



Forecasting Growth of Australian Industrial Output Using Interest Rate Models

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Abstract

We examine the ability of short rates and yield spreads to forecast the growth in Australian industrial output. We find that since 1990, the short rate has a significant increase in its predictive power for forecasting output growth in many industries. We document this increase. The yield spread, on the other hand, is useful in predicting the growth of industries with a 'longer' production cycle, such as manufacturing and wholesale trade. Hence, the predictive power of the yield spread on total GDP, is mainly from its ability to forecast these industries. Our out-of-sample forecasts show that yield spread is a good forecasting device for many industries, particular for output growth over longer horizons.

Keywords: Forecasting, Industrial outputs, Yield spreads.

1. Introduction

The predictive power of yield spreads of interest rates on GDP growth has been well studied in recent years. Some notable literature include Stock and Watson (1989), Estrella and Hardouvelis (1991) and Ang, Piazzesi and Wei (2006). Empirical evidence has proven that the predictive power varies for different countries and from period to period. One extension of these studies could be to examine the predictive power of yield spread on industrial level GDPs. This kind of research will not only provide forecasts for different industrial GDPs but also help us to understand the forecast ability of yield spreads on overall GDP growth. By decomposing the total GDP into different industries, we are able to determine which industries in the economy are more predictable by yield spreads, and therefore help us to understand about the forecasting ability of yield spreads in more detail.

Unfortunately this kind of study is not able to be done across different countries. One of the difficulties is the availability of data. Many countries do not provide quarterly GDP data for different industries. Hejazi and Pasalis (2000) have done the study using monthly data for Canada. They found that the predictive power of the term structure was mainly for manufacturing and service industries.

We want to further extend this study to the Australian economy. In particular, we wish to examine the forecast abilities for short and long interest rates as well as the difference of the two, the yield spread on industrial level output growth. Our study includes all major GDP components. This allows us to investigate the details of why yield spreads can predict future growth in GDP. In particular, we find the following results. First, there is evidence in our result that Australian's economy has been through different regimes between 1980s and the early 1990s. In the new regime, the short rate becomes very effective in carrying out monetary policies, thus its predictive power on the outputs of most industries is largely improved. Second, the predictive power of the short rate and of the yield spread varies to different industries. The short rate is more useful in predicting industries such as construction and retail trade. On the other hand, the yield spread provides additional explanatory power to the industries which have a longer production cycle, such as manufacturing and wholesale trade. As a result of this, we find that the predictive power in yield spread on the total GDP is from its ability to predict the output growth in manufacturing and wholesale trade. Third, our out-of-sample forecasts show that yield spread is particularly useful when predicting output growth over longer horizons.

The structure of the article is as follows: Section 2 discusses the industry output data used in this study. Section 3 reviews some basic relationships between the yield from long bond and that from short bond. Section 4 discusses the estimation results using the entire sample. Section 5 discusses the possible regime changes and re-estimates the model using the data from the new regime. Section 6 further investigates the differences of the forecast ability between short rate and yield spread. Section 7 calculates the out-of-sample forecasts and evaluate their results and the last section concludes the paper.

2. Data for industry outputs

The data we used was specially prepared for us by the Australian Bureau of Statistics (ABS). It contains the quarterly industrial level of outputs between 1974 Q3-2005 Q4. Table 1 lists the names of those industries. Some of the industries are aggregated to form a bigger section of industry. For example, primary industry is an aggregation of agriculture, forestry and fishing and mining and the utility component includes services of electricity, gas and water. Most of the industries have a self-explanatory name. The business and property services industry include both the business and property services. The property services include service provided by property operators, developers, real estate agents and so on. The activity of owner occupiers renting or leasing their own dwellings to themselves is put under the name of ownership of dwellings.

We would like to have a data set in which the spending by public sectors is separated from those by private sectors, since they are expected to behave differently in respond to changes in interest rates. Unfortunately the separation is not available in Australia. Nevertheless, we believe industries such as education, health and community services and government administration and defence, consists of a large portion of services provided by the public sectors. Therefore, the estimation results for these industries should be interpreted with caution.

Table 1 lists the percentage shares of each industry component to total GDP output for different periods and the averages over the sample. As can be seen, most of the components retain their shares over time. However the manufacturing industry in Australia is continuously declining in our sample period. Its shares drop from about 22% to about 12% from 1974 to 2005. The lost shares are mainly picked up by the service industry, in which the share increased from about 66% to about 73% for the same time period.

We want to focus our study on those major industries, in particular those industries whose average share in our sample is above 5%. The government administration and defence is also included, since it is interesting to see how these public financed sectors react to interest rate changes. Finally, for completeness and comparison, we also estimated the models for total service industry and total GDP.

3. Some Reviews

Before we move on to the models and results, it is worthwhile to review the relationships between short rate, long yield and yield spread and the mechanism that how the slope of the yield spread is related to economic activity. Let R_t^1 be the yield of a 1 period zero coupon bond and R_t^k be the yield of a k period zero coupon bond. Then the yield spread between these two yields at any given time t is just $(R_t^k - R_t^1)$. The relationship between these two yields is that the k period yield can be approximated by a weighted average of the expected future 1 period yield plus a term premium (Campbell, Lo and MacKinlay, 1997). In particular, we have the following equation,

$$R_t^k = (1/k) \sum_{i=0}^{k-1} E_t R_{t+i}^1 + TP_t^k, \quad (3.1)$$

Where TP_t^k is term premium. Therefore, the k period yield (or the long yield, as it is often referred as) contains the current 1 period yield (or the short rate, as often referred to as) and future expected 1 period yields. From (3.1), we can obtain the expression for yield spread $(R_t^k - R_t^1)$ by subtracting the current 1 period yield R_t^1 from both sides of the equation,

$$R_t^k - R_t^1 = (1/k) \sum_{i=1}^{k-1} E_t (R_{t+i}^1 - R_t^1) + TP_t^k. \quad (3.2)$$

Hence, (3.2) states that yield spread $(R_t^k - R_t^1)$ can be interpreted as an average of the expected change between future short rates to the current short rate plus a term premium. In other words, the yield spread contains the information of people's expectation about future short rate movements relative to the current one, or more directly, yield spread contains information of people's expectation about future economic conditions. As will be seen later, this interpretation is very important for some of our results.

What is the relationship between economic activity and yield spread? A common explanation using the effects of monetary policy is that, to respond to an increase in the current short rate, the economic agents realize that the future short rates do not increase as much as the current short rate, or they may even decrease (Campbell, 1998), given that the future inflation pressure is eased. This expected movements in the future short rates causes the long yield to decrease. Hence the slope of the yield spread at a given time would be flatter or even negative sloping. Meanwhile, the increase in the interest rate causes a reduction in economic activity. Later on, we will argue that this explanation may be misleading. It does not emphasis the fact that the yield spread contains information about the expected future economic conditions. In a later section, our results will show that this information is quite useful to some industries in making their production decisions.

4. The model and estimation results using the whole sample

To test how industry outputs respond to the changes in short rate, long yield and yield spread, we first use these three variables separately as the explanatory variables in three simple regressions,

$$y_{t+k} = \alpha_0 + \alpha_1 x_t + \varepsilon_t, \quad (4.1)$$

where y_{t+k} is the k th quarter growth rate of the corresponding industrial outputs and x_t represents the short rate R_t^1 , the long yield R_t^k or the yield spread $(R_t^k - R_t^1)$ respectively. The short rate is used to capture the change in current monetary policy. The long yield and the yield spread are used since they both have information about future economic conditions. We use 3-month treasury bills for the short rate and the 10 year government bonds for the long yield. Both series can be found on line in the Reserve Bank's data set.

The growth rates on the LHS of the models are overlapping. When overlapping data is used for a set of explanatory variables consisting of information at time t , the forecasting errors are serially correlated. In fact, it is not difficult to show that the error is a moving average (MA) of order $k-1$ process. The OLS estimator is no longer efficient but is still a consistent estimator in this case. Moreover, the independent variable x_t in (4.1) cannot be assumed to be strictly exogenous. To see this, note that strict exogeneity requires that the future x_t is not correlated with past and future ε_t (Hansen and Hodrick, 1980), which is certainly not true in our case given the fact that our dependent variable is overlapping. Thus, we cannot use the generalized least squares (GLS) estimator to estimate the model, since the GLS estimator is inconsistent when the dependent variable is not strictly exogenous. We overcome this problem by using the traditional OLS estimator to obtain consistent estimates and use the Newey-West estimator to correct the standard errors (Newey and West, 1987).

