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The Term Structure and Real Activity in Canada

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Abstract

This paper examines the predictive content of the term structure of interest rates for economic activity in Canada. Recent papers for the United States and other countries find that the slope of the term structure is a very good predictor of output growth. We find a strong, positive relationship between the spread across long and short rates and future changes in real GDP in Canada. This relationship is strongest at the 1-year horizon or just beyond.

The term structure also helps predict inflation at horizons beyond two years in equations including the output gap and lagged inflation.

Using the theoretical framework provided in the paper, we examine the conditions under which the term spread would better reflect the stance of monetary policy than a short-term interest rate and argue that these conditions are likely to be satisfied in the data.

Résumé

Dans la présente étude, les auteurs examinent la capacité de prévision de la structure à terme des taux d'intérêt au regard de l'activité économique au Canada. Des études récentes menées aux États-Unis et dans d'autres pays ont montré que la pente de la structure des taux d'intérêt est un très bon indicateur avancé de la croissance de la production. Selon les auteurs, il existe une forte relation positive entre l'écart des taux à long et à court terme et les variations futures du PIB réel au Canada. La relation la plus forte est observée pour les horizons d'un an ou un peu plus.

La structure à terme des taux d'intérêt sert aussi à prévoir l'inflation sur des horizons de plus de deux ans dans des équations comprenant l'écart de production et l'inflation retardée.

À l'aide du cadre théorique retenu, les auteurs analysent les conditions dans lesquelles l'écart entre les taux à long terme et les taux à court terme refléterait mieux l'orientation de la politique monétaire qu'un taux à court terme et soutiennent que les données semblent satisfaire ces conditions.

Summary

This paper provides a detailed examination of the predictive content of the term structure of interest rates for economic activity in Canada. Recent papers by Estrella and Hardouvelis (1991) for the United States and Harvey (1991) for the G-7 countries find that the slope of the term structure is a very good predictor of output growth.

Our main empirical findings are as follows:

- There is a strong, positive relationship between the slope of the term structure and changes in future real income. This relationship is strongest at the 1-year horizon or just beyond, but is considerably weaker at shorter horizons.
- A comparison of different spreads reveals that, in general, the greater the difference in maturities between short and long rates, the better the predictive ability for output at the 1-year horizon and just beyond. However, the spread between long rates and a mid-term rate is best for predicting output at horizons beyond 2 years. Hence, the difference between the average yield of 10-year-and-over government bonds and the 30-day commercial paper rate is best at predicting growth up to 2 years, but the difference between yields of 10-year-and-over bonds and of 1- to 3-year bonds is better at predicting growth beyond 2 years.
- A one percentage-point increase in the 10-year-minus-30-day spread, sustained for 4 quarters, translates into an increase in real income of more than 1 per cent over the next 4 quarters.
- The term structure is more strongly related to aggregate output growth than to any individual component of aggregate demand. The term structure is most strongly related to expenditure on consumer durables at the 1-year horizon, and to investment expenditure at horizons beyond 4 years.
- The predictive content of the term structure is robust to the inclusion of other domestic financial variables such as real interest rates, real M1, real stock prices, the profit rate and Statistics Canada's index of leading indicators. In fact, only real interest rates add significant

incremental explanatory power for output at the 1-year horizon and beyond.

- The U.S. spread is dominated by the Canadian spread in predicting Canadian output growth. However, the negative estimated coefficient for the U.S. spread indicates that it may be affecting Canadian output through the exchange rate.
- A simple term-structure-based indicator model for 4-quarter growth is unstable over time. However, the instability seems related to a change in trend growth in the 1970s and can be remedied by using detrended output growth as the dependent variable.
- The term structure helps predict inflation at horizons beyond 2 years. This is over and above the contribution of the output gap and lagged inflation. This finding is reassuring given the existence of a Phillips curve combined with the predictive power of the spread for future output.
- The predictive power of the spread appears to be not just a cyclical phenomenon that is endogenous to the cycle. Rather, the spread has important predictive content for future growth over and above that which could be predicted from the current state of the business cycle (as measured by the output gap).

1. Introduction

Several recent studies have documented the strong predictive power of the slope of the term structure for real activity. Estrella and Hardouvelis (1991) find that the slope of the yield curve (the difference between long and short rates) is a good predictor of future U.S. real activity. They find that the term structure has predictive content beyond that of the index of leading indicators and real short-term interest rates. Harvey (1991) analyses the relation between the term structure and future economic growth in the G-7 countries and finds a generally strong relationship, particularly in Canada and the United States.

We examine the issue of which definition of the term structure works best: in particular, which area of the yield curve best serves as a predictor of growth. We also evaluate the predictive power of the term structure relative to other common financial variables, namely, the level of interest rates, real M1, stock prices and the profit rate. The predictive power of the Canadian term structure for Canadian real activity is also assessed relative to the U.S. term structure.

We construct a 4-quarter-ahead forecasting model based on the term structure (augmented by other financial variables). The performance of this model is assessed historically. Encouraged by the success of the term structure at predicting real activity, we also examine the usefulness of the term structure as a predictor of inflation.

We also provide a theoretical framework for interpreting the term structure-output relationship. One interpretation of the spread between short and long rates is that it is a better measure of the pure ”liquidity effect” of monetary policy than, say, a short rate alone. This is the view of, for example, Bernanke and Blinder (1990) and Laurent (1988). Thus, a period of low short rates relative to long rates could just reflect the temporary “liquidity” effect on short rates of an expansionary monetary policy. We explore this idea within our framework and show the conditions under which the spread would better reflect the stance of monetary policy than a real short-term interest rate.

Another interpretation of the spread is that it reflects anticipated changes in real consumption growth. This view is based on the predictions of the consumption-based asset pricing models of Lucas (1978) and Breeden (1979). Harvey (1988) argues that this is in fact the case. Periods of low short rates relative to long rates could just reflect the fact that consumption growth is low and is expected to pick up. We report evidence relevant to an evaluation of this approach. A related possibility is, as would be the case even in Keynesian models, that real interest rates react endogenously to the state of the cycle in such a way as to induce a positive relationship between the slope of the term structure and future output growth. We therefore conduct a test for the possibility that the term structure is cyclical and endogenous to the business cycle.

The remainder of the paper proceeds as follows. Section 2 reviews some previous work. Section 3 assesses the time-series properties of various spread measures and compares their predictive power for output. Section 4 examines the relationship between the spread and the components of aggregate expenditure. Section 5 compares the spread to other financial variables in predicting real activity. Section 6 evaluates the forecasting ability of augmented term structure models. Section 7 deals with the predictive content of the term structure for inflation. Section 8 discusses the possible interpretations of the term structure-output relationship and presents the results of a test of reverse causation.

2. A review of the literature on the term structure

The term structure of interest rates has been used to forecast a plethora of economic variables. These include future levels of interest rates (Fama 1984); Mankiw and Miron 1986; Mishkin 1988); the inflation rate (Frankel and Lown 1991; Fama 1990; Mishkin 1989, 1990); consumption growth (Harvey 1988); employment (Bernanke 1990); and output growth (Estrella and Hardouvelis 1991). In the present paper we focus primarily on the term structure’s ability to forecast output growth and its components, though we also provide results on its ability to forecast the inflation rate. For this reason, the following review emphasizes the literature dealing with the term structure as a predictor of output growth.

