SUMMARY

We review the forecasting performance of the World Interest Rate Model (WIRM) in the year since it was first published. The WIRM is an econometric model of real interest rates in 17 OECD countries. It consists of three parts:

- **The fundamentals,** which depend on a country's economic record and prospects, including its current account and inflation rate, its level of government debt, and the riskiness of its bonds.
- **Short run factors.** Markets overshoot and undershoot fundamentals, and the WIRM captures this. These temporary swings depend on 90-day interest rates, inflation rates and so on.
- **Ripple effects.** Movements in one country can spill into other countries, at least for a short time.

We tested the model by checking its forecast accuracy over the five quarters from June 1996 to September 1997. In this period, bond yields fell in all of the 17 countries included in the model. The main findings are:

- Overall, the WIRM picked the global bond rally well. Its forecasts were accurate for most countries, and considerably better than 'simple' models such as a constant spread model.
- More than half the forecasting error was due to incorrect assumptions. In the middle of last year, Consensus Forecasts and market forward curves were based on a scenario of global economic recovery – especially in Germany and Japan. That did not happen. This highlights the age-old problem of garbage in, garbage out. However, that is not the WIRM's fault – *any* forecasting technique depends on accurate inputs. The underlying scenario must be right, regardless whether the forecaster uses a sophisticated econometric model or the 'rubbing the belly' method.
- A quarter of the error was due to ripple effects, in which errors in one equation rippled through the rest of the model. Almost all the blame can be laid on the Japanese equation, which substantially over-predicted yields. Even when we feed in what actually happened to Japanese inflation and 90-day interest rates, the WIRM is unwilling to forecast yields near 2.0%.
- The poor performance of the Japanese equation begs an obvious question: has the WIRM failed for Japan, or is it telling us that the market has pushed Japanese yields too low? Either way, the exercise with Japan highlights one of the advantages of using the WIRM. It tells us how far from historical norms a country may be, so we can make our own judgement call on whether that is realistic or not.
- With Japan excluded from the model, the other 16 country forecasts are remarkably good. For the OECD, the average forecast error is 35 basis points. Germany's average error is only 17 bp, and after 15 months the US equation has a *cumulative* error of only 2 bp. New Zealand's forecasts are also accurate.
- We also illustrate another useful feature of the WIRM: scenario analysis. The WIRM provides an easy way to analyse the impact of different economic scenarios, in a way that is consistent both internally and with average historical behaviour. For example, we look at the impact on bond yields if the 'new paradigm' school turns out to be correct.

CONTENTS

INTRODUCTION

A year ago, we published our World Interest Rate Model, or WIRM. The WIRM is an economic model of real interest rates in 17 OECD countries. It is based on work initially carried out at the OECD,[1] but extended in several ways. The model estimates 'fundamental' real interest rates by looking at a country's economic fundamentals, such as its current account balance, government debt, inflation history, the riskiness of its bonds, and the world equilibrium rate of return. It combines the fundamentals with both short-run and global influences, such as swings in monetary policy and the ripple effects that the G3 countries have on the rest of the world.

This WIRM has been behind our six-monthly publication, *World Interest Rate Forecasts.* After a year, it is time to check how well the model has performed. We do this by testing the accuracy of its forecasts since the middle of 1996. In this report we review the model, explain a couple of minor changes to its structure, and discuss the sources of its forecast errors. We also compare the WIRM's forecasts with so-called naïve forecasting methods, to see whether it can beat basic benchmarks.

We started the forecasts from the middle of 1996 for two reasons. First, it represents a peak in real interest rates in most OECD countries. Average 10-year bond yields have fallen by approximately 100 bp since June 1996, and we are curious whether the WIRM picked the global bond rally. Second, it ensures we are testing the model over a period outside of the sample it was estimated on. It is not difficult to estimate a model that looks good in sample; it is much harder to find one that forecasts as well out of sample.

THE STRUCTURE OF THE WIRM

A brief recap of the WIRM would be helpful for understanding the sources of error (the original WIRM is described in detail in our *Financial Research Paper No. 7).* The WIRM is a three-piece pack – an econometric *ménage à trois.* It can be separated into: the long-run or 'fundamental' influences; the short-run or temporary dynamics; and the 'ripple effects'.

The fundamental components depend on the principle of the 'Great Arbitrageur in the Sky.' In a global capital market, capital will flow across borders until risk-adjusted returns are equalised. The risk factors will depend on an individual country's track record and its current economic performance. These risk factors include government debt levels, current account balances, and the inflation history. Crucially, these factors should be priced equally in each country. That is, investors should not need to know the name of the country they are investing in. They simply look at the economic statistics, and two countries with the same track record – and same prospects – should have the same long term real interest rates.

Clearly, this type of arbitrage is not immediate. Markets overshoot, and the WIRM allows for temporary deviations from long-run equilibrium. These deviations can depend on where a country is in the business cycle and on the influence of monetary and fiscal policy. Short term interest rates and changes in inflation have the biggest short-run impacts in the model.