We report the results for the output growth over 1 - 8 quarters for each industry in Table 2. We can conclude from the results that firstly, some of the industries do not show any relationship to the three explanatory variables. For example, some of those industries are education, health and community service and government administration and defence. This is as expected, since we argued previously that a large amount of spending in these industries is possibly from the public sector and therefore insensitive to interest rate changes. The growth in primary industry output is also not correlated to any of the three explanatory variables. Again, this result is in line with our expectation, since production in primary industry is mainly due to factors such as weather and basic demands from both domestic and international markets. Given that Australia is a large primary resource and agriculture product net exporter, the outputs in the primary industry may be more related to overseas economic conditions rather than those of the local economy. The next two industries which are insensitive to rate changes are bit surprising. They are the growth rates for industries of business and property service and finance and insurance. We can see that the reported adjusted R^2 s are very low for all growth in both industries, indicating that there is little explanatory power by the three explanatory variables. It is difficult to interpret the result, since given the nature of these two industries, they should be, at least, highly correlated with the change in the short rate.

Secondly, the models are good for the industries of ownership of dwellings, retail and wholesale trade and construction. The three variables, the short rate, the long yield and the yield spread are in general, significant at the conventional level for growth in most of these industries, with an exception of the yield spread, which seems not be able to predict the growth in ownership of dwellings. The R^2 s are in general, reasonable and it seems that it is improving as we try to predict the growth rates over longer horizons.

Thirdly, for the manufacturing industry and total service and total GDP, the results are mixed. The short rate and the long yield are not very significant in all the models. Again this result is difficult to explain. The short rate captures the current monetary policy and therefore, it is hard to imagine that the total service industry and total GDP do not respond to its changes. The yield spread, on the other hand, showed some significant explanatory power for some of the growth rates in manufacturing and total

GDP. However, the corresponding R^2 s are in general, poor. The highest R^2 s for manufacturing and total GDP are only 7 and 12%, respectively.

In summary, our first estimation results are not as good as we initially expected. Some of the industrial outputs which are supposed to be highly predictable by these interest rate models are in fact, not successfully predicted. In the next section, we give a possible explanation of why this happened.

5. Possible regime switches and estimation results in the new regime

The Australian monetary policy has gone through many significant changes from mid 70s to early 90s. According to former Reserve Bank of Australia Governor, Ian Macfarlane, there were 4 regime changes in monetary policy over that period: First, the fixed exchange rate regime, which finished in the early 70s. Second, the monetary targeting regime between 1976 and 1985 to reflect the change from a fixed exchange regime to the floating exchange rate regime. Third, a transitional period, during which the economy moved away from the monetary targeting system and lasted until the early 90s, and four, the inflation targeting regime, since 1993 until the present (Macfarlane, 1997). Not all of these monetary policy changes have a long impact on the behaviors of economic agents. However, some of these changes are so great that they might have changed people's behavior in the long run. Hence, we may have possible regime changes in our sample data between 70s and early 90s. Moreover, there is literature, for example Smith and Summers (2002),

that find the GDP growth volatility in Australia has been reduced dramatically since 1984, which is coincide to the above time that monetary policy changes. Therefore, the evidences point to a possible regime change between 1984 - 1993.

Knowing that we might have a possible regime change, we need to re-examine the models for different regimes. Hence, we re-estimated the model using sample data from 1990 - 2005. The reason that we choose 1990 as the new starting point is not only that it is between 1984 - 1993, but more importantly, beginning from 1990, the Reserve Bank of Australia started to use the targeting rate to implement the monetary policy. That is, the Reserve Bank set a target for the cash rate in the over-night money market and let the market forces to determine the quantity of money demanded and supplied. We believe that this is a more effective way to implement the monetary policy in the new economic environment faced at that time. Thus, 1990 is chosen as the starting point for the new sample. Furthermore, using data from 1990 rather than say, from 1993, allows us to include the 1992 'we had to have' recession, and hence allows more variations in the data.

Table 3 reports the re-estimation results (Note 1) for all the industries we estimated in the previous section. As can be seen that the estimation results improve significantly using the new samples. Perhaps the most obvious change is for the short rate model. The short rate became a significant factor for output growth over all horizons of manufacturing, business and property services, ownership of dwellings, finance and insurance, retail and wholesale trade, construction, total service and total GDP. The corresponding t statistics yield some very large values, indicating the importance of the short rate in predicting output growth in those industries. We can also see the improvement from the adjusted R²s. For example, in manufacturing industry, previously the adjusted R²s were about 6 - 7%, now they are about 20 - 30% in the short rate model. This result is consistent with the argument we gave above that since switching to the targeting rate system, short rates become more effective in carrying out monetary policy.

Of course, we still have the industries of primary, education and government administration and defence, in which the growth rates do not respond to changes in the short rate. But this is as expected for the reasons discussed previously. Interestingly, the short rate seems can predict the growth rates over 7 and 8 quarters for the health and community service industry. The adjusted R² increases to 24% for the 8-quarter growth.

All of these indicate that using different samples does make the estimation results change dramatically, which in turn, makes us to believe that an important regime switch did occur around the time we discussed above. Therefore, from now on, we will restrain our analysis on the sample between 1990-2005.

The results also show that the long yield and the yield spread are useful for predicting the growth in some industries. In particular, it seems the long yield can predict the growth for ownership of dwellings, finance and insurance, retail trade and construction. The yield spread seems to be useful in predicting the output growth for manufacturing, wholesale trade, total service and total GDP. From the reviews in section 3, we know that the long yield consists of both the current short rate and future expected short rates. Hence, we cannot identify whether the predictive power in the long yield is from the current short rate or the future expected short rates, or both. The next section will explore the relationship in more detail.

6. Does yield spread provide extra information for prediction

Different industries may react differently to the current short rate changes. For example, we would expect that the growth in the construction industry to be more dependent upon the current interest rate changes rather than the expected changes in future short rates, since its production cycle is relatively short compared to the industries such as manufacturing. In the manufacturing industry, when firms facing a current short rate change, they will react (particularly when the short rate has become very effective now). However, parts of their production may not be able to adjust immediately given the inflexibility of investment and plans. Hence, their production decisions need to be forwarding looking. This is when the information about future economic conditions becomes important. The yield spread which summaries the expected future short rate movements certainly provides such information and thus, is a useful device in predicting the production growth. Generally, we would expect that industries with longer production cycle share the same situation and hence yield spreads should be useful for the prediction of the growth as well. On the other hand, for the industries which have relatively short production cycle, such as construction, their growth depends on future economic conditions to a less extent, therefore it is more appropriate to use the short rate to forecast it.

The important lesson here is that when discussing the predictive power of yield spread, the explanations given by many text books may be blurred. They normally give the following story: When there is a interest rate hike, the long yield will decrease for the reasons discussed in section 2, hence, the yield spread will be flatter or downward slopping. Meanwhile, economic activities is suppressed as a result of the rate hike. Therefore, the relationship between the yield spread and the economic activities is positive. This explanation sometimes could be confusing as it may sound like that the predictive power of the yield spreads comes only from short rates. This is not true as we discussed above. The results presented later will also support our argument here, which is, yield spreads provide additional explanatory power to

short rates on the growth of certain industries because they contain future economic information.

To test the above discussion, a common method is to run a regression that includes both terms of the short rate and the yield spread. That is, to run the following regression,

$$y_{t+k} = \beta_0 + \beta_1 R_t^1 + \beta_2 (R_t^k - R_t^1) + \varepsilon_t. \quad (6.1)$$

If the coefficient of the yield spread is still significant in this regression, then it really indicates that the future short rate movements contained in the yield spread, plays an important role in predicting output growth. On the other hand, if the yield spread lost its predictive power while the short rate is also present as an explanatory variable, it indicates that the growth is more dependent upon the changes in current short rate. We ran (6.1) for all the industries except for education, health and community services and government administration and defence, since a large proportion of output in those industries involves spending from public sectors and their estimation results were shown to be, in general, insignificant in the previous section. The regression is again estimated for the growth over 1 to 8 quarters. The results are reported in Table 4.