Estrella and Hardouvelis (1991) use the difference between the 10-year government bond rate and the 90-day T-bill rate to forecast U.S. output growth and its components up to 5 years into the future. They find that the term structure is an excellent predictor of output growth and its private components. They find that a 1 percentage point increase in the spread translates into just over a 1 percentage point increase in growth a year later. When they add extra variables to their model, such as the growth rate of an index of leading indicators, a short term interest rate, the inflation rate and a lagged growth rate, the term structure remains significant at predicting output growth up to three years out. Out of sample, the term structure-based models outperform American Statistical Association / National Bureau of Economic Research survey-based forecasts of output growth for the 3 following quarters. In terms of the components of growth, the authors find that the term structure is most closely related to durables consumption and investment.

Lowe (1992) uses the Estrella and Hardouvelis methodology to determine the term structure's significance at explaining Australian output growth and inflation. The spread between the 10-year T-bond and the 6-month bank bill is the term structure variable used. The author finds that for every 1 percentage point increase in the spread, the rate of output growth over the next 12 months increases by about 0.5 per cent. The peak forecasting horizon of the term structure is roughly 6 quarters, becoming insignificant at predicting output growth at the 3-year horizon and beyond. At very short forecasting horizons (less than 2 quarters), the index of leading indicators is found to be a better predictor of output than the term structure. In terms of the components of output, the term structure is a better forecaster of investment than it is of consumption.

Harvey (1991) builds term-structure-based models of output growth for the G-7 countries. For a given country, models are built which encompass a local term structure (spread) measure, the U.S. spread and a world spread (constructed by weighting each country's spread based on its share of total G-7 gross national product). For the 1970-89 period, the results indicate that the Canadian models are the best performers based on $\overline{R}^2$. Adding the U.S. spread or the world spread to the simple Canadian spread-based model does little to increase the model's explanatory power. For many countries, out-of-sample forecasts based on the term structure outperform forecasts originating from commercial macroeconometric models.

Bernanke (1990) uses several competing interest rate differentials to predict nine indicators of real activity and the inflation rate in the United States.[1] The author generally finds the difference between the yield on 6-month commercial papers and T-bills (the "risky" spread) to be one of the best predictors, while the difference between 1- and 10-year bonds is one of the weakest. However, he also notices that the predictive power of the risky spread has diminished somewhat during the 1980s. He concludes that if one were to subscribe to the view that the risky spread is a measure of the stance of monetary policy, then the predictive ability of this variable is unlikely to return for two reasons: 1) changes in the Federal Reserve's operating procedures during the 1980s reduced the reliability of interest rates in general as indicators of monetary policy; and 2) financial innovation, deregulation and international integration have increased the substitutability among money market instruments, thereby reducing the sensitivity of interest rate spreads to monetary policy.

Harvey (1989) compares the performance of stock market-based indicator models with bond market-based models. Subtracting the yield of the 90-day T-bill rate from both 5- and 10-year bond rates, the author finds that these two models perform significantly better than models which use the Standard and Poor's composite index to explain variations in economic growth between 1953 and 1989. The term differential models explained more than 30 per cent of the variation in growth and successfully predicted the four recessions that occurred in the United States between 1969 and 1981. The stock index-based models explained less than 5 per cent of the variation and predicted no less than nine recessions between 1961 and 1988. When compared with commercial forecasting models, the simple term structure model achieves the lowest root mean square error for out-of-sample forecasts between 1976 and 1985.

We turn next to a detailed examination of the indicator properties of the term structure for Canadian economic activity.

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1. They are industrial production, unemployment rate, capacity utilization, employment, housing starts, retail sales, personal income, durable orders and consumption.

3. A comparison of various yield spreads

Figure 1 (p. 48) plots the spread between the 10-year-plus government bond yield and the 30-day commercial paper rate, denoted by *S10M30*, lagged by 4 quarters, against the 4-quarter growth rate of gross domestic product (GDP). There is a clear relationship between the two series, especially as of the early 1970s. Periods of low short rates relative to long rates tend to be followed by higher than average output growth. However, before proceeding further with our analysis of this relationship, a comparison of alternative yield differentials is in order.

The alternative yield spreads (defined always as the longer rate minus the shorter rate) considered are as follows:

S10M90 10-year-plus government bond yield minus 90-day commercial paper rate

S10M30 10-year-plus government bond yield minus 30-day commercial paper rate

S10MC 10-year-plus government bond yield minus call loan rate

S10M1T3 10-year-plus government bond yield minus 1- to 3-year government bond yield

S10M3T5 10-year-plus government bond yield minus 3- to 5-year government bond yield

S1T3M90 1- to 3-year government bond yield minus 90-day commercial paper rate

S1T3M30 1- to 3-year government bond yield minus 30-day commercial paper rate

S1T3MC 1- to 3-year government bond yield minus call loan rate

S3T5M90 3- to 5- year government bond yield minus 90-day commercial paper rate

S3T5M30 3- to 5-year government bond yield minus 30-day commercial paper rate

S3T5MC 3- to 5-year government bond yield minus call loan rate

S90M30 90-day commercial paper rate minus 30-day commercial paper rate

Further details on these data are provided in the Data appendix.[2]

Table 1 (p. 26) provides summary statistics on the above spreads based on quarterly data for the period 1961:1 to 1991:4. The mean spreads are generally close to zero. Differences in volatility are quite large. Generally, the greater the difference in maturities, the greater the standard deviation. Thus, the standard deviation of the spread between the call loan rate and long bonds *(S10MC)* is more than three times as volatile as the spread between 3- to 5-year and long bonds *(S10M3T5)*. It would therefore seem that much of the variability in the spread comes from variability at the short end.

Table 1 also presents the first four lags of the autocorrelation function for each spread. It is evident that while there is quite a bit of persistence in the short run, the autocorrelations do tend to die off fairly quickly (with the exception of *S10M1T3* and *S10M3T5*). T-statistics from augmented Dickey-Fuller tests presented in Table 1 indicate that we generally can reject the null hypothesis of a unit root. The exceptions are *S10M1T3* and *S10M3T5*, but even here the non-rejection is a close call. We will thus proceed under the assumption that the spreads are stationary. This is convenient, because quarterly output growth, the variable to be predicted, appears stationary, and Dickey-Fuller tests support this.

Table 2 (p. 27) presents cross-correlations between the various spread variables and the cumulative, annualized *k*-quarter growth rate of output *k* quarters ahead. The *k*-quarter growth rate of output is defined as:

2. We use commercial paper for the 30- and 90-day rates because of the thinness of the treasury bill market before 1975. Substituting treasury bill rates for commercial paper rates made very little difference to our results, which implies that the "risky" spread – the spread between corporate and government paper rates – does not help to predict Canadian output growth once the term structure is included in the regression.

$$GkY_t = \frac{400}{k} \times \log\left(\frac{Y_t}{Y_{t-k}}\right) \tag{1}$$

where k = quarter (1, 2, 3, 4, 6, 8, 12, 16 and 20)

Y = level of output.

The table correlates the spread at time t with GkY at time $t + k$. The cross-correlations reveal that, overall, the spread variables tend to be quite strongly related to future growth, with the peak correlations occurring at the 4- to 6-quarter horizon. In general, the wider the spread between long and short rates the higher the correlation with future output growth. The exception to this rule is that the spread based on the call loan rate does not do as well as those based on 30 and 90 day rates.