1. *See Arian Orr, Malcolm Edey, and Michael Kennedy, 'Real Long Term Interest Rates: The Evidence From Pooled-Time-Series,'* OECD Economic Studies, *No. 25 II.*

The third part of the WIRM captures the 'ripple' effects in a global capital market. Developments in one country can spill into other countries, at least for a short while. For example, a bond rally in the US can trigger a rally in Canada and Australia. In the WIRM, real rates in the G3 are determined simultaneously (i.e., US rates depend on German rates; German rates depend on US and Japanese rates, etc). Furthermore, US or German rates appear directly in the equations for many other countries. However, in the long run, real rates in each country return to their own fundamental levels.

CHANGES TO THE MODEL

There have been several changes to the WIRM since it was originally published. Most of these changes are small housekeeping matters or have been made to ensure that the forecasts are less sensitive to the starting point. The main changes are:

- The *equity risk* variable was dropped from the long run part of the model. This variable measured the riskiness of bonds relative to equities in each country. It was proxied by the beta coefficient of bonds relative to a portfolio of domestic assets consisting of bonds and equities. It added little to the model – it did not explain much of the historical variation in real rates – and was difficult to forecast.
- Australia's real rates were removed from New Zealand's equation and replaced with US rates. This was done for two reasons. There is growing evidence that Australia's bond market is having less influence on New Zealand's over time, and that the US influence is rising. Secondly, the US equation gives better forecasts than the Australian equation and as a consequence New Zealand's forecasts should be better.
- The database was updated, and the system of equations re-estimated over a longer sample period (1985:1 – 1996:4). This led to minor changes in the coefficients.

FORECASTING PERFORMANCE

The forecasts cover the period 1996:3 to 1997:3, a total of five quarters. They are dynamic forecasts, which means that the forecast for a particular quarter depends on last period's *forecast,* rather than last period's *actual* real interest rate. This ensures that the errors are cumulative, the toughest test for a model. We calculate the average absolute error (i.e., ignoring the sign) for each of the five quarters of the forecast.

a) Feeding in actual data

The best test of the WIRM is to check how it would have performed if the inputs had been correct. In other words, suppose that Consensus forecasts and the forward curve from the middle of last year got it right. If the market had perfect foresight about 90-day rates, inflation rates, and so on, what would the WIRM have predicted? Clearly, if we fed in *actual* Consensus forecasts and forward rates, the WIRM's forecast errors may be large. However, it would be difficult to know how much blame lies with the WIRM and how much with incorrect inputs.

The results of this test are shown in the solid (black) lines on Figure 1, and in Table 1. Overall, the results are encouraging. The WIRM picked the decline in New Zealand's bond rates, although the market managed to surprise with the *speed* of the decline. The average absolute error over the five-quarter period was 33 bp. Australia's equation picked the decline in bond rates, although again it was surprised by the speed and