Looking at the results for manufacturing industry, we see that the short rate is as expected, still a significant factor in determining the growth over all periods. The coefficients of the yield spread are not as significant as their counterparts in the simple yield spread only regression. Only the coefficient in the 1 quarter growth regression has a t statistics over 2. Does this mean that the predictive power of the yield spread is only from the short rate, that the growth in manufacturing industry depends only on the current economic condition but not the future? One problem with using this type of analysis is that the short rate and the yield spread may be correlated, causing the multicollinearity problem in estimation. To give a general idea, the correlation of the two in our sample between 1990:Q1 and 2005:Q4 is about -0.33, which may cause the t statistics to be smaller. In fact, if we look at the adjusted R^2 s, we can see that they are all improved from those of simple regressions, (alternatively, the t statistics of the yield spread coefficients are all above 1). The highest adjusted R^2 can go up to 41% compared to the 31% in the simple regression case. This indicates that the yield spread is adding explanatory power to the model. Hence, we conclude that the lower values in the t statistics are due to the correlations between the two independent variables. The yield spread actually adds more explanatory power to the model in the presence of the short rate. This is consistent with our expectations that the growth in the manufacturing industry depends on both the change in the current short rate as well as the future expected short rate movements. An example that shows the yield spread does more than the short rate in prediction.

An alternative way to draw the similar conclusion is to use the three regression estimation results we had in the previous section and note the equation (6.1), which again, states that yield spread contains the expected changes of future short rates from the current one. If, for example, the short rate coefficient is significant in model 1 and the long yield coefficient is significant in model 2, then the explanatory power could be from the short rate or from both the short rate and the expected changes of future short rates. If however, the short rate coefficient is significant, the long yield coefficient is not significant, but the yield spread coefficient is significant, then it clearly shows that the predictive power is from both the current short rate and the expected changes of future short rates. For example, looking at the manufacturing outputs in Table 3, we find that the coefficients for the short rate and the yield spread are about 5% significant for output growth over all different periods. On the other hand, the coefficients for the long yield are in general, not significant (with an exception for output growth over 2 period perhaps). Hence, it indicates that both of the current short rate and the expected changes in the future short rates have explanatory power on output growth in manufacturing.

Using the above analysis, we find that the wholesale industry is similar to the manufacturing industry, in which both the short rate and the yield spread show explanatory power for output growth. The adjusted R^2 can go as high as 58% compared to 42% in the case of the short rate only model. On the other hand, the yield spread seems not adding much predictive power for output growth in the industries of property and business services, finance and insurance, retail trade and construction. These results are in line with our expectations, since the production cycle in these industries are shorter than that in manufacturing and wholesale trade. Therefore, firms in these industries are more subject to the current economic conditions rather than the future ones and consequently, the output growth in these industries is more related to the short rate, rather than the yield spread. Note that this analysis is only based on the static regression result we presented in Table 3 and 4. In the next section, when we calculate the out-of-sample forecasts for these industries, we will see that the future expected economic conditions contained in the yield spread, are sometimes quite useful in predicting the output growth in these industries.

The results for ownership of dwellings are a bit special. The adjusted R^2 s are somewhat increased using model (6.1) comparing to the short rate only model, particularly for output growth over 4 and 5 periods. Therefore, we have some evidence that the yield spread provides additional prediction power for output growth. However, the signs on the coefficients of the yield spread are all negative. In general, they should be positive as argued before that a rate hike causes a pessimistic sentiment about the future, hence reduces economic activities. One possible explanation could be that, since the activities in ownership of dwellings are owners renting the premises to themselves, during bad economic

times, people are likely to do business at home. Therefore we see the negative relationship between the output growth and the yield spread.

The yield spread can also provide extra information to explain the growth in the total service and the total GDP. We can see this by the improvement in the adjusted R^2 s for the two variables. The highest adjusted R^2 for total service increased to 58% in model (6.1) from 49% in the short rate only model. For total GDP, the increase in the highest adjusted R^2 is from 49% to 57%. This is not surprising since some of their components are highly correlated with the yield spread. From this result, we can further conclude that the predictive power of the yield spread on the future growth in GDP is from its ability to predict the growth in manufacturing, wholesale and possibly ownership of dwellings components. This information helps us to understand more about the relationship between the yield spread and the growth in total GDP. For example, if the predictive power of the yield spread on GDP growth is mainly due to its ability to predict the manufacturing component in total GDP, and if the shares of the manufacturing component is continuously declining, just as it is in our sample between 1974 - 2005, we may see that the predictive ability of the yield spread on GDP growth becomes smaller and smaller in the future.

Our estimation results using the new sample period are, in general, very good. We have seen the relative strong predictive power from the short rate and the yield spread on output growths of many industries. We are now ready to evaluate the goodness of the forecasts from the above models and see which model is more suitable to make the forecast in practice for different industries.

7. The out of sample forecasting

In this section, we compare the out-of-sample forecasts from those models we discussed above with the forecasts from a benchmark forecasting models. In particular, we compare the forecasts from five models. Model 1 - 3 is (4.1) with the short rate, the long yield and the yield spread to be the independent variable respectively. Model 4 is (6.1), which has both the short rate and the yield spread as the explanatory variables. Model 5 is similar to (4.1) with the independent variable being the lagged growth rate of GDP. Some industry components might be better forecasted by the lagged GDP growth. Note that the number of lags in GDP growth depends on the growth period in the model. Thus, to forecast one quarter growth, the GDP growth is lagged one, for two quarter growth, the GDP growth is lagged two and so on. Finally, we also calculated the forecasts from a simple AR (1) model. To compare these results, we calculate the root mean square errors (RMSE) for those forecasts errors. We then take ratios of the RMSEs to those of the AR(1) forecasts. Thus, the AR (1) model is used as the bench mark. If the calculated ratio is greater than one, then it indicates that the forecast is worse than that from the AR (1) model. Of course, the smallest ratio indicates that the forecast from that model outperforms the forecasts from other models.

Forecasts are made for all industries except for health and community service, education and government administration and defence, for the same reasons mentioned before. We include primary industry in this analysis, because although its growth is not sensitive to rate changes, it may be better forecasted by the lagged GDP growth model. Similar to the previous sections, we include the forecasts for the output growth of total services and total GDP. Given that we don't have a large sample size, only 20 quarters out-of-sample forecasts were made. The first forecast was made for the March quarter in 2001. We then moved forward by one quarter, and included the March quarter 2001 data in the estimation and forecasting for the next quarter growth. Our forecast horizons are for output growth over 1, 4 and 8 quarters. Table 5 reports the RMSE ratios for these forecasts.

In general, the forecasts from model 1 - 5 are better than their counterparts from the simple AR (1) model, as most of the RMSE ratios are less than a unit. Of course, if the ratio is very close to 1, say 0.99, we cannot conclude that the forecast from that model is better than that from the AR (1) model. Focusing on growth rates over 4 and 8 quarters, the forecasts from model 3, the yield spread only model, seem to be the best for most of the industries. The RMSE ratios of model 3 are smallest for the industries of manufacturing, property and business services, finance and insurance, retail trade, wholesale trade, total service and total GDP. The results are a little surprising for two reasons. First, we did not expect that the yield spread would give better forecasts than the short rate for the industries of property and business services, finance and insurance and retail trade, since in the previous section, we have seen that the growth rates in these industries are more correlated to the short rate, rather than the yield spread. Here we found that the yield spread gave the best out-of-sample forecast for these industries. Second, it seems that for output growth over 4 and 8 quarters (Note 2), at least in our sample, model 4, the model which includes both the short rate and the yield spread, does not necessarily give better out-of-sample forecasts. It seems the yield spread can do a better job by its own. Therefore, these results show that the out-of-sample forecast results could be different from the results from the static regressions we presented previously. It is difficult to say whether this unexpected difference is due to the small forecasting samples we are using.