Table 3 (p. 28) presents the results of regressing GkY_t on the spread at time $t - k$. Thus the form of the regressions is:

$$GkY_t = \alpha_0 + \alpha_1 SPREAD_{t-k} + \varepsilon_t \tag{2}$$

Note that there are special econometric problems involved in the estimation of this regression. Our data is quarterly but the forecasting horizon k varies from 1 to 20 quarters ahead. The overlapping data generates a moving-average error of order $k - 1$, which produces inconsistent standard errors (though not coefficient estimates). In order to obtain correct inference on the coefficients, we use the Newey and West (1987) adjustment method to correct for a moving-average process of order $k - 1$ in the residuals.[3] Equation (2) is the basic regression estimated by Estrella and Hardouvelis for the United States.

Overall, the regression results in Table 3 show that the spread is very closely related to future growth. For example, the results with the spread between the long bond (10-year-plus) and the 30-day rate, *S10M30*, indicate that at

3. Alternatively, we tried choosing the lag length of the moving average process by examining the estimated autocorrelation function of the ordinary least squares residuals. The standard errors were not very sensitive to this change.

every horizon examined, the coefficient on the spread is positive and significantly different from zero, even at the 1 per cent significance level. The term structure seems to perform best at the 4-quarter horizon, though, with explanatory power as measured by the $\overline{R}^2$ being generally lower at shorter and longer horizons. Based on the 4-quarter horizon regression for *S10M30*, a 1 percentage point increase in the spread translates into about a 1.3 percentage point increase in growth a year later. The magnitude of this relationship is similar to that reported by Estrella and Hardouvelis (1991) for the United States, but is higher than that for Australia reported by Lowe (1992).

How do the various spreads compare as predictors of growth? The results in Table 3 also indicate that, as suggested by the cross-correlations in Table 2, the wider spreads tend to perform best as predictors of output growth. Thus, in comparing spreads with the 10-year-plus bond, the shorter rate-based spreads *S10M90* and *S10M30* perform better than *S10M1T3*, which in turn performs better than *S10M3T5*. The exception to this tendency is the call-based spread, which is weaker than both the 30- and 90-day-based spreads. In comparing the latter two spreads, a slight advantage goes to *S10M30*: for instance, at the 4-quarter horizon, the $\overline{R}^2$ for *S10M30* is 0.59 versus 0.56 for *S10M90*. The spread between the 1- to 3-year bond and the long bond, *S10M1T3*, also does well, with an $\overline{R}^2$ of 0.55 at the 4-quarter horizon. In fact, while the peak $\overline{R}^2$ for *S10M1T3* is somewhat below those for *S10M30* and *S10M90*, it outperforms all other spreads at horizons beyond g9 2 years.

While the data tend to favour the wider spread measures as predictors of real activity, the question remains as to which area of the yield curve, the short end or the long end, contributes most to the relationship. Table 4 (p. 29) reports regression results for the case where long-short spreads, *S10M30* and *S10M90*, are split into long-middle spreads and middle-short spreads. The splits are done two ways: into *S10M1T3* and *S1T3M30 (S1T3M90)*, and into *S10M3T5* and *S3T5M30 (S3T5M90)*. The results suggest that the middle-short spreads perform best at shorter horizons, while the long-middle spreads maintain their statistical significance throughout the forecasting horizon. In fact, at the 3-year horizon, *S10M1T3* alone is actually slightly better than the combined models, indicating that *S1T3M30* and *S1T3M90* contribute very little.

Pursuing the investigation further, we split *S10M30* into a long-short *(S10M90)* and a short-short *(S90M30)* spread. We find that *S90M30* is significant for the shorter forecasting horizons, becoming insignificant at 4 quarters and beyond. However, in spite of its limited forecasting horizon, of all the spread-based models examined in Tables 3 and 4, the results show that this type of split leads to the highest $\overline{R}^2$ statistics at the 1- and 2-quarter horizons.

Overall, these results suggest that the term structure is most powerful when a wide long-short spread, such as that between the 10-year-plus government bond yield and a 30-day rate, is used to predict output growth at the 1-year horizon or just beyond. However, if the forecasting horizon is beyond 2 years, then a long-middle spread such as that between the 10-year-plus rate and the 1- to 3- year bond rate is preferable.

In the remainder of this paper, we focus on the spread between the 10-year-plus government bond yield and the 30-day commercial paper rate, *S10M30*. We choose this rather than *S10M90* simply because the 30-day rate tends to outperform the 90-day rate in nearly all the models examined, both in and out of sample.

4. The term structure and the components of aggregate expenditure

The predictive power of the term structure for the components of expenditure is of interest regardless of whether one subscribes to the *money* view of the term structure-output relationship or to the *real* or endogenous view. If the slope of the term structure reflects the stance of monetary policy and if interest rates are the primary transmission mechanism, then one would expect the spread to be most closely related to components like consumer durables and investment, which are very interest sensitive. Durable goods would also be most affected by changes in the cost of borrowing now relative to the expected cost in the future. Thus, if the term structure of interest rates embodies such expectations, changes in the slope of the yield curve would cause substitutions of purchases from one period to another. If the slope of the term structure simply reflects anticipations of future, relative to current, consumption growth, then one would expect the spread to be most closely linked to consumption.

Table 5 (p. 30) presents regressions of *k*-quarter growth rates of the components of aggregate expenditure on *S10M30* lagged *k* quarters. Let *GkX* be the *k*-quarter growth rate of component *X*, with the growth rate defined as in equation (1). The regressions are of the form:

$$GkX_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \varepsilon_t \tag{3}$$

For comparison purposes, Table 5 also includes regression results using aggregate expenditure (output) growth as the dependent variable. One somewhat surprising feature of the results is that the spread is a better predictor of aggregate expenditure than of any single component, even consumer durables.

Overall, among the components, the spread is most closely related to consumption at horizons under 2 years and to investment at horizons beyond 2 years. The relationship with consumption is strongest around the 1-year horizon and, consistent with our expectations, is concentrated in consumer durables. At this horizon, the next strongest relation is with housing. The relationship with non-durables is weak, perhaps casting doubt on the consumption-based asset pricing view, while the stronger links to consumer durables and to a lesser extent housing is at least broadly consistent with the *money* view. The predictive content for government expenditure is weak at all horizons, consistent with the presumably exogenous nature of government spending.

The term structure is a poor predictor of investment at horizons under 2 years but performs quite well farther out.[4] In fact, at longer horizons, the spread is a better predictor of investment than of any other component of expenditure, including consumer durables expenditure. The long lead to investment is mainly due to the machinery and equipment category, but the

4. This finding is different from that reported for the United States by Estrella and Hardouvelis (1991). They find that, at the 4-quarter horizon, the relationships with investment and consumption of durables are about equally strong.

relation to non-residential construction increases over time as well. The 1-year lead of the term structure to consumption and output and the longer lead to investment seem roughly consistent with a multiplier-accelerator view of the world in which monetary shocks impact first on interest-sensitive consumer expenditure and later, through the accelerator, on investment expenditures.

The term structure also has significant predictive content for future export growth, peaking at the 4- to 6-quarter horizon, presumably reflecting the exchange rate effects of interest rate changes.

In summary, a decline in short rates relative to long rates tends to be followed about a year later by higher growth in consumption (especially durables), housing and exports. Investment growth tends to rise 2 years later even as growth rates of the other components of expenditure are attenuating.

5. The term structure versus other financial variables

Thus far, our basic equation for output has been one linking *k*-quarter growth *k* quarters ahead to a single value of a spread variable with no other explanatory variables. Details on this basic equation for output are provided in Table 6 (p. 31). The question naturally arises: How does the term structure perform relative to other financial variables as a predictor of economic activity? Certainly, there is much evidence that real short-term interest rates help predict output several quarters ahead. Also, growth in real M1 tends to predict output growth 1 to 2 quarters ahead, even in the presence of a real or nominal interest rate (Muller 1992). Stock prices also tend to be good predictors of future real activity (Cozier and Rahman 1988).