FIGURE 1: FORECAST SCENARIOS

New Zealand

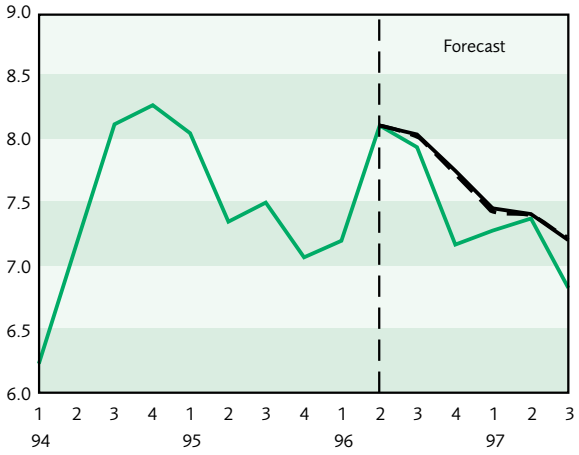


Fig 1a

United States

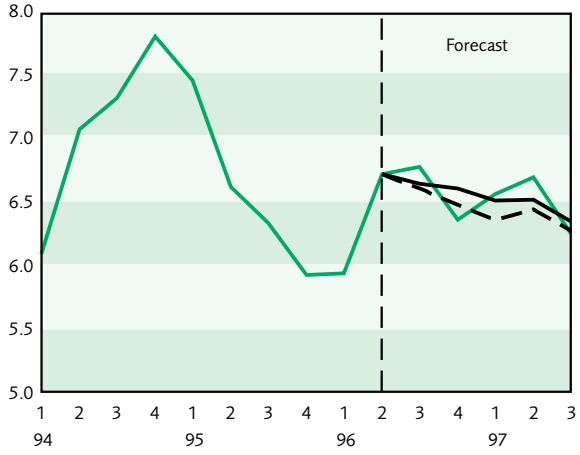


Fig 1b

Germany

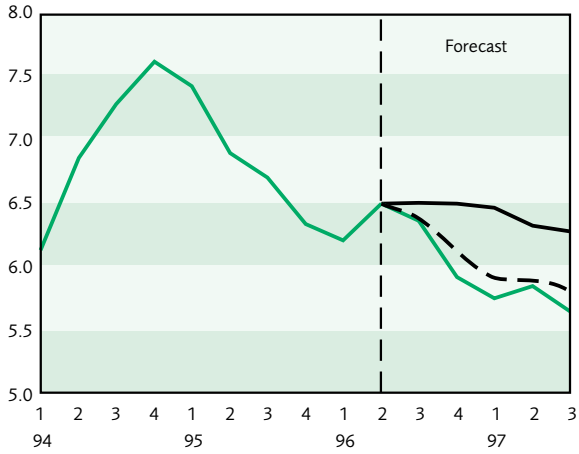


Fig 1c

Japan

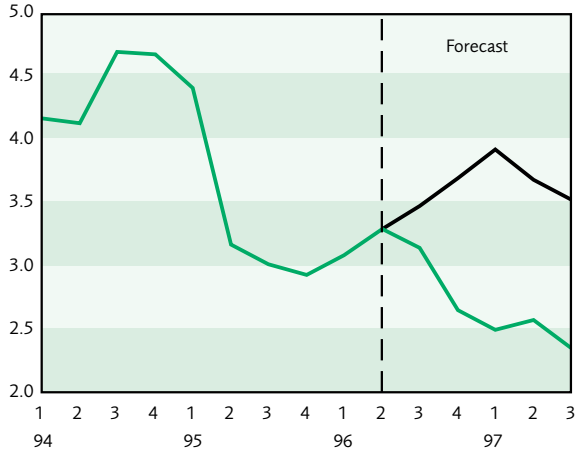


Fig 1d

Australia

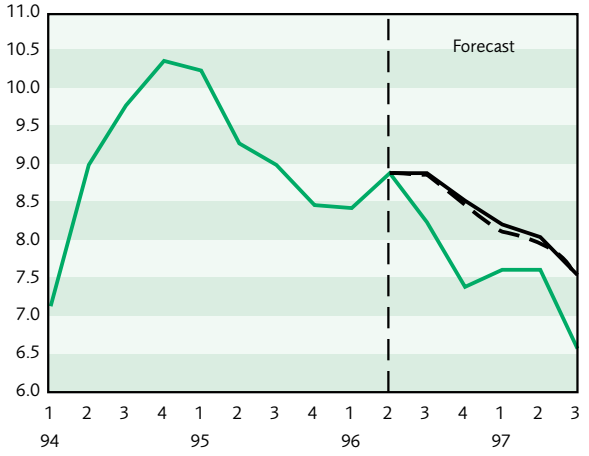


Fig 1e

OECD

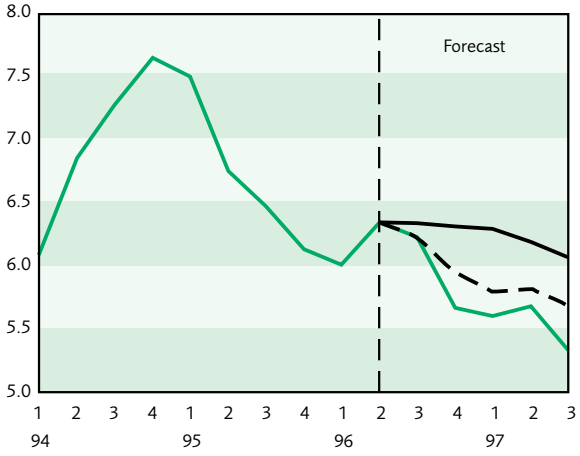


Fig 1f

Actual — WIRM's Forecasts — — WIRM Excluding Japan

TABLE 1: FORECAST ERRORS, ACTUAL INPUTS, ALL 17 COUNTRIES

Average Absolute Errors (bp)

Forecast Horizon	NZ	US	Germany	Japan	France	Italy	UK	Canada	Australia	Austria	Belgium	Denmark	Ireland	Nether-lands	Spain	Sweden	Switzer-land	OECD Average
1 Qtr	13	14	15	34	20	16	23	20	65	14	21	32	48	26	18	14	7	21
2 Qtrs	76	25	59	105	70	105	62	106	114	65	86	74	92	80	107	63	29	60
3 Qtrs	23	5	72	143	93	119	76	95	59	93	121	107	90	109	140	106	47	71
4 Qtrs	5	18	48	111	68	105	77	110	43	79	113	89	47	99	133	62	49	64
5 Qtrs	48	10	63	118	78	183	109	159	97	95	150	113	66	124	98	82	50	69
Average	33	14	51	102	66	106	69	98	76	69	98	83	69	87	99	65	37	57

TABLE 2: FORECAST ERRORS, ACTUAL INPUTS, INDIVIDUAL EQUATIONS

Average Absolute Errors (bp)

Forecast Horizon	NZ	US	Germany	Japan	France	Italy	UK	Canada	Australia	Austria	Belgium	Denmark	Ireland	Nether-lands	Spain	Sweden	Switzer-land	OECD Average
1 Qtr	17	19	6	20	9	16	13	29	72	6	12	17	34	15	18	25	3	16
2 Qtrs	67	7	17	52	25	105	23	89	101	31	51	18	54	39	96	13	11	29
3 Qtrs	25	25	19	86	35	119	34	99	58	46	80	42	52	59	102	28	24	41
4 Qtrs	10	26	9	87	34	105	59	122	54	45	89	54	64	68	80	5	34	41
5 Qtrs	62	2	16	123	42	183	84	154	96	58	119	67	58	84	60	17	31	42
Average	36	16	13	74	29	106	43	98	76	37	70	40	52	53	71	18	20	35

magnitude of the drop. The US equation does particularly well. After five quarters, the equation is out by only 10 bp. It tracks the slight decline in US rates well, with no consistent over- or under-prediction. The average absolute error over the five quarters is only 14 bp.