For the primary, the ownership of dwellings and the construction industries, it is the short rate only model that yields the best forecast for their growth over 4 and 8 quarters. This result is not surprising for the ownership of dwellings and the construction industries, since their output growth is highly correlated to changes in the short rate. For the primary industry, although its growth does not seem to be sensitive to any rate changes, the short rate model still give better

forecasts than the model using lagged GDP growth or the AR (1) model.

If we focus on the forecasts for the growth over a 1 quarter period, then, there is no model that outperforms the others for all industries. The short rate model is still the best for the construction industry. The yield spread model gives better forecasts for finance and insurance and retail trade industries. Model 4 which includes both the short rate and the yield spread, gives the smallest RMSE ratio for the industries of manufacturing, wholesale trade, total service and total GDP. Finally model 5, the lagged GDP growth model, provides better forecasts for growth in ownership of dwellings and primary industry output. This result is not surprising, since growth over a 1 quarter period is subject to the changes of many short term factors, which makes it very volatile and therefore, difficult to predict.

In summary, the out-of-sample analysis indicates that the yield spread is an important device in predicting the output growth for most industries and total GDP. This is particularly true when the

growth rates are over longer horizons such as 4 or 8 quarters. The growth rate over shorter periods such as 1 quarter is difficult to predict and no simple model can give a satisfactory result. Of course, our conclusion is based on only 20 out-of-sample forecasts. In the future, when more data is available, the results could be more convincing. Nevertheless, it is a still useful information for forecasting.

8. Conclusion

We examined the predictive power of the short rate, the long yield and the yield spread for industry level output growths in Australia. Through this study, we find that firstly, the short rate and the yield spread are useful in predicting output growth for many, but not all industries. In particular, output in the primary industry and the services that are largely provided by public sectors, are unlikely to be predictable by the interest rate models. Secondly, ever since the Reserve Bank of Australia switched to the targeting cash rate system as the way to implement monetary policies from the beginning of 1990, short rates became very effective tools for influencing the output growth in many industry components. In other words, the predictive power of the short rate has significantly increased since 1990. This is shown in our estimation results using samples after 1990. Thirdly, the yield spread can also help to predict the growth in some industries, but it works for a different reason to that for the short rate. Since it contains the information about the expected future economic conditions, it is useful for the industries which are more dependent upon the future economic information, for example, manufacturing and wholesale trade. On the other hand, industries such as construction and retail trade are more affected by the current short rate changes and not by the yield spread.

As a result of the above conclusion, we can see that the predictive power of yield spread on total GDP is mainly from its predictability on the manufacturing and wholesale industries. We note that the shares of the manufacturing in total GDP are continuously declining over time in Australia. We would suspect that the predictive power of the yield on total GDP may be reduced as a result of this in the future.

The out-of-sample forecast analysis shows that it is difficult to forecast the growth over shorter horizons such as 1 quarter, given that output growth is often affected by many short term factors. For the growth rates over longer horizons such as 4 quarter or 8 quarters, the yield spread seems to outperform the short rate in terms of RMSEs, even for the industries in which the yield spread was not particularly useful in the static regression analysis. This is an interesting result, but we need to be cautious since our results are based on a relative small number of out-of-sample forecasts.

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Notes

Note 1. We also estimated the model using the cash rate as the short rate. The results are very similar to the results using the 3-month treasury bills.

Note 2. For the 4 quarter growth, the yield spread only model gives a slightly better RMSE ratio than the short rate only model in ownership of dwellings. However, for the growth over 8 quarter, the short rate model gives a much smaller RMSE ratio than that from the yield spread model.

Table 1: Percentage Shares of Industry Components

Industries	Sep 74	Dec 85	Dec 95	Dec 05	Average
Manufacturing	22.07%	16.99%	14.52%	12.02%	16.23%
Property and business services	8.71%	9.58%	11.13%	12.61%	10.42%
Ownership of dwellings	7.29%	8.43%	8.41%	8.96%	8.46%
Primary industries	7.52%	8.32%	8.82%	7.77%	8.34%
Finance and insurance	5.91%	6.11%	7.42%	7.62%	6.85%
Retail trade	7.63%	7.33%	6.18%	6.20%	6.69%
Construction	7.08%	6.72%	5.90%	7.15%	6.50%
Health and community services	5.09%	5.95%	6.40%	6.80%	6.07%
Wholesale trade	7.08%	5.42%	5.15%	5.11%	5.52%
Education	4.66%	5.83%	5.50%	4.69%	5.49%
Government spending	5.11%	5.10%	4.69%	4.28%	4.84%
Transport and storage	4.22%	4.75%	4.77%	4.84%	4.59%
Utility	2.74%	3.16%	3.06%	2.35%	2.96%
Accommodation, cafes and restaurants	2.44%	2.20%	2.18%	2.22%	2.27%
Personal	2.28%	2.00%	1.98%	1.90%	2.03%
Communication	1.11%	1.44%	2.45%	3.19%	1.95%
Cultural	1.32%	1.56%	1.43%	1.62%	1.47%
Total service	66.00%	68.78%	70.94%	73.05%	69.77%
GDP residual	-2.66%	-0.81%	-0.18%	0.00%	-0.84%
Total GDP	100.00%	100.00%	100.00%	100.00%	100.00%

Table 2: Summary of Estimation Results for Different Industries and Total GDP Using the Sample of 1974 - 2005 (cont'd)

		1- Qtr	2- Qtr	3- Qtr	4- Qtr	5- Qtr	6- Qtr	7- Qtr	8- Qtr
Retail trade	Short rate model								
	Coefficient	-0.27	-0.24	-0.24	-0.26	-0.27	-0.27	-0.26	-0.25
	t stats	-1.96	-2.67	-2.77	-3.14	-3.66	-4.05	-4.34	-4.66
	Adjusted R ²	0.03	0.07	0.10	0.15	0.21	0.25	0.27	0.29
	Long yield model								
	Coefficient	-0.25	-0.23	-0.24	-0.25	-0.25	-0.26	-0.26	-0.25
	t stats	-1.76	-2.03	-2.13	-2.27	-2.37	-2.53	-2.62	-2.73
	Adjusted R ²	0.01	0.03	0.06	0.09	0.12	0.15	0.18	0.19
	Yield spread model								
Construction	Coefficient	0.48	0.43	0.40	0.45	0.50	0.46	0.41	0.40
	t stats	1.47	2.07	2.04	2.41	2.93	2.95	3.08	3.55
	Adjusted R ²	0.02	0.04	0.05	0.10	0.15	0.16	0.15	0.16
	Short rate model								
	Coefficient	-0.67	-0.72	-0.76	-0.77	-0.75	-0.71	-0.66	-0.62
	t stats	-2.36	-2.63	-2.67	-2.71	-2.66	-2.49	-2.35	-2.17
	Adjusted R ²	0.03	0.07	0.11	0.15	0.18	0.18	0.19	0.19
	Long yield model								
	Coefficient	-0.74	-0.78	-0.82	-0.82	-0.80	-0.75	-0.70	-0.65
Health & community service	t stats	-1.84	-1.98	-2.05	-2.07	-2.02	-1.93	-1.87	-1.82
	Adjusted R ²	0.02	0.05	0.08	0.11	0.13	0.13	0.13	0.13
	Yield spread model								
	Coefficient	0.81	0.92	0.99	1.05	1.08	1.04	0.97	0.90
	t stats	1.26	1.64	2.06	2.73	2.82	2.53	2.14	1.84
	Adjusted R ²	0.00	0.02	0.03	0.05	0.07	0.08	0.08	0.08
	Short rate model								
	Coefficient	0.02	0.02	0.00	-0.01	-0.02	-0.01	0.00	-0.01
	t stats	0.15	0.20	-0.07	-0.26	-0.31	-0.19	-0.09	-0.15
Wholesale trade	Adjusted R ²	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Long yield model								
	Coefficient	0.02	0.01	0.00	0.00	0.01	0.01	0.01	0.01
	t stats	0.11	0.11	0.03	0.06	0.11	0.15	0.18	0.21
	Adjusted R ²	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	Yield spread model								
	Coefficient	-0.03	-0.04	0.03	0.08	0.09	0.07	0.05	0.07
	t stats	-0.12	-0.23	0.20	0.68	0.91	0.74	0.55	0.66
	Adjusted R ²	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00
Education	Short rate model								
	Coefficient	-0.50	-0.54	-0.59	-0.60	-0.59	-0.56	-0.52	-0.48
	t stats	-2.80	-2.94	-2.91	-2.86	-2.88	-2.74	-2.45	-2.20
	Adjusted R ²	0.04	0.09	0.15	0.19	0.22	0.23	0.24	0.24
	Long yield model								
	Coefficient	-0.50	-0.53	-0.57	-0.56	-0.55	-0.53	-0.50	-0.48
	t stats	-1.97	-2.00	-2.07	-2.13	-2.18	-2.20	-2.19	-2.17
	Adjusted R ²	0.02	0.05	0.09	0.11	0.12	0.13	0.14	0.15
	Yield spread model								
Wholesale trade	Coefficient	0.74	0.87	0.99	1.08	1.08	1.01	0.89	0.79
	t stats	1.46	1.91	2.71	3.13	3.02	2.62	2.12	1.76
	Adjusted R ²	0.01	0.04	0.09	0.13	0.16	0.16	0.15	0.14
	Short rate model								
	Coefficient	0.12	0.07	0.07	0.07	0.06	0.06	0.05	0.05
	t stats	0.92	0.61	0.63	0.62	0.65	0.68	0.57	0.54
	Adjusted R ²	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Long yield model								
	Coefficient	0.11	0.09	0.10	0.10	0.10	0.11	0.11	0.13
Education	t stats	0.76	0.69	0.74	0.73	0.79	0.91	1.03	1.20
	Adjusted R ²	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
	Yield spread model								
	Coefficient	-0.21	-0.04	-0.02	-0.01	0.00	0.03	0.11	0.16
	t stats	-0.70	-0.16	-0.10	-0.07	0.02	0.25	0.80	1.21
	Adjusted R ²	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.01