Accordingly, we attempt to assess the marginal predictive content of the term structure relative to these other variables. We extend our basic term structure regression by adding a vector of variables (Z) as follows:

$$GkY_t = \alpha_0 + \alpha_1 SPREAD_{t-k} + \alpha_2 Z_{t-k} + \varepsilon_t \qquad (4)$$

The additional variables that we report results for are the real 90-day commercial paper rate, the growth rate of real M1, the growth rate of real stock prices and a U.S. term structure variable. Final prediction error (FPE) criteria for choosing lag length for each variable usually led to a single lag being optimal. Nevertheless, for the real interest rate we judgmentally use a 4-quarter moving average, since it performs somewhat better than a single value. In the case of real M1 and the real stock price, we use a 4-quarter growth rate after finding this transformation to provide a better fit.

The term structure versus a real interest rate

The results of estimating equation (4) with the real interest rate as the additional explanatory variable are presented in Table 7 (p. 32). The real interest rate, *RR90*, is calculated as the 90-day commercial paper rate minus the 4-quarter rate of change of the consumer price index (CPI). The results in Table 7 actually use a 4-quarter moving average of the real interest rate, denoted by *M4ARR90*.

The results indicate that the real interest rate clearly has incremental explanatory power relative to the spread. Moreover, real interest rates have the expected negative relationship with the change in output growth. *RR90* remains significant at explaining changes in output up to the 8-quarter forecasting horizon. Nevertheless, the magnitude and significance of the term structure is hardly affected by the inclusion of the real interest rate. For instance, at the 4-quarter forecasting horizon, the coefficient on the spread drops slightly from 1.29 to 1.17, but the t-statistic actually increases from 8.6 to 10.0. The absolute value of the t-statistic for the real interest rate is 4.4. The inclusion of the real interest rate increases $\overline{R}^2$ from 0.59 to 0.65.

The term structure versus real M1

Table 8 (p. 33) allows us to assess the predictive content for output of real M1 relative to the term structure. Real M1 is measured by M1 divided by the CPI. The regressions use *G4RM1*, which is the 4-quarter growth rate of real M1. Real M1 is significant only at the 1- and 2-quarter horizons – consistent with the indicator model research at the Bank. However, even at these short horizons, the spread remains significant at the 1 per cent level. By the 3-quarter horizon, real M1 drops out of the picture.

The term structure versus real stock prices

Table 9 (p. 34) shows the results of incorporating the 4-quarter growth rate of real stock prices as measured by the Toronto Stock Exchange index divided by the CPI. As was the case for real M1, real stock prices generally help predict growth only at short horizons: 1 to 2 quarters. In fact, at the 4-quarter horizon, the $\bar{R}^2$ statistic decreases relative to the model that excludes stock prices.

The Canadian term structure versus the U.S. term structure

Table 10 (p. 35) adds the difference between the yields of 10-year U.S. government bonds and the 30-day U.S. commercial paper rate *(S10M30US)* to our basic model. The results indicate that the U.S. spread only marginally improves the fit of the model at the very short- and medium-term forecasting horizons, but significantly improves the fit at the very long horizon (4 to 5 years). At the 20-quarter horizon, the $\bar{R}^2$ statistic increases to 0.22 from 0.12 for the simple model, whose results are reported in Table 6 (p. 31).

It is interesting to note that the estimated coefficients for *S10M30US* are all negative. The negative sign is somewhat surprising given the high short-run correlation between U.S. and Canadian growth, as well as a positive relationship between the U.S. term structure and U.S. growth. Presumably therefore, the exchange rate effect is dominating the direct effect of U.S. output on Canadian exports and output. With a widening of the U.S. spread as a result of lower short-term rates in the U.S., the Canadian dollar would appreciate, thereby reducing the trade balance and slowing growth in Canadian activity. [5]

The term structure plus all four variables

In Table 11 (p. 36), the four variables that have been found to have incremental predictive content for growth over and above the term structure are added jointly to the regressions. The most significant effect of

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5. It is worthy of note that when the U.S. spread is included alone, its coefficient is positive (results not reported). This probably reflects two things. First, a drop in U.S. short rates would normally lead to lower Canadian rates, thus tending to raise Canadian output. Second, a drop in U.S. short rates raises U.S. economic activity, and therefore Canadian trade and output as well.

this is to reduce real M1's contribution to insignificance, even at short horizons. Real stock prices are still significant up to the 3-quarter horizon and real interest rates up to 6 quarters. The U.S. term structure is only significant at the long-term forecasting horizons. The domestic term structure remains highly significant even at the 20-quarter horizon, but it still performs best both in terms of statistical significance and the magnitude of its coefficient around the 1-year horizon.

Other variables

In addition to the aforementioned financial variables, we also individually include lagged output growth, various measures of profits and Statistics Canada's leading indicator. Table 12 (p. 37) summarizes our 4-quarter output growth prediction equations. Note that the addition of a 4-quarter lag of *G4Y* to the basic *S10M30* prediction equation adds little information to the model. However, when lagged *G4Y* is added to our augmented model, which includes *M4ARR90*, *G4RM1*, *G4RTSE* and *S10M30US* in addition to *S10M30*, we find that lagged *G4Y* is significant at the 5 per cent level.

Results using the profit rate, the growth rate of real profits and Statistics Canada's index of leading indicators are omitted, since these variables performed very poorly in the presence of the term structure. In fact, the estimated coefficients of the index of leading indicators were often negative.

6. Forecasting with the term structure

The empirical results from the last section imply that, for forecasting changes in output 4 quarters ahead, the term structure equation should be augmented with the level of real interest rates. Figure 2 (p. 49) plots actual and fitted (4-step-ahead forecast) values from this equation. Overall, the fit seems good. However, the model misses the depths of both the 1981-82 and the 1990-91 recessions. By way of comparison, Figure 3 (p. 50) plots the same information for the unaugmented term structure model (from the fourth row of Table 6 (p. 31). The improvement in prediction that comes by including the real interest rate is fairly clear.

Based on Figure 2, there seems to be some improvement over time in the fit of the model, particularly starting in the early 1970s. Chow tests for stability were conducted to verify whether the model is stable over time. Rolling Chow tests reject parameter stability, particularly early in the period. The Chow test for a break at 1973:1 yields an F-statistic greater than 7.0, which with a critical value of 2.7 at the 5 per cent significance level, is a strong rejection of stability. The actual results of the rolling Chow tests are presented in Figure 4 (p. 51). We notice from this graph that at almost every possible sample split we must reject the null hypothesis of parameter stability at the 1 per cent level. However, examination of the parameters from the rolling tests reveal that the main instability is in the constant term, which declines over time, with a significant drop in the 1970s. This is not surprising given the productivity growth slowdown commencing in the 1970s. A dummy variable equal to 0 before 1973:1 and 1 afterwards is highly significant in the model (more on this later), while the coefficient on the spread remains unchanged.

To assess the performance of the prediction model, we conducted out-of-sample forecasts of 4-quarter growth in output 4 quarters ahead. The term structure model is sequentially updated. Table 13 (p. 38) compares the root mean square error (RMSE), mean absolute error (MAE), and mean error (ME) of forecasts obtained using various *S10M30*-based models. Note that the allowance for a single shift in trend growth in 1973 lowers the RMSE of the term structure model to 1.64 from 1.84 for the model without the dummy.