Forecasts for the OECD average are less accurate than for the US or New Zealand. The German and Japanese equations substantially over-predict bond rates, even when actual 90-day rates and inflation rates are fed into the equations. These errors ripple through to the rest of the model. Next, we try to isolate the source of this error.

b) Removing Japan

It is not obvious where the blame lies because German and Japanese rates feed into each other's equations. One way to find out is to remove one of these equations from the WIRM and feed in *actual* bond rates for that country, then forecast with the remaining 16 equations. This exercise showed that the Japanese equation was the major source of forecast error over this period. The dashed lines in Figure 1 show the forecasts of the WIRM excluding Japan.[2] A glance at the German graph shows that Japan was clearly to blame. By removing Japan from the model, the German forecasts become remarkably good. The five-quarter-ahead error is only 17 bp, and the average absolute error over the forecast horizon is 12 bp. An improved set of German forecasts leads to better forecasts throughout the model. The OECD average, excluding Japan, has a cumulative error of 42 bp at the end of 15 months, and an average error of 35 bp over the whole forecast period. Average errors range from 13 bp for Germany to 106 bp for Italy. The US equation is marginally worse with Japan removed from the WIRM, but the difference is minor and the end-point is remarkable: the cumulative error is only 2 bp.

At the time of writing, Japan's nominal 10-year bond yields were 1.94%. But no matter how hard we torture the WIRM, it will not confess that Japanese bond yields should be below 2%. What can be deduced from this? To some extent, it may imply a failure of the model. Even if we feed in very low short-term interest rates, low inflation expectations, low actual inflation outcomes, etc, the WIRM prefers to see bond yields rising. That is largely because Japan's *fundamental* nominal yields are currently around 4.25%. The structure of the WIRM – and historical experience – means that actual yields seldom diverge from fundamentals for long periods. The market, apparently, has a different view.

An alternative explanation – and one that we prefer – is that the WIRM is telling us something important about Japan's bonds. Yields are currently significantly below anything that historical experience would regard as reasonable for Japan, even allowing for the state of the business cycle and its prospects for economic recovery. The WIRM is suggesting that the market has got carried away with its negative sentiments concerning Japan. Even if the market's scenario of a slow and faltering economic outlook is correct, yields should be higher than they currently are. Sell Japanese bonds.

Regardless which interpretation you prefer – a failure of the WIRM, or a market being carried away with 'irrational despondency' – the exercise highlights one of the benefits of using a model such as the WIRM. The large gap between the market price and what the model thinks is reasonable forces us to think more deeply about what is a fair price for Japanese bonds. Draw your own conclusions.