Government administration & defence	Short rate model								
	Coefficient	-0.10	-0.08	-0.06	-0.04	-0.02	0.00	0.02	0.03
	t stats	-0.88	-0.73	-0.55	-0.41	-0.21	0.03	0.25	0.49
	Adjusted R ²	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	0.00
	Long yield model								
	Coefficient	-0.05	-0.05	-0.03	-0.01	0.01	0.03	0.04	0.05
	t stats	-0.37	-0.35	-0.26	-0.10	0.08	0.24	0.45	0.59
	Adjusted R ²	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00
	Yield spread model								
	Coefficient	0.31	0.23	0.15	0.14	0.11	0.06	0.05	0.01
	t stats	1.18	0.94	0.65	0.62	0.54	0.34	0.28	0.09
	Adjusted R ²	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01
Total service	Short rate model								
	Coefficient	-0.07	-0.09	-0.10	-0.11	-0.11	-0.11	-0.10	-0.10
	t stats	-1.23	-1.25	-1.27	-1.40	-1.49	-1.48	-1.42	-1.35
	Adjusted R ²	0.00	0.02	0.04	0.06	0.08	0.09	0.09	0.10
	Long yield model								
	Coefficient	-0.09	-0.09	-0.10	-0.11	-0.11	-0.10	-0.10	-0.09
	t stats	-1.08	-0.99	-1.04	-1.11	-1.14	-1.16	-1.14	-1.11
	Adjusted R ²	0.00	0.01	0.02	0.04	0.04	0.05	0.05	0.05
	Yield spread model								
	Coefficient	0.08	0.11	0.13	0.17	0.19	0.19	0.19	0.19
	t stats	0.50	0.80	1.06	1.52	1.73	1.62	1.51	1.43
	Adjusted R ²	-0.01	0.00	0.01	0.03	0.05	0.06	0.07	0.08
Total GDP	Short rate model								
	Coefficient	-0.11	-0.14	-0.16	-0.16	-0.15	-0.14	-0.13	-0.12
	t stats	-1.39	-1.48	-1.51	-1.55	-1.55	-1.54	-1.46	-1.32
	Adjusted R ²	0.01	0.03	0.05	0.07	0.08	0.09	0.09	0.09
	Long yield model								
	Coefficient	-0.11	-0.13	-0.13	-0.13	-0.12	-0.11	-0.10	-0.09
	t stats	-0.98	-0.90	-0.94	-0.97	-0.95	-0.92	-0.89	-0.87
	Adjusted R ²	0.00	0.01	0.02	0.03	0.03	0.03	0.03	0.03
	Yield spread model								
	Coefficient	0.13	0.26	0.32	0.33	0.32	0.32	0.31	0.29
	t stats	0.68	1.47	2.12	2.36	2.27	2.16	1.93	1.64
	Adjusted R ²	0.00	0.02	0.04	0.06	0.08	0.10	0.11	0.12

Table 3: Summary of Estimation Results for Different Industries and Total GDP Using the Sample of 1990 - 2005