Another way to allow for a shifting trend growth rate is to use detrended output growth as the dependent variable. Table 14 (p. 39) presents results using *G4YC*, the 4-quarter output growth rate minus the 4-quarter Hodrick-Prescott trend of output, as the dependent variable. We immediately notice that the constant term is close to zero and insignificant for each model examined. By contrast, *S10M30* is significant at the 1 per cent level in each model. We further notice that the $\overline{R}^2$ statistic is in the 0.45 to 0.47 range when we add *M4ARR90, G4RM1, G4RTSE* and *S10M30US*, both together and separately. We achieve significant incremental explanatory power only when we add *G4YC* lagged by 4 quarters, where $\overline{R}^2$ increases from 0.45 to

0.54 for the simple *S10M30* model and from 0.47 to 0.60 for the expanded model.

A rolling Chow test was subsequently performed to test the stability of the estimated parameters obtained when regressing *G4YC* against *S10M30*, *M4ARR90*, *G4RTSE* and *G4YC* lagged by 4 quarters. The results are plotted in Figure 5 (p. 52). We can clearly see that the F-statistics are much lower for this model, where we can only reject the null of parameter stability for a handful of points at the 5 per cent level. Only when splitting the sample in the early 1980s can we reject the null hypothesis at the 1 per cent level.

Figure 6 (p. 53) shows the relationship between *G4YC* and *S10M30* lagged by 4 quarters. It is apparent from this graph that *S10M30* is a good predictor of *G4YC*. Figures 7 and 8 (pp. 54 and 55) are the *G4YC* equivalents of Figures 2 and 3. We can clearly see that the expanded model captures the peaks and troughs of *G4YC* more effectively than the simple *S10M30* model.

Figure 9 (p. 56) plots the out-of-sample forecasts of *G4YC* using the expanded model. It appears that the term structure can better forecast the turning points of *G4YC* than those of *G4Y*, which are presented in Figure 5. In fact, the *G4YC* forecasting performance statistics presented in Table 15 (p. 40) reveal that the RMSEs are significantly lower than their *G4Y* counterparts in Table 13.

Table 16 (p. 41) is the *GkYC* equivalent of Table 4 (p. 29), where we split long-short spreads into long-medium and medium-short spreads. Somewhat surprisingly, we find that no model dominates significantly up to the 8-quarter horizon. The $\overline{R}^2$ statistics are all very similar up to that point.

7. The term structure as a predictor of inflation

The performance of the term structure as a predictor of output, especially at the 1-year horizon, suggests that it ought to be a predictor of inflation too, particularly beyond that horizon. This is due to the fact that output (or the output gap) is a good predictor of inflation in the near term.

We assess the incremental predictive power of the term spread over the output gap and inflation dynamics (lagged inflation) by estimating the following equation for *GkP*, which is the annualized *k*-quarter inflation rate:

$$GkP_t = \alpha_0 + \alpha_1 SPREAD_{t-k} + \alpha_2 G1P_{t-k} + \alpha_3 G1P_{t-k-1} + \alpha_4 G1P_{t-k-2} + \alpha_5 YGAPT_{t-k} + \varepsilon_t \qquad (5)$$

Now *GkP* is defined as in equation (1) with *P* replacing *Y*. Thus *G1P* is the simple 1-quarter inflation rate. *YGAPT* is the output gap as measured by the percentage deviation of output from trend output based on the Hodrick-Prescott filter.

Estimation results for equation (5) using the CPI to measure inflation are presented in Table 17 (p. 42). At short to medium term horizons (up to 2 years), the gap clearly dominates the term structure as a predictor of inflation. In the presence of the gap, the term structure is insignificant at the 5 per cent significance level at horizons under 2 years. By the 4-year horizon, however, the term structure is significant, while the gap is insignificant. Moreover, the coefficient on the spread tends to increase with the length of the horizon while that on the gap peaks at the 8-quarter horizon and declines for longer horizons.

Results using the GDP deflator to measure inflation are given in Table 18 (p. 43). In contrast to the CPI results, both the spread and the output gap are now statistically significant at all forecasting horizons considered. However, in terms of significance, the spread is most important at long horizons, while the gap's significance peaks around the 2-quarter horizon.

Overall, these results imply that the spread has some predictive content for inflation, at least over long horizons. This seems consistent with the fact that the term structure predicts output well at a 1-year horizon, which would imply that it contains information about future output gaps that is not captured by the current gap. Other interpretations are possible, though, and the predictive power of the spread should be compared to variables such as monetary growth.

As currently specified, the models presented suffer from parameter instability. Figures 10 and 11 (pp. 57 and 58) plot the F-statistics from rolling

Chow tests performed on the *G20PC* and *G20P* models respectively. We choose these models since the t-statistic for the spread is highest at the 20-quarter horizon in each case. As with the *G4Y* model, the null hypothesis of parameter stability must be rejected for a number of periods. Once again, upon viewing the estimated parameters over a moving sample, it appears that the constant term is responsible for most of the instability.

8. A framework for interpreting the term structure

In this section, a framework for understanding movements in the term structure and its predictive content for economic activity is proposed. The term spread is decomposed into influences coming from the liquidity effects of monetary policy on real interest rates, movements in equilibrium real interest rates, and changes in expected inflation. We believe that the framework allows for a more careful discussion of the reasons for the link between the term structure and activity and, in particular, highlights the conditions required for it to better reflect the stance of monetary policy than a short-term interest rate.

Let i_t denote the short-term or 1-period nominal interest rate at time t. This can be decomposed into a 1-period real interest rate, r_t, and expected 1-period-ahead inflation, $E_t\pi_{t+1}$:

$$i_t = r_t + E_t\pi_{t+1} \tag{6}$$

The expectations term, E_t, denotes the expectation conditional on information at time t, I_t:

$$E_tX_{t+i} = E[X_{t+i}|I_t] \tag{7}$$

Let i_t^k denote the long-term or k-period nominal interest rate. Adopting the expectations theory of the term structure, the long rate can be written as the average of expected future short rates plus a term premium, ρ^k:

$$i_t^k = \frac{1}{k}(i_t + E_ti_{t+1} + \ldots + E_ti_{t+k-1}) + \rho_t^k \tag{8}$$

Next, we assume that the real interest rate, r_t, comprises two elements. First, there is a possibly time-varying equilibrium real interest rate, r_t^*, that is determined by non-monetary factors. This corresponds to the Wicksellian natural rate that is determined by equilibrium forces. We see this equilibrium rate as being influenced by domestic real forces in the short run, but determined by world real interest rates in the long run. In any case, we envisage the possibility of persistent movements in the equilibrium component of real rates.

The second component of the real interest rate is a "disequilibrium" component that arises due to monetary disturbances or so-called liquidity effects. This liquidity effect is the short-run effect of changes in the supply of settlement balances engineered by the monetary authorities.[6] Monetary shocks can temporarily affect real interest rates under a number of scenarios: (i) agents have rational expectations, but cash settings by the monetary authorities are unpredictable based on available information; (ii) agents have adaptive or slowly adjusting expectations; or (iii) agents are locked into precommitments or contractual arrangements that prevent them from quickly adapting to new information. We capture the effects of liquidity shocks by the term l_t. Thus the real interest rate can be written:

$$r_t = r_t^* - l_t \tag{9}$$

Combining equations (6), (8) and (9) yields the following equation for the long-term nominal interest rate:

$$i_t^k = \frac{1}{k}E_t\sum_{i=0}^{k-1} r_{t+i}^* - \frac{1}{k}E_t\sum_{i=0}^{k-1} l_{t+i} + \frac{1}{k}E_t\sum_{i=0}^{k-1}\pi_{t+i+1} + \rho_t^k \tag{10}$$

Equation (10) says that the current long-term nominal interest rate can be decomposed into four components: current and expected future equilibrium real interest rates; current and expected future liquidity effects of monetary shocks; expected future inflation rates; and the term premium.