2. i.e., we feed actual *Japanese rates into the rest of the model.*

FIGURE 2: FORECASTS USING CONSENSUS INPUTS

New Zealand

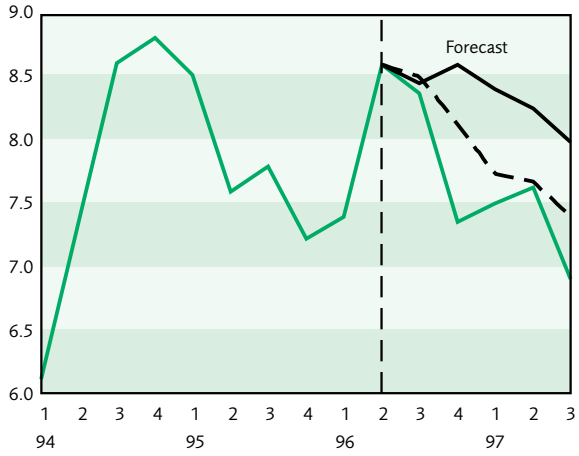


Fig 2a

United States

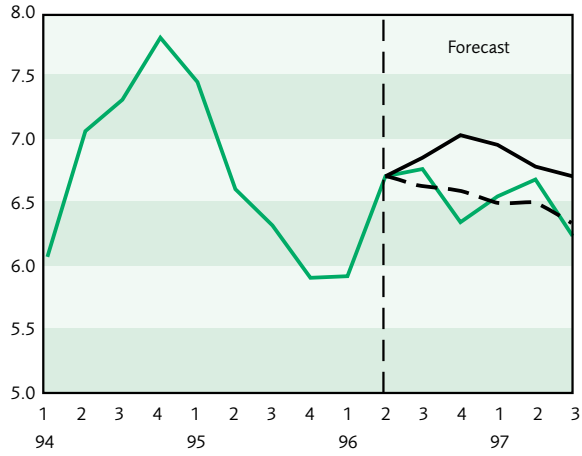


Fig 2b

Germany

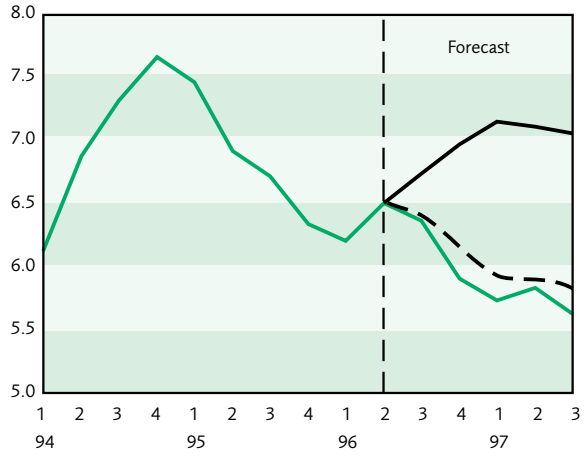


Fig 2c

Japan

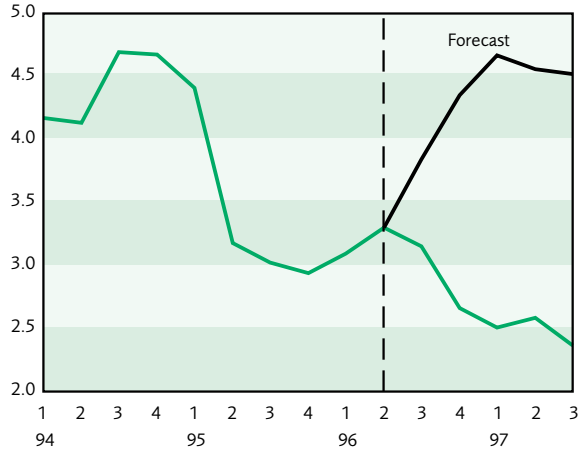


Fig 2d

Australia

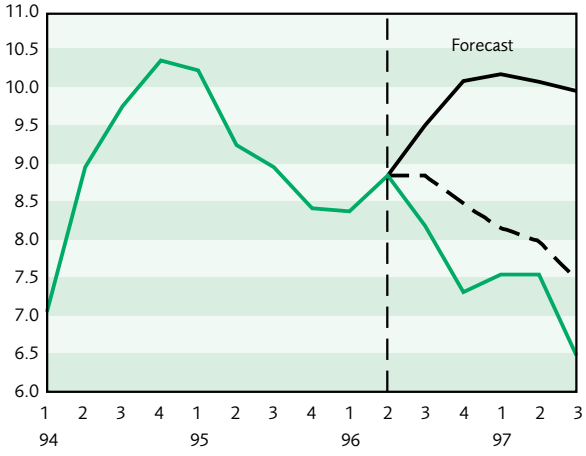


Fig 2e

OECD

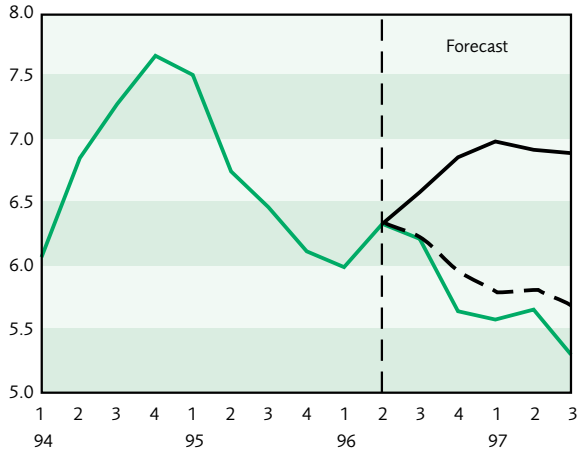


Fig 2f

Actual — Using Consensus Inputs — — Using Actual Data

c) Removing all ripple effects

A further check is to isolate the fraction of error that is due to the ripple effects in the model. This is done by forecasting the equations one at a time rather than as a system. Hence, for example, New Zealand's equation is used to produce forecasts using actual US rates as inputs. The average error across the OECD (excluding Japan) is now 34 bp, only slightly lower than the forecasts in section (b) (see Table 2). That reflects the fact that, with Japan excluded from the model, the US and German equations perform very well. Hence, taking the extra step of removing these links from the simultaneous part of the model leads to only minor improvements in the forecasts.

d) Changes to the model

As mentioned, the changes to the model were not large. However, to see their impact we re-ran the forecasts using the same inputs as above but this time using the revised version of the WIRM. The forecasts were so similar that we do not report them here. Overall, the changes to the model shaved approximately 2 bp off the average forecast error.

e) Consensus and forward curve inputs

The final set of forecasts shows the results from the WIRM as if we were doing the forecasting in June 1996. That is, it uses the original version of the WIRM, the version that we used in our first issue of *World Interest Rate Forecasts.* In addition, the inputs to the model are based on Consensus forecasts of the explanatory variables. The 90-day track for each country is based on the forward curve on 28 June 1996.

The results are shown in Figure 2 (the solid black line). The model was forecasting a rise in bond rates throughout the OECD. US rates were predicted to rise a little and then fall back to their starting level; German and Japanese rates were expected to *rise* substantially. Overall, the forecasts are poor for most countries. In every country, bond rates came in lower than forecast for each of the five quarters. For the OECD as a whole, in 1997:3 bond rates came in 158 bp lower than forecast. Obviously, this is a large cumulative error. The errors range from 51 bp for Ireland to an enormous 339 bp in Australia. New Zealand's bonds came in 106 bp below forecast.