		1 - Qtr	2 - Qtr	3 - Qtr	4 - Qtr	5 - Qtr	6 - Qtr	7 - Qtr	8 - Qtr
Manufacturing	Short rate model								
	Coefficient	- 0 . 6 9	- 0 . 6 5	- 0 . 6 1	- 0 . 5 8	- 0 . 5 2	- 0 . 4 6	- 0 . 3 9	- 0 . 3 3
	t stats	- 3 . 6 4	- 3 . 7 0	- 4 . 0 8	- 4 . 8 5	- 4 . 6 3	- 4 . 0 4	- 3 . 2 8	- 2 . 8 6
	Adjusted R ²	0 . 0 9	0 . 1 6	0 . 2 0	0 . 2 6	0 . 3 1	0 . 3 1	0 . 2 9	0 . 2 4
	Long yield model								
	Coefficient	- 0 . 4 2	- 0 . 4 3	- 0 . 4 1	- 0 . 3 8	- 0 . 3 4	- 0 . 2 9	- 0 . 2 5	- 0 . 2 1
	t stats	- 1 . 9 2	- 1 . 9 7	- 1 . 8 1	- 1 . 6 5	- 1 . 4 2	- 1 . 2 0	- 1 . 0 5	- 0 . 9 8
	Adjusted R ²	0 . 0 2	0 . 0 5	0 . 0 7	0 . 0 9	0 . 1 0	0 . 0 9	0 . 0 8	0 . 0 7
	Yield spread model								
	Coefficient	1 . 3 6	1 . 2 2	1 . 1 5	1 . 1 4	1 . 0 6	1 . 0 1	0 . 9 0	0 . 7 8
	t stats	3 . 0 6	2 . 4 4	2 . 0 0	2 . 0 7	2 . 1 8	2 . 3 7	2 . 1 6	1 . 9 6
	Adjusted R ²	0 . 0 8	0 . 1 2	0 . 1 5	0 . 2 1	0 . 2 7	0 . 3 1	0 . 3 1	0 . 2 7
Property & business services	Short rate model								
	Coefficient	- 0 . 6 8	- 0 . 6 3	- 0 . 5 6	- 0 . 5 6	- 0 . 5 2	- 0 . 4 7	- 0 . 3 9	- 0 . 2 9
	t stats	- 2 . 1 5	- 2 . 6 8	- 2 . 4 4	- 2 . 9 1	- 2 . 6 8	- 2 . 4 4	- 2 . 1 1	- 1 . 6 9
	Adjusted R ²	0 . 0 5	0 . 1 0	0 . 1 1	0 . 1 5	0 . 1 9	0 . 2 1	0 . 1 8	0 . 1 1
	Long yield model								
	Coefficient	- 0 . 4 9	- 0 . 5 0	- 0 . 4 6	- 0 . 4 7	- 0 . 4 3	- 0 . 3 9	- 0 . 3 1	- 0 . 2 1
	t stats	- 1 . 3 5	- 1 . 7 7	- 1 . 5 5	- 1 . 5 7	- 1 . 3 9	- 1 . 3 1	- 1 . 1 1	- 0 . 8 4
	Adjusted R ²	0 . 0 2	0 . 0 5	0 . 0 6	0 . 0 9	0 . 1 0	0 . 1 1	0 . 0 8	0 . 0 4
	Yield spread model								
	Coefficient	1 . 0 4	0 . 8 5	0 . 7 1	0 . 7 1	0 . 7 1	0 . 6 9	0 . 6 5	0 . 5 6
	t stats	1 . 5 3	1 . 5 5	1 . 3 3	1 . 3 2	1 . 3 5	1 . 2 4	1 . 2 5	1 . 2 4
	Adjusted R ²	0 . 0 2	0 . 0 3	0 . 0 3	0 . 0 4	0 . 0 6	0 . 0 8	0 . 0 9	0 . 0 8
Onwership of Dwellings	Short rate model								
	Coefficient	- 0 . 1 3	- 0 . 1 3	- 0 . 1 3	- 0 . 1 3	- 0 . 1 2	- 0 . 1 1	- 0 . 1 0	- 0 . 1 0
	t stats	- 4 . 1 5	- 3 . 5 3	- 3 . 5 9	- 4 . 0 8	- 4 . 4 8	- 3 . 9 7	- 3 . 2 2	- 2 . 9 1
	Adjusted R ²	0 . 0 8	0 . 1 0	0 . 1 3	0 . 1 6	0 . 1 9	0 . 2 1	0 . 2 2	0 . 2 4
	Long yield model								
	Coefficient	- 0 . 1 4	- 0 . 1 5	- 0 . 1 6	- 0 . 1 6	- 0 . 1 6	- 0 . 1 4	- 0 . 1 2	- 0 . 1 1
	t stats	- 3 . 7 1	- 3 . 3 3	- 3 . 5 3	- 3 . 8 6	- 4 . 2 0	- 4 . 1 5	- 3 . 4 1	- 2 . 6 8
	Adjusted R ²	0 . 0 9	0 . 1 2	0 . 1 7	0 . 2 2	0 . 2 7	0 . 3 0	0 . 2 8	0 . 2 6
	Yield spread model								
	Coefficient	0 . 0 0	- 0 . 0 1	- 0 . 0 3	- 0 . 0 5	- 0 . 0 6	- 0 . 0 4	- 0 . 0 1	0 . 0 3
	t stats	- 0 . 0 2	- 0 . 0 8	- 0 . 3 1	- 0 . 4 5	- 0 . 4 4	- 0 . 3 3	- 0 . 1 0	0 . 2 3
	Adjusted R ²	- 0 . 0 2	- 0 . 0 2	- 0 . 0 2	- 0 . 0 1	- 0 . 0 1	- 0 . 0 1	- 0 . 0 2	- 0 . 0 1
Primary	Short rate model								
	Coefficient	0 . 3 3	0 . 3 1	0 . 2 6	0 . 2 2	0 . 1 8	0 . 0 9	0 . 0 5	0 . 0 1
	t stats	0 . 6 8	0 . 7 7	0 . 6 5	0 . 5 5	0 . 4 8	0 . 2 8	0 . 1 9	0 . 0 3
	Adjusted R ²	- 0 . 0 1	- 0 . 0 1	- 0 . 0 1	- 0 . 0 1	- 0 . 0 1	- 0 . 0 2	- 0 . 0 2	- 0 . 0 2
	Long yield model								
	Coefficient	0 . 1 1	0 . 1 3	0 . 1 2	0 . 1 7	0 . 2 1	0 . 2 0	0 . 2 0	0 . 1 3
	t stats	0 . 1 8	0 . 2 3	0 . 2 6	0 . 3 9	0 . 4 8	0 . 4 8	0 . 5 1	0 . 3 8
	Adjusted R ²	- 0 . 0 2	- 0 . 0 2	- 0 . 0 2	- 0 . 0 1	- 0 . 0 1	- 0 . 0 1	0 . 0 0	- 0 . 0 1
	Yield spread model								
	Coefficient	- 1 . 0 2	- 0 . 8 7	- 0 . 7 2	- 0 . 3 4	- 0 . 0 3	0 . 3 7	0 . 5 6	0 . 5 1
	t stats	- 0 . 6 5	- 0 . 7 3	- 0 . 8 1	- 0 . 5 5	- 0 . 0 7	0 . 7 9	1 . 2 1	0 . 9 8
	Adjusted R ²	- 0 . 0 1	0 . 0 0	0 . 0 0	- 0 . 0 1	- 0 . 0 2	- 0 . 0 1	0 . 0 1	0 . 0 1
Finance & Insurance	Short rate model								
	Coefficient	- 0 . 6 9	- 0 . 7 0	- 0 . 7 2	- 0 . 7 5	- 0 . 7 6	- 0 . 7 5	- 0 . 7 2	- 0 . 6 6
	t stats	- 3 . 3 2	- 2 . 6 7	- 2 . 8 0	- 3 . 5 9	- 4 . 7 9	- 6 . 0 6	- 6 . 6 8	- 6 . 7 1
	Adjusted R ²	0 . 1 5	0 . 2 2	0 . 2 9	0 . 3 6	0 . 4 3	0 . 4 9	0 . 5 2	0 . 5 1
	Long yield model								
	Coefficient	- 0 . 6 7	- 0 . 6 9	- 0 . 7 2	- 0 . 7 5	- 0 . 7 4	- 0 . 7 1	- 0 . 6 6	- 0 . 6 0
	t stats	- 3 . 2 2	- 2 . 8 2	- 2 . 8 8	- 3 . 1 7	- 3 . 2 9	- 3 . 2 7	- 3 . 1 4	- 2 . 9 9
	Adjusted R ²	0 . 1 3	0 . 1 9	0 . 2 5	0 . 3 0	0 . 3 4	0 . 3 7	0 . 3 7	0 . 3 5
	Yield spread model								
	Coefficient	0 . 3 6	0 . 3 9	0 . 4 0	0 . 4 8	0 . 5 9	0 . 7 1	0 . 7 8	0 . 8 0
	t stats	0 . 9 7	1 . 0 2	0 . 9 6	1 . 0 5	1 . 2 4	1 . 5 2	1 . 7 7	1 . 9 3
	Adjusted R ²	- 0 . 0 1	0 . 0 0	0 . 0 0	0 . 0 2	0 . 0 4	0 . 0 7	0 . 1 1	0 . 1 4