The slope of the yield curve or term spread, s_t^k, at time t is defined as:

6. We focus on reserves rather than an aggregate like M1 or M2 because of the way that central banks actually influence rates. This is typically done through the manipulation of some reserve measure rather than through broader aggregates like M1 and M2, which are endogenously determined by the actions of private agents and the banking sector.

$$s_t^k = i_t^k - i_t \tag{11}$$

By substituting equations (6), (9) and (10) into equation (11), we obtain the following equation for the term spread at time *t*:

$$s_t^k = -\left(\frac{k-1}{k}\right) r_t^* + \frac{1}{k} E_t \sum_{i=1}^{k-1} r_{t+i}^*$$

$$+\left(\frac{k-1}{k}\right) l_t - \frac{1}{k} E_t \sum_{i=1}^{k-1} l_{t+i}$$

$$-\left(\frac{k-1}{k}\right) E_t \pi_{t+1} + \frac{1}{k} E_t \sum_{i=1}^{k-1} \pi_{t+1+i} + \rho_k^t \tag{12}$$

Equation (12) says that, abstracting from the term premium, the spread can be decomposed into three components, each of which is a weighted sum of a short-run effect with weight $-(k - 1)/k$, and a long-run effect with weight $1/k$. Alternatively, define the expected, average long-run values of r^*, l and π, as follows:

$$E_{t,k} r^* = E_t \sum_{i=1}^{k-1} \left(\frac{1}{k-1}\right) r_{t+i}^* \tag{13}$$

$$E_{t,k} l = E_t \sum_{i=1}^{k-1} \left(\frac{1}{k-1}\right) l_{t+i} \tag{14}$$

$$E_{t,k} \pi = E_t \sum_{i=1}^{k-1} \left(\frac{1}{k-1}\right) \pi_{t+1+i} \tag{15}$$

Then the term spread can be more written succinctly as

$$s_t^k = -\beta (r_t^* - E_{t,k} r^*) + \beta (l_t - E_{t,k} l) - \beta (E_t \pi_{t+1} - E_{t,k} \pi) + \rho_t^k \tag{16}$$

where $\beta = (k - 1)/k$

Equation (16) says that the spread is related inversely to the gap between the short-run equilibrium real rate and its expected future level, directly to the degree of liquidity relative to its expected future level, and inversely to short-run expected inflation relative to its longer-run future expected level. Thus, abstracting from the term premium, an increase in the slope of the term structure could reflect the fact that equilibrium real rates are temporarily low, that monetary conditions have temporarily eased, or that inflation is expected to increase.

It shall prove useful to be more explicit about the processes governing the three components of the spread. Assume that the equilibrium interest rate, the liquidity shock and inflation follow simple first-order autoregressive processes. Thus:

$$r_t^* = \phi r_{t-1}^* + \varepsilon_t \quad , 0 \le \phi \le 1 \tag{17}$$

$$l_t = \lambda l_{t-1} + \mu_t \quad , 0 \le \lambda \le 1 \tag{18}$$

$$\pi_t = \theta \pi_{t-1} + \eta_t \quad , 0 \le \theta \le 1 \tag{19}$$

where ϕ, λ and θ are the degrees of persistence of shocks to equilibrium real interest rates, liquidity effects and inflation respectively, and ε_t, μ_t and η_t are random shocks.[7] We can now examine the impact of the degree of persistence on the relationship between the spread and its determinants.

Effects of inflation

With the inflation process (really the public's perceived process) as in equation (19), the effect of inflation on the spread is given by:

$$\frac{\partial s_t^k}{\partial \pi_t} = -\left[1 - \frac{(1-\theta^k)}{k(1-\theta)}\right]\theta < 0 \qquad \text{for } 0 \le \theta < 1, \tag{20}$$

$$= 0 \qquad \text{for } \theta = 1 \tag{21}$$

7. For analytical convenience, r_t, l_t and η_t are in terms of deviations from their respective mean levels.

This says that a shock to inflation will in general result in a decline in the spread, as short rates rise more than long rates. There is, however, much evidence that inflation has a unit root over much of postwar history, or at least one cannot easily reject this hypothesis. A unit root means that the effect of inflation on the spread disappears. So the higher the degree of persistence in inflation expectations, the smaller the impact of inflation on the spread.

Effects of equilibrium real rates

The effect of changes in equilibrium real rates on the term spread is given by:

$$\frac{\partial s_t^k}{\partial r_t^*} = -\left[1 - \frac{(1-\phi^k)}{k(1-\phi)}\right] < 0 \qquad \text{for } 0 \leq \phi < 1, \tag{22}$$

$$= 0 \qquad \text{for } \phi = 1. \tag{23}$$

Thus, increases in equilibrium real rates produce declines in the spread in general. For example, a drop in output demand that is associated with a recession will induce the term structure to slope upwards more steeply. The more persistent shocks are to equilibrium rates, the smaller the effect will be on the spread. In the limit, shocks to real rates that are perceived to be permanent will not change the term structure.

Effects of liquidity shocks

Since we have strong priors from theory that monetary shocks have only transitory effects on real interest rates (as expectations and contracts will eventually adjust), there is good reason to view λ as being less than unity and in fact close to zero. The liquidity effect on the spread is given by:

$$\frac{\partial s_t^k}{\partial l_t} = \left[1 - \frac{(1-\lambda^k)}{k(1-\lambda)}\right] \geq 0. \tag{24}$$

Therefore, a negative liquidity shock produces an inverted term structure. The liquidity effect on the term structure is stronger the lower the degree of persistence of monetary shocks.

Does any effect predominate?

Our framework suggests that all three factors – particularly movements in equilibrium real rates and liquidity shocks – can generate movements in the term structure. A valid question is: Under what conditions would the term structure primarily reflect the stance of monetary policy? Based on the foregoing discussion, sufficient conditions are that inflation expectations are highly persistent and that movements in equilibrium real interest rates are either small or, when they do occur, are persistent. Whether or not these conditions are satisfied is of course an empirical matter.

A related question is: Under what conditions would the spread better reflect the stance of policy than a short-term real interest rate? The answer to this is basically the same as the previous one. To see this, note that under a unit-root inflation process and totally transitory monetary shocks, the spread is simply:

$$s_t^k = -\left[1 - \frac{(1-\phi^k)}{k(1-\phi)}\right] r_t^* + \left(\frac{k-1}{k}\right) l_t + \rho_k^t \tag{25}$$

The greater the degree of persistence in the real equilibrium interest rate, the less a given change in it will affect the spread. That is, the spread tends to net out fundamental changes in the real rate. In contrast, the short-term real interest rate (assuming that inflation expectations are perfectly measured) is given by:

$$r_t = r_t^* - l_t \tag{26}$$

This moves one-for-one with the expected real rate, in the absence of liquidity effects. Thus, it would be less correlated than the term spread with monetary factors.The short rate will be a noisier proxy of the stance of policy as long as there is some persistence in the real equilibrium interest rate process.

Another possibility is measurement error. The comparison above assumes that real interest rates can be measured perfectly. In reality of course, the real interest rate must be computed by subtracting an estimate of expected inflation. If expected inflation is measured with error, then equation (26) for the real interest rate includes an estimation error that will further weaken its correlation with the monetary shock. The spread, on the other hand, automatically nets out the market's forecast of changes in expected inflation, at least in the unit root case.