Of course, this is an unfair and unflattering test for the WIRM. In fact, it is not really testing the WIRM at all. It is testing whether Consensus forecasts were any good, and whether the forward curve got the future 90-day track right. There is an obvious problem of garbage in, garbage out. In the middle of last year the market clearly got the underlying scenario wrong. In particular, it was expecting the German and Japanese economies to recover and has been surprised by how long those recoveries have taken. For example, the market was predicting short-term interest rates in Germany to rise to 4.7% by September 1997, led by a Bundesbank that was tightening monetary policy as the economy picked up. The recovery has not yet happened, and short-term interest rates have remained static. The story is similar in Japan and Australia. The market made two very poor calls in the middle of last year, with neither economy having recovered to the extent expected. Australia's 90-day rates were expected to rise to 8.6%, but in fact they fell to 5.0%.

With a scenario of 'world economic recovery' being fed into the WIRM, it is no surprise that it picked a rise in bond rates. The important point is that any forecasting technique relies on accurate inputs, no matter whether that technique is based on a complex econometric model or the simple 'finger in the wind' method. Even subjective forecasting methods depend on getting the underlying scenario right.

SUMMARY OF SOURCES OF ERROR

We have split the total forecast error into its four components:

- Incorrect assumptions (inputs)
- Changes to the model
- Ripple (feed-through) effects
  - caused by Japan
  - caused by the other countries
- The remainder

The sources of error are summarised in Figure 3 and Table 3. Over half the total error is due to incorrect assumptions – the 'world economic recovery' scenario that turned out to be wrong. Only a small fraction can be explained by the changes to the model, but 22% of the errors are caused by ripple effects. Almost all of this can be blamed on a poor forecast from the Japanese equation. The ripple effects from the US and Germany are low. This is not because these countries don't have a big influence in the model, but is because the forecasts from these equations are good.

The errors that are left over are either where the WIRM got it wrong, or where the WIRM is right but the market got a little carried away over the past 15 months. Looking at the remaining error, the cumulative forecast error for the OECD is 42 bp at the end of five quarters and 35 bp on average over the whole forecast period. Overall, these errors are encouragingly low.

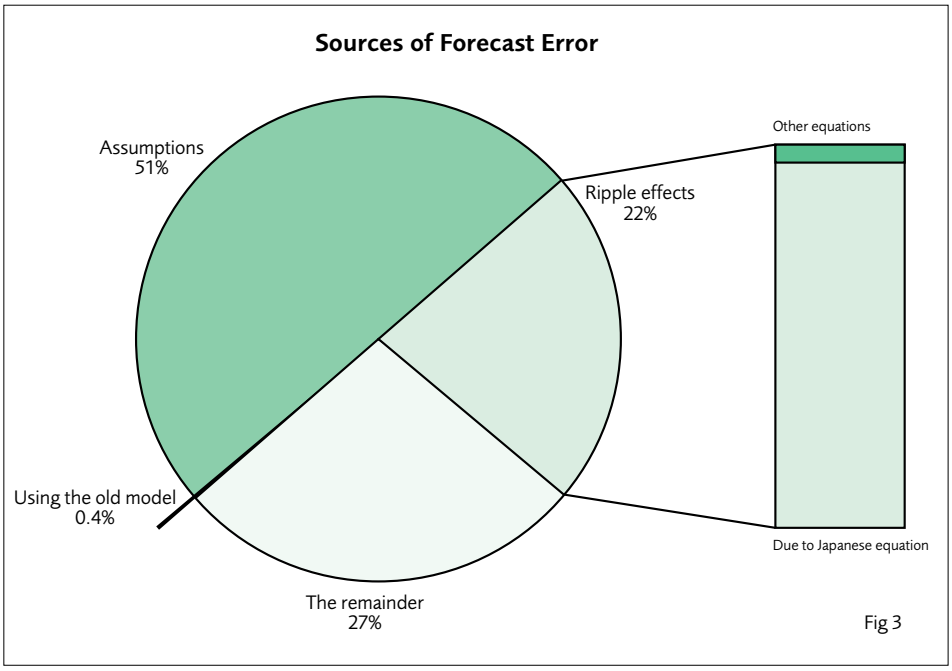


Fig 3

The model picked the global bond rally, once the appropriate monetary policy assumptions had been fed in. On balance, however, it over-estimated bond yields for most countries. For example, between June 1996 and September 1997, German yields fell 86 bp, but the WIRM predicted a decline of 70 bp. French yields fell 100 bp, compared with a prediction of 59 bp. New Zealand yields fell 165 bp, while the WIRM predicted 103 bp. This was a period of growing optimism that inflation throughout the OECD was likely to remain low. The WIRM penalises countries that have a history of high inflation, and assumes that it takes a long history of low inflation before the market becomes convinced that a particular country has indeed reformed and joined the low inflation club. However, the market seems to be giving most countries the benefit of the doubt. European Monetary Union (EMU) may be playing a role. Under EMU, several countries will import the credibility of German monetary policy and thereby gain the advantage of not having to build low-inflation credibility themselves. That has lowered inflation expectations world-wide, and may explain why bonds in most countries have rallied further than the WIRM had expected. On the other hand, it is also possible that the global bond market has undershot and is due for a correction in the coming months.