Retail trade	Short rate model	Coefficient	-0.53	-0.52	-0.53	-0.45	-0.37	-0.32	-0.31	-0.31
		t stats	-2.26	-2.37	-2.76	-2.98	-3.73	-5.65	-6.60	-6.79
		Adjusted R ²	0.08	0.17	0.23	0.25	0.26	0.27	0.34	0.41
	Long yield model	Coefficient	-0.48	-0.48	-0.49	-0.44	-0.39	-0.34	-0.32	-0.30
		t stats	-1.83	-1.82	-2.02	-2.35	-2.90	-3.43	-3.22	-2.83
		Adjusted R ²	0.05	0.12	0.17	0.21	0.24	0.26	0.29	0.31
	Yield spread model	Coefficient	0.40	0.43	0.45	0.32	0.19	0.15	0.21	0.30
		t stats	1.03	0.91	0.84	0.64	0.46	0.45	0.73	1.16
		Adjusted R ²	0.00	0.01	0.02	0.01	0.00	-0.01	0.02	0.06
Construction	Short rate model	Coefficient	-2.17	-1.93	-1.92	-1.81	-1.63	-1.40	-1.15	-0.97
		t stats	-2.96	-3.23	-4.48	-5.74	-5.31	-4.34	-3.50	-3.03
		Adjusted R ²	0.13	0.16	0.24	0.28	0.29	0.26	0.21	0.19
	Long yield model	Coefficient	-1.69	-1.62	-1.71	-1.68	-1.55	-1.37	-1.13	-0.95
		t stats	-2.52	-2.87	-3.48	-3.60	-3.25	-2.75	-2.21	-1.83
		Adjusted R ²	0.06	0.09	0.16	0.20	0.22	0.21	0.17	0.14
	Yield spread model	Coefficient	2.83	2.21	1.94	1.67	1.42	1.15	0.98	0.93
		t stats	1.98	1.74	1.69	1.55	1.26	0.96	0.84	0.83
		Adjusted R ²	0.04	0.03	0.04	0.04	0.03	0.02	0.02	0.02
Health & community service	Short rate model	Coefficient	0.01	-0.04	-0.06	-0.10	-0.14	-0.18	-0.23	-0.25
		t stats	0.06	-0.31	-0.42	-0.68	-1.11	-1.91	-4.03	-5.90
		Adjusted R ²	-0.02	-0.02	-0.01	0.00	0.03	0.08	0.19	0.24
	Long yield model	Coefficient	-0.02	-0.07	-0.12	-0.16	-0.18	-0.20	-0.24	-0.25
		t stats	-0.10	-0.42	-0.74	-1.04	-1.35	-1.78	-2.63	-3.58
		Adjusted R ²	-0.02	-0.01	-0.01	0.02	0.04	0.08	0.16	0.20
	Yield spread model	Coefficient	-0.14	-0.08	-0.22	-0.19	-0.07	0.07	0.16	0.19
		t stats	-0.23	-0.20	-0.68	-0.80	-0.34	0.34	0.70	0.87
		Adjusted R ²	-0.02	-0.02	-0.01	-0.01	-0.02	-0.01	0.00	0.01
Wholesale trade	Short rate model	Coefficient	-1.52	-1.39	-1.29	-1.13	-0.97	-0.88	-0.78	-0.70
		t stats	-5.89	-5.67	-5.10	-4.47	-4.45	-4.48	-4.02	-3.58
		Adjusted R ²	0.21	0.34	0.42	0.38	0.38	0.39	0.35	0.34
	Long yield model	Coefficient	-1.09	-0.96	-0.90	-0.80	-0.67	-0.57	-0.48	-0.40
		t stats	-2.60	-2.13	-1.95	-1.80	-1.65	-1.48	-1.26	-1.05
		Adjusted R ²	0.09	0.14	0.17	0.16	0.14	0.12	0.10	0.08
	Yield spread model	Coefficient	2.38	2.38	2.31	2.05	1.91	1.94	1.82	1.79
		t stats	3.12	2.90	2.69	2.61	2.85	3.44	3.86	4.37
		Adjusted R ²	0.11	0.22	0.29	0.26	0.30	0.39	0.40	0.47
Education	Short rate model	Coefficient	-0.19	-0.14	-0.10	-0.07	0.00	0.09	0.16	0.21
		t stats	-1.18	-0.82	-0.53	-0.34	-0.01	0.47	1.02	1.57
		Adjusted R ²	0.01	0.00	-0.01	-0.01	-0.02	0.00	0.07	0.17
	Long yield model	Coefficient	-0.02	0.01	0.03	0.05	0.10	0.17	0.22	0.26
		t stats	-0.09	0.03	0.13	0.19	0.44	0.89	1.53	2.39
		Adjusted R ²	-0.02	-0.02	-0.02	-0.01	0.00	0.04	0.11	0.22
	Yield spread model	Coefficient	0.76	0.67	0.60	0.52	0.41	0.25	0.10	0.03
		t stats	1.88	1.51	1.40	1.34	1.26	1.03	0.64	0.22
		Adjusted R ²	0.06	0.07	0.07	0.07	0.05	0.01	-0.01	-0.02

Government administration & defence	Short rate model								
	Coefficient	-0.08	-0.08	-0.03	0.00	0.02	0.05	0.05	0.03
	t stats	-0.53	-0.59	-0.26	0.04	0.25	0.97	1.35	1.16
	Adjusted R ²	-0.01	-0.01	-0.02	-0.02	-0.02	-0.01	-0.01	-0.01
	Long yield model								
	Coefficient	-0.10	-0.14	-0.13	-0.09	-0.06	-0.02	0.01	0.01
	t stats	-0.41	-0.80	-0.75	-0.58	-0.46	-0.16	0.12	0.07
	Adjusted R ²	-0.01	-0.01	0.00	-0.01	-0.01	-0.02	-0.02	-0.02
	Yield spread model								
	Coefficient	-0.03	-0.21	-0.37	-0.37	-0.32	-0.30	-0.18	-0.13
	t stats	-0.04	-0.40	-0.91	-0.98	-0.98	-0.98	-0.65	-0.52
	Adjusted R ²	-0.02	-0.01	0.01	0.02	0.03	0.04	0.01	0.00
Total service	Short rate model								
	Coefficient	-0.43	-0.42	-0.40	-0.37	-0.34	-0.31	-0.28	-0.25
	t stats	-6.47	-8.26	-7.70	-6.73	-5.59	-4.95	-4.38	-3.93
	Adjusted R ²	0.25	0.38	0.44	0.47	0.49	0.49	0.48	0.45
	Long yield model								
	Coefficient	-0.31	-0.31	-0.31	-0.30	-0.27	-0.24	-0.21	-0.18
	t stats	-2.90	-2.75	-2.58	-2.42	-2.13	-1.89	-1.63	-1.42
	Adjusted R ²	0.11	0.18	0.22	0.25	0.26	0.24	0.21	0.18
	Yield spread model								
	Coefficient	0.66	0.64	0.59	0.54	0.51	0.51	0.51	0.50
	t stats	2.61	3.08	2.72	2.31	2.26	2.35	2.54	2.78
	Adjusted R ²	0.13	0.19	0.20	0.20	0.23	0.27	0.31	0.37
Total GDP	Short rate model								
	Coefficient	-0.53	-0.50	-0.48	-0.46	-0.41	-0.37	-0.33	-0.29
	t stats	-5.61	-5.41	-5.97	-5.99	-5.02	-4.39	-3.90	-3.65
	Adjusted R ²	0.23	0.31	0.40	0.47	0.49	0.49	0.46	0.44
	Long yield model								
	Coefficient	-0.40	-0.39	-0.39	-0.37	-0.33	-0.29	-0.24	-0.21
	t stats	-3.07	-2.81	-2.64	-2.34	-1.99	-1.72	-1.49	-1.36
	Adjusted R ²	0.11	0.16	0.22	0.26	0.26	0.24	0.20	0.17
	Yield spread model								
	Coefficient	0.74	0.69	0.64	0.63	0.62	0.63	0.62	0.59
	t stats	2.48	2.32	2.14	2.13	2.15	2.24	2.38	2.52
	Adjusted R ²	0.09	0.12	0.14	0.18	0.22	0.28	0.33	0.36

Table 4: Results for the Model Including both Short Rate and Yield Spread Using Sample 1990 - 2005