Ultimately though, a resolution of the question of which variable is a better measure of the stance of monetary policy ought to be on empirical grounds. Presumably, one test would be to check the relationship between the particular rate variable and a measure of central bank liquidity. More work is needed to assess the predictive content for interest rates and the term structure of shocks to bank reserves.

Another question that we could ask of the framework is: Why does the spread predict output? One obvious answer to this is that monetary shocks typically result in a stimulus to output several quarters later. Therefore, a positive monetary shock will tend to steepen the term structure (by reducing short rates relative to long rates) and raise future output growth rates. A steeper yield curve would also encourage purchasers of durable goods to move their spending forward in time, and hence stimulate output.

Another possibility is that equilibrium real rates predict future growth as consumption-based asset pricing models predict. Real business cycle models typically embody the same conditions for real interest rate determination as the consumption-based asset-pricing models. However, our empirical finding that the term structure predicts other components of expenditure such as investment and exports seems inconsistent with this approach. Furthermore, the finding that the level of short-term rates also relates negatively to future growth is also difficult to explain in such a context.

However, real business cycle models are not the only ones in which real interest rates fluctuate endogenously. In the broad class of Keynesian and new-Keynesian models, real interest rates can move procyclically in response to real shocks to the IS curve. As mentioned above, periods of lower than normal output may also tend to be periods of lower than normal real interest rates. But recessions are temporary and are followed by periods of higher than average growth. Therefore, a steepening of the term structure that is induced by an endogenous decline in real, short-term rates will be followed by an increase in growth – mirroring the pattern induced by a monetary shock.

One way to test for this endogeneity of the term structure to the business cycle is to include the current level of the output gap as a regressor in our basic term structure model. If the term structure leads growth only because of its comovement with the output gap, then inclusion of the gap should render it insignificant. Table 19 (p. 44) presents the results of adding a measure of the output gap (based on the Hodrick-Prescott detrending method) to the term structure regressions. The gap does come in negatively and significantly, consistent with the endogenous interest rate view. While the coefficient on the spread is reduced somewhat, from 1.29 to 1.04 at the 4-quarter horizon, it remains highly significant. In terms of out-of-sample forecasts, presented in Table 20 (p. 45), the inclusion of *YGAPT* increases the RMSE for each model examined. The results are similar for detrended output growth, *GkYC,* whose results are presented in Tables 21 and 22 (pp. 46 and 47). The spread coefficient is again reduced somewhat at every forecasting horizon, but nevertheless remains significant for up to 8 quarters. Out-of-sample, *YGAPT* improves the forecasts of the simple spread-based models, but worsens the forecast of augmented models that include *M4ARR90.*

These results suggest that there may be an endogenous or even anticipatory element to the strong empirical relation between the term structure and future growth. However, lots of room still remains for an exogenous element to play a role. Moreover, another measure of the gap we tried, the RDXF measure, reduced the explanatory power of the term structure much less than *YGAPT.*

Table 1: Statistics for SPREAD variables
Sample: 1961:1 to 1991:4 (124 observations)

Spread	Mean	S.D.	AC1	AC2	AC3	AC4	D.F. statistic
S10M90	0.29	1.51	0.821	0.622	0.418	0.262	-4.10*
S10M30	0.46	1.59	0.792	0.614	0.429	0.265	-4.16*
S10MC	0.97	1.70	0.619	0.612	0.501	0.340	-3.98*
S10M1T3	0.67	0.79	0.834	0.644	0.518	0.417	-3.33
S1T3M90	-0.38	0.93	0.714	0.502	0.340	0.217	-3.78*
S1T3M30	-0.21	1.04	0.631	0.436	0.333	0.200	-3.86*
S1T3MC	0.30	1.22	0.293	0.351	0.346	0.204	-3.97*
S3T5M90	-0.17	1.16	0.767	0.575	0.381	0.243	-4.01*
S3T5M30	0.00	1.26	0.712	0.540	0.384	0.243	-4.04*
S3T5MC	0.51	1.43	0.451	0.495	0.429	0.289	-4.08*
S10M3T5	0.46	0.52	0.817	0.621	0.513	0.428	-3.36
S90M30	0.17	0.23	0.342	0.208	0.360	0.211	-4.79*

D.F. statistic refers to the Dickey-Fuller statistic. * indicates rejection of the null hypothesis for a unit root at the 5 per cent level. S.D. is the standard deviation. AC1, AC2, AC3 and AC4 are the lagged autocorrelations of first, second, third and fourth order respectively.

Table 2: Cross-correlation between spread variables and growth

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Spread	Annualized cumulative growth, *k* quarters ahead								
	1	2	3	4	6	8	12	16	20
S10M90	0.464	0.614	0.708	0.727	0.694	0.564	0.312	0.212	0.169
S10M30	0.491	0.635	0.726	0.741	0.704	0.566	0.305	0.211	0.180
S10MC	0.476	0.568	0.654	0.673	0.667	0.558	0.318	0.250	0.243
S10M1T3	0.441	0.588	0.683	0.718	0.708	0.602	0.409	0.312	0.225
S1T3M90	0.374	0.492	0.563	0.562	0.518	0.401	0.158	0.072	0.082
S1T3M30	0.415	0.522	0.587	0.582	0.534	0.406	0.153	0.078	0.103
S1T3MC	0.376	0.407	0.465	0.469	0.468	0.386	0.176	0.140	0.191
S3T5M90	0.440	0.573	0.658	0.663	0.620	0.496	0.245	0.156	0.139
S3T5M30	0.469	0.593	0.673	0.674	0.627	0.494	0.236	0.155	0.153
S3T5MC	0.433	0.490	0.562	0.569	0.562	0.469	0.246	0.198	0.223
S10M3T5	0.369	0.511	0.595	0.637	0.635	0.536	0.360	0.269	0.182
S90M30	0.343	0.344	0.345	0.327	0.285	0.188	0.045	0.056	0.127