The time profile of the forecast errors is shown in Figure 4. Out of sample, the average one-quarter-ahead forecast error is only 16 bp. This is substantially lower than the average error within the sample over which the WIRM was estimated. Unsurprisingly, the errors are larger at longer forecast horizons. However, they stabilise around 40 bp after nine months. This reflects the fact that in the long run the WIRM is anchored by the fundamentals, and these fundamentals are based on sound economics. Naïve models that simply extrapolate past behaviour, and which do not have a firm fundamental anchor, would generally find their forecast errors growing continuously larger at longer horizons; they would not stabilise.

TABLE 3: FORECAST ERROR SUMMARY – SOURCES OF ERROR

Average Absolute Errors (OECD), bp

		Consensus Inputs	Actual Data	Revised Model	Remove Japan	Remove All Ripple Effects	No change	Constant Spread
1996:	3	36	20	21	15	16	16	21
	4	120	62	60	35	29	68	53
1997:	1	139	72	71	41	41	75	71
	2	125	65	64	40	41	67	80
	3	158	70	69	45	42	102	91
Average		116	58	56	35	34	66	63

OTHER FORECASTING TESTS

As a final check of the WIRM, we compare its forecasts with two naïve methods. The first assumes **no change** to bond rates; the second assumes a **constant spread** over US or German rates, depending on the country in question. The forecast errors from these methods are summarised in Table 3. The forecast errors from the WIRM are approximately half the errors from the naïve methods, once Japan has been removed from the system. Even with the bias caused by a poor Japanese equation, the WIRM still beats the naïve methods. The WIRM is more accurate over all forecast horizons, but the biggest improvement occurs at a horizon of six months and longer. As mentioned above, the WIRM's errors stabilise but the simple methods get worse the further out they go. For example, the constant spread model has an average error after five quarters of 91 bp, compared with the WIRM's 42 bp.

SCENARIO ANALYSIS

The results discussed above have shown two important uses of the WIRM: providing baseline forecasts; and indicating when a country's bond yields have moved in a way significantly at odds with historical relationships. But probably the most useful application of the WIRM is to do scenario analysis. What if the 'New Paradigm' school in the US is correct? What might be the impact of a meltdown on Asian stock exchanges? How different do the outlooks from bullish and bearish scenarios look? The WIRM provides an easy way to analyse the impacts of different assumptions, and to have these flow through bond rates in a consistent way.

This is illustrated in Figure 5. The WIRM was used to produce forecasts from 1997:4 to 1999:4. The central scenario comes from our October 1997 issue of *World Interest Rate Forecasts,* and is based on Consensus forecasts and forward rates as at the end of September 1997. The central scenario sees a sell-off in bond rates in each of the G3 countries over 1998; the sell-off is particularly large in Japan and Germany, and somewhat milder in the US.

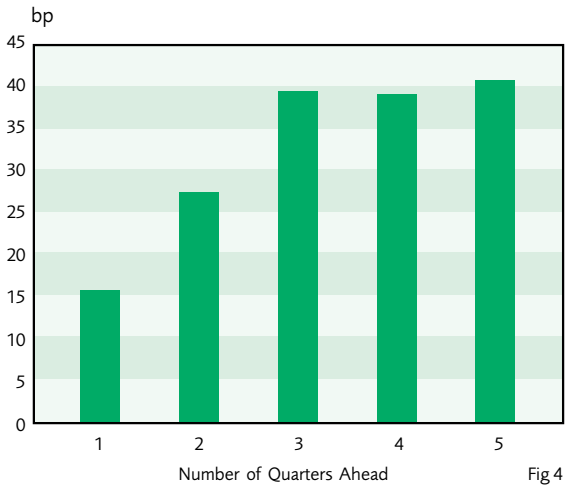
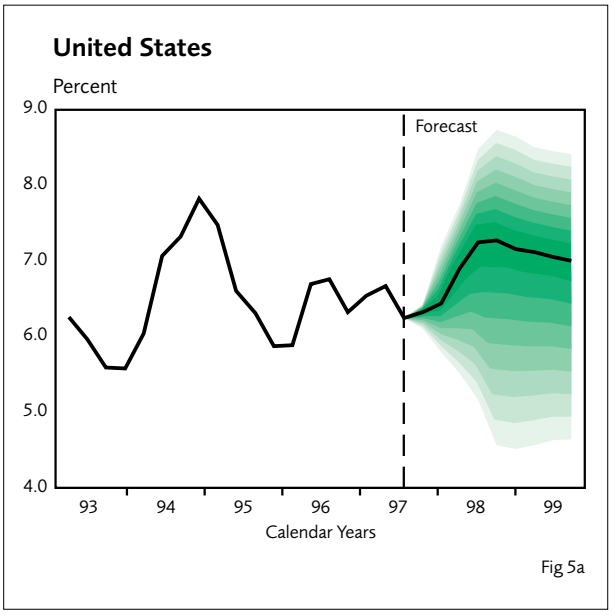
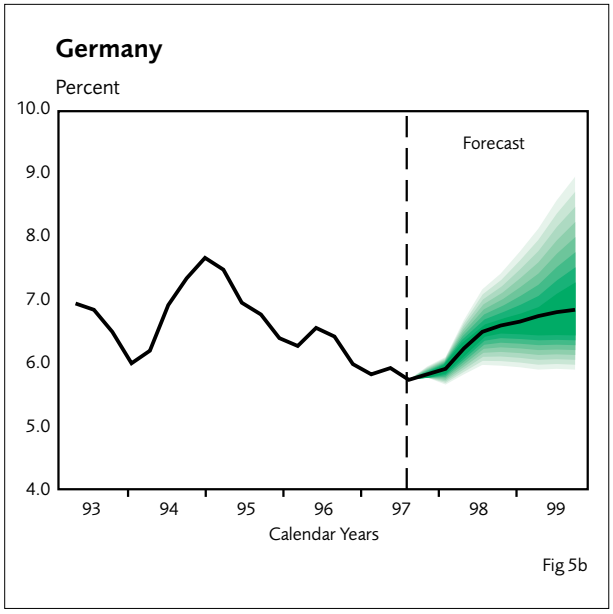
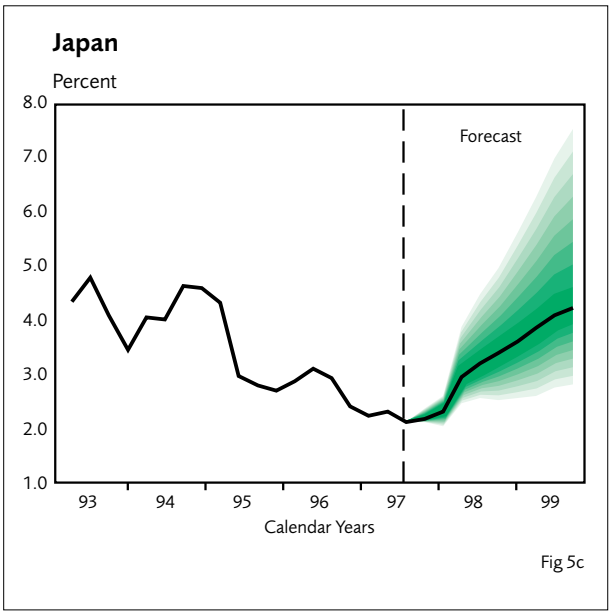