		1 - Qtr	2 - Qtr	3 - Qtr	4 - Qtr	5 - Qtr	6 - Qtr	7 - Qtr	8 - Qtr
Manufacturing	Short rate	-0.53	-0.51	-0.48	-0.44	-0.39	-0.32	-0.27	-0.23
	t stats	-2.36	-2.35	-2.54	-3.10	-3.28	-2.85	-2.32	-1.97
	Yield spread	0.98	0.84	0.78	0.78	0.74	0.73	0.65	0.57
	t stats	2.03	1.59	1.31	1.46	1.62	1.85	1.71	1.56
	Ajusted R ²	0.12	0.20	0.25	0.34	0.41	0.44	0.43	0.36
Property & business services	Short rate	-0.58	-0.56	-0.50	-0.51	-0.46	-0.41	-0.33	-0.22
	t stats	-1.64	-2.09	-1.90	-2.18	-2.04	-1.91	-1.59	-1.14
	Yield spread	0.63	0.43	0.32	0.30	0.32	0.33	0.36	0.35
	t stats	0.87	0.74	0.57	0.59	0.72	0.74	0.79	0.82
	Ajusted R ²	0.05	0.10	0.10	0.15	0.19	0.21	0.19	0.13
Onwership of Dwellings	Short rate	-0.14	-0.15	-0.16	-0.16	-0.16	-0.14	-0.12	-0.11
	t stats	-3.96	-3.48	-3.66	-4.02	-4.23	-3.98	-3.41	-2.99
	Yield spread	-0.10	-0.12	-0.16	-0.18	-0.19	-0.17	-0.12	-0.07
	t stats	-1.19	-1.25	-1.71	-1.98	-2.01	-1.93	-1.70	-1.28
	Ajusted R ²	0.07	0.11	0.15	0.21	0.26	0.29	0.27	0.25
Primary	Short rate	0.19	0.18	0.16	0.19	0.21	0.19	0.18	0.12
	t stats	0.32	0.36	0.34	0.41	0.48	0.48	0.53	0.40
	Yield spread	-0.89	-0.74	-0.59	-0.19	0.14	0.54	0.72	0.62
	t stats	-0.50	-0.52	-0.56	-0.25	0.21	0.81	1.07	0.84
	Ajusted R ²	-0.02	-0.02	-0.02	-0.03	-0.03	-0.02	0.00	0.00
Finance & Insurance	Short rate	-0.71	-0.72	-0.75	-0.78	-0.77	-0.74	-0.69	-0.62
	t stats	-3.25	-2.74	-2.89	-3.48	-4.15	-4.72	-4.97	-4.92
	Yield spread	-0.15	-0.16	-0.19	-0.15	-0.05	0.06	0.17	0.23
	t stats	-0.35	-0.34	-0.41	-0.34	-0.14	0.19	0.69	1.12
	Ajusted R ²	0.14	0.21	0.28	0.35	0.42	0.48	0.52	0.51
Retail trade	Short rate	-0.52	-0.51	-0.52	-0.46	-0.40	-0.35	-0.33	-0.30
	t stats	-2.04	-2.19	-2.59	-2.87	-3.43	-4.17	-4.39	-4.31
	Yield spread	0.02	0.05	0.04	-0.05	-0.15	-0.15	-0.08	0.02
	t stats	0.06	0.11	0.10	-0.14	-0.48	-0.60	-0.33	0.08
	Ajusted R ²	0.06	0.15	0.22	0.24	0.25	0.27	0.33	0.40
Construction	Short rate	-1.93	-1.78	-1.83	-1.77	-1.62	-1.41	-1.17	-0.97
	t stats	-2.48	-2.81	-4.04	-4.86	-4.42	-3.57	-2.78	-2.25
	Yield spread	1.45	0.88	0.49	0.24	0.06	-0.08	-0.06	0.04
	t stats	0.95	0.66	0.51	0.35	0.09	-0.11	-0.07	0.04
	Ajusted R ²	0.12	0.15	0.23	0.27	0.28	0.25	0.20	0.17
Wholesale trade	Short rate	-1.28	-1.13	-1.03	-0.90	-0.75	-0.63	-0.53	-0.44
	t stats	-4.41	-5.25	-5.25	-4.77	-4.95	-5.45	-4.74	-3.69
	Yield spread	1.46	1.53	1.49	1.32	1.28	1.39	1.35	1.39
	t stats	2.13	2.70	2.80	2.99	3.66	5.18	6.01	6.92
	Ajusted R ²	0.24	0.42	0.52	0.47	0.49	0.55	0.54	0.58
Total service	Short rate	-0.37	-0.36	-0.35	-0.33	-0.29	-0.26	-0.23	-0.19
	t stats	-4.61	-5.74	-5.69	-5.49	-4.85	-4.50	-4.09	-3.66
	Yield spread	0.39	0.38	0.32	0.27	0.27	0.28	0.31	0.33
	t stats	1.57	2.30	2.26	2.13	2.44	2.90	3.37	3.99
	Ajusted R ²	0.29	0.43	0.48	0.51	0.54	0.56	0.57	0.58
Total GDP	Short rate	-0.46	-0.44	-0.43	-0.40	-0.36	-0.31	-0.26	-0.22
	t stats	-3.92	-3.84	-4.48	-4.97	-4.58	-4.30	-3.88	-3.62
	Yield spread	0.41	0.36	0.31	0.30	0.32	0.36	0.39	0.39
	t stats	1.36	1.31	1.39	1.85	2.48	3.09	3.43	3.82
	Ajusted R ²	0.25	0.33	0.42	0.50	0.54	0.57	0.57	0.57

Table 5: RMSE Ratios for Out-Of-Sample Forecasts

		1-Qtr	4-Qtr	8-Qtr
Manufacturing	Model 1	1 . 0 3	0 . 9 0	0 . 9 0
	Model 2	1 . 0 8	0 . 9 1	0 . 9 1
	Model 3	0 . 9 1	0 . 8 0	0 . 8 0
	Model 4	0 . 8 9	0 . 8 2	0 . 8 2
	Model 5	1 . 1 2	0 . 9 5	0 . 9 6
Property & business services	Model 1	1 . 0 3	1 . 0 1	1 . 0 2
	Model 2	1 . 0 2	0 . 9 9	0 . 9 9
	Model 3	0 . 9 9	0 . 9 5	0 . 9 5
	Model 4	0 . 9 9	0 . 9 7	0 . 9 7
	Model 5	0 . 9 3	0 . 9 6	0 . 9 6
Onwership of Dwellings	Model 1	0 . 5 6	0 . 6 2	0 . 4 8
	Model 2	0 . 9 2	1 . 0 5	1 . 0 5
	Model 3	0 . 6 6	0 . 6 0	0 . 6 9
	Model 4	0 . 9 7	1 . 1 6	1 . 4 3
	Model 5	0 . 5 2	1 . 0 1	0 . 8 0
Primary	Model 1	0 . 9 7	0 . 7 9	0 . 7 6
	Model 2	1 . 0 1	0 . 8 2	0 . 7 8
	Model 3	1 . 0 2	0 . 8 5	0 . 8 1
	Model 4	1 . 0 2	0 . 8 3	0 . 8 0
	Model 5	0 . 9 1	0 . 8 3	0 . 8 1
Finance & Insurance	Model 1	1 . 4 4	1 . 1 6	0 . 8 2
	Model 2	1 . 3 3	1 . 3 6	1 . 2 9
	Model 3	0 . 9 0	0 . 6 6	0 . 3 5
	Model 4	1 . 4 0	1 . 2 7	1 . 1 7
	Model 5	1 . 4 4	0 . 8 7	0 . 5 2
Retail trade	Model 1	0 . 9 3	0 . 9 1	0 . 8 9
	Model 2	0 . 8 9	0 . 8 8	0 . 8 8
	Model 3	0 . 8 7	0 . 8 4	0 . 8 2
	Model 4	0 . 8 8	0 . 8 6	0 . 8 6
	Model 5	0 . 9 0	0 . 8 9	0 . 8 9
Construction	Model 1	0 . 4 5	0 . 4 9	0 . 4 9
	Model 2	0 . 5 3	0 . 5 2	0 . 5 5
	Model 3	0 . 8 9	0 . 6 7	0 . 5 6
	Model 4	0 . 6 3	0 . 6 2	0 . 6 0
	Model 5	0 . 7 7	0 . 5 5	0 . 5 3
Wolesale trade	Model 1	1 . 0 1	1 . 0 1	1 . 0 5
	Model 2	1 . 0 4	1 . 0 4	1 . 1 1
	Model 3	0 . 9 8	0 . 9 4	0 . 9 0
	Model 4	0 . 9 5	0 . 9 7	0 . 9 8
	Model 5	1 . 0 1	0 . 9 8	1 . 0 0
Total service	Model 1	1 . 0 3	1 . 0 7	1 . 1 5
	Model 2	1 . 0 1	1 . 0 8	1 . 2 4
	Model 3	0 . 9 9	0 . 9 4	0 . 9 3
	Model 4	0 . 9 4	0 . 9 8	1 . 0 8
	Model 5	1 . 1 5	1 . 1 1	1 . 1 3
Total GDP	Model 1	0 . 8 1	0 . 8 0	0 . 8 3
	Model 2	0 . 8 0	0 . 8 1	0 . 8 6
	Model 3	0 . 8 5	0 . 7 6	0 . 7 6
	Model 4	0 . 7 8	0 . 7 8	0 . 8 1
	Model 5	1 . 0 0	0 . 8 7	0 . 8 9

Model 1: Short rate model

Model 3: Yield spread model

Model 5: Lagged GDP growth model

Model 2: Long yield model

Model 4: Short rate & yield spread model