Fig 4

FIGURE 5: FORECAST SCENARIOS







The shades of green represent different subjective probabilities. The darkest band contains the central scenario. We judge there to be a 10% chance that bond yields will be in that band at any point in time. The next darkest shade takes the distribution out to 20%, then 30%, and so on.

To check how sensitive the central forecast is to different assumptions, we ran several alternative scenarios through the model. For each country in the G3 we subjectively estimated a range for inflation and 90-day interest rates at the end of 1999. For example, we supposed that there would be a 90% change that US inflation is between 0% and 4% in 1999, and a 90% chance that its 90-day rates are between 3 and 8 per cent. For Germany, we assume its inflation rate is also between 0% and 4% (with 90% probability), and its 90-day rates between 2% and 7%. For Japan, the ranges are minus 2% to +4% inflation, and 0.1% to 5% for the 90-day rate. We then use the WIRM to produce forecasts based on the most bearish scenario, then the next most bearish, and so on, down to the most bullish scenario.

The results of this exercise are summarised in Figure 5.

Although this exercise is only illustrative, it does produce some interesting results. The risks are approximately evenly balanced for the US, but they are clearly on the upside for German and Japanese yields. Even a very bullish scenario (from a bond point of view) sees yields only holding their current level or increasing slightly. In Japan's case, even an inflation rate of -2% and 90-day rates close to zero are not enough to push yields below 2%. It will take a sustained drop in *long-term* inflation expectations – into negative territory – to achieve that.

SUMMARY

The WIRM did surprisingly well at picking the global bond rally since June 1996. When we decompose the forecast error into its different causes, more than half of the error is caused by incorrect assumptions. In the middle of 1996, Consensus forecasts and the forward curve were based on a scenario of world economy recovery. Most importantly, the market was expecting both the Japanese and German economies to recover strongly. That scenario turned out to be wrong. This highlights the age-old forecasting problem of garbage in, garbage out. However, *any* forecasting technique depends on accurate inputs. The underlying scenario must be right, regardless whether the forecaster uses a sophisticated econometric model or the 'rubbing the belly' method.

Approximately a quarter of the error was due to 'ripple effects', and all the blame for that can be laid at the feet of the Japanese equation. The WIRM steadfastly refuses to believe that Japan's bond yields should be anywhere near 2.0%. The WIRM's poor forecasts of Japan ripple through the rest of the model – it causes Germany's forecasts to be too high, and that in turn affects the whole D-mark bloc. However, when we remove Japan from the model the remaining equations do extremely well. For example, Germany's five-quarter-ahead cumulative forecast error is only 17 bp, and after 15 months the US equation is only 2 bp out!

The poor performance of the Japanese equation begs an obvious question: has the WIRM failed for Japan, or is it telling us that the market has pushed Japanese yields too low? The reader can make his or her own assessment. Either way, it highlights one of the main benefits of using a model such as the WIRM when thinking about bond rates.

Finally, the WIRM is substantially more accurate than naïve forecasting methods such as assuming no change or a constant spread over US or German rates. The biggest improvement comes at a horizon of six months and longer. The WIRM is anchored by the fundamentals, which in turn are based on sound economics, and so its forecast errors stabilise after six months. In contrast, errors from naïve methods grow continuously at longer horizons.

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