Table 3: Comparisons of various spread variables

$$GkY_t = \alpha_0 + \alpha_1 SPREAD_{t-k} + \varepsilon_t$$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Spread	Annualized cumulative growth, *k* quarters ahead																	
	1		2		3		4		6		8		12		16		20	
	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$
S10M90	1.30 (0.21)**	0.22	1.39 (0.17)**	0.39	1.41 (0.16)**	0.53	1.34 (0.17)**	0.56	1.11 (0.18)**	0.53	0.86 (0.17)**	0.39	0.51 (0.17)**	0.18	0.35 (0.15)*	0.12	0.29 (0.10)**	0.10
S10M30	1.31 (0.20)**	0.25	1.37 (0.16)**	0.42	1.37 (0.14)**	0.56	1.29 (0.15)**	0.59	1.08 (0.16)**	0.55	0.83 (0.15)**	0.40	0.50 (0.15)**	0.19	0.35 (0.13)**	0.13	0.30 (0.09)**	0.12
S10MC	1.19 (0.20)**	0.23	1.14 (0.20)**	0.33	1.15 (0.21)**	0.45	1.10 (0.22)**	0.48	0.97 (0.17)**	0.50	0.77 (0.13)**	0.38	0.47 (0.09)**	0.19	0.35 (0.07)**	0.15	0.32 (0.07)**	0.15
S10M1T3	2.38 (0.42)**	0.20	2.54 (0.36)**	0.36	2.58 (0.34)**	0.49	2.51 (0.33)**	0.55	2.14 (0.32)**	0.54	1.80 (0.29)**	0.45	1.25 (0.28)**	0.29	0.90 (0.24)**	0.20	0.63 (0.19)**	0.13
S1T3M90	1.69 (0.37)**	0.14	1.80 (0.31)**	0.25	1.83 (0.32)**	0.33	1.68 (0.36)**	0.34	1.35 (0.41)**	0.29	0.95 (0.35)**	0.19	0.44 (0.32)	0.05	0.28 (0.27)	0.02	0.29 (0.19)	0.03
S1T3M30	1.70 (0.35)**	0.17	1.73 (0.29)**	0.28	1.72 (0.29)**	0.37	1.57 (0.32)**	0.36	1.26 (0.35)**	0.32	0.89 (0.29)**	0.20	0.42 (0.26)	0.06	0.29 (0.22)	0.04	0.32 (0.16)*	0.06
S1T3MC	1.30 (0.30)**	0.14	1.14 (0.35)**	0.17	1.15 (0.38)**	0.23	1.07 (0.39)**	0.23	0.95 (0.29)**	0.24	0.71 (0.20)**	0.17	0.36 (0.12)**	0.06	0.28 (0.09)**	0.05	0.32 (0.11)**	0.09
S3T5M90	1.62 (0.27)**	0.20	1.70 (0.23)**	0.34	1.73 (0.23)**	0.46	1.60 (0.26)**	0.47	1.31 (0.30)**	0.43	0.98 (0.27)**	0.30	0.55 (0.26)*	0.13	0.38 (0.22)	0.08	0.35 (0.16)*	0.09
S3T5M30	1.59 (0.26)**	0.23	1.62 (0.22)**	0.37	1.62 (0.21)**	0.48	1.49 (0.24)**	0.49	1.23 (0.26)**	0.44	0.91 (0.23)**	0.30	0.51 (0.21)*	0.13	0.37 (0.18)*	0.09	0.36 (0.14)**	0.11
S3T5MC	1.29 (0.25)**	0.19	1.18 (0.28)**	0.25	1.19 (0.31)**	0.34	1.12 (0.32)**	0.35	0.98 (0.24)**	0.36	0.76 (0.17)**	0.27	0.44 (0.10)**	0.12	0.34 (0.09)**	0.10	0.35 (0.10)**	0.14
S10M3T5	3.01 (0.71)**	0.13	3.34 (0.67)**	0.26	3.39 (0.67)**	0.36	3.36 (0.63)**	0.42	2.87 (0.60)**	0.42	2.33 (0.55)**	0.33	1.46 (0.50)**	0.18	0.96 (0.46)*	0.11	0.60 (0.38)	0.05
S90M30	6.43 (1.52)**	0.12	5.28 (1.68)**	0.13	4.80 (1.83)**	0.14	4.31 (1.89)*	0.13	3.34 (1.49)*	0.10	2.22 (1.09)*	0.06	1.19 (0.77)	0.02	1.30 (0.76)	0.04	1.71 (0.82)*	0.09

* Significantly different from zero at the 5 per cent level ** Significantly different from zero at the 1 per cent level

Table 4: Split term structure models

$GkY_t = \alpha_0 + \alpha_1 SPREAD1_{t-k} + \alpha_2 SPREAD2_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Spread	Annualized cumulative growth, *k* quarters ahead																	
	1		2		3		4		6		8		12		16		20	
	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$
S10M1T3 S1T3M90	1.84 (0.50)** 0.87 (0.42)*	0.22	1.97 (0.38)** 0.92 (0.25)**	0.40	2.02 (0.33)** 0.92 (0.17)**	0.55	2.04 (0.28)** 0.76 (0.17)**	0.60	1.79 (0.27)** 0.56 (0.20)**	0.57	1.61 (0.29)** 0.30 (0.20)	0.46	1.26 (0.32)** -0.00 (0.24)	0.28	0.93 (0.30)** -0.06 (0.24)	0.20	0.60 (0.22)** 0.06 (0.18)	0.12
S10M3T5 S3T5M90	1.42 (0.74) 1.26 (0.32)**	0.21	1.76 (0.60)** 1.26 (0.22)**	0.39	1.80 (0.52)** 1.27 (0.17)**	0.53	1.99 (0.41)** 1.10 (0.18)**	0.57	1.82 (0.38)** 0.86 (0.21)**	0.54	1.60 (0.37)** 0.61 (0.19)**	0.41	1.13 (0.41)** 0.31 (0.20)	0.20	0.71 (0.45) 0.23 (0.21)	0.12	0.30 (0.39) 0.28 (0.19)	0.09
S10M1T3 S1T3M30	1.69 (0.46)** 1.05 (0.37)**	0.25	1.88 (0.35)** 1.01 (0.22)**	0.43	1.95 (0.30)** 0.97 (0.15)**	0.58	1.98 (0.24)** 0.81 (0.16)**	0.62	1.75 (0.26)** 0.61 (0.18)**	0.59	1.58 (0.28)** 0.35 (0.18)	0.47	1.22 (0.31)** 0.06 (0.21)	0.28	0.88 (0.29)** 0.03 (0.20)	0.20	0.54 (0.21)** 0.15 (0.16)	0.13
S10M3T5 S3T5M30	1.36 (0.68)* 1.30 (0.29)**	0.24	1.77 (0.56)** 1.24 (0.20)**	0.42	1.85 (0.48)** 1.22 (0.16)**	0.56	2.02 (0.38)** 1.06 (0.17)**	0.60	1.84 (0.37)** 0.83 (0.18)**	0.57	1.63 (0.37)** 0.59 (0.16)**	0.43	1.13 (0.41)** 0.31 (0.17)	0.21	0.70 (0.45) 0.25 (0.18)	0.14	0.28 (0.37) 0.31 (0.17)	0.11
S10M90 S90M30	1.11 (0.21)** 4.43 (1.40)**	0.27	1.26 (0.17)** 2.96 (1.24)**	0.43	1.31 (0.14)** 2.35 (1.14)*	0.56	1.25 (0.13)** 1.95 (1.05)	0.59	1.05 (0.16)** 1.50 (0.69)*	0.54	0.83 (0.16)** 0.92 (0.65)	0.39	0.50 (0.18)** 0.51 (0.80)	0.18	0.32 (0.16)* 0.85 (0.90)	0.13	0.23 (0.10)* 1.38 (0.91)	0.15

* Significantly different from zero at the 5 per cent level

** Significantly different from zero at the 1 per cent level

Table 5: Components of output

$GkX_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

X	Annualized cumulative growth, *k* quarters ahead																	
	1		2		3		4		6		8		12		16		20	
	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$	α_1	$\bar{R}^2$
Total expenditures	1.31 (0.20)**	0.25	1.37 (0.16)**	0.42	1.37 (0.14)**	0.56	1.29 (0.15)**	0.59	1.08 (0.16)**	0.55	0.83 (0.15)**	0.40	0.50 (0.15)**	0.19	0.35 (0.13)**	0.13	0.30 (0.09)**	0.12
Consumption	0.99 (0.21)**	0.14	1.08 (0.17)**	0.33	1.06 (0.17)**	0.43	1.05 (0.17)**	0.48	0.90 (0.17)**	0.44	0.72 (0.17)**	0.33	0.50 (0.15)**	0.20	0.37 (0.12)**	0.13	0.32 (0.08)**	0.12
Durables	3.55 (0.76)**	0.12	3.63 (0.53)**	0.31	3.35 (0.47)**	0.39	3.19 (0.45)**	0.42	2.58 (0.40)**	0.41	1.99 (0.40)**	0.29	1.29 (0.36)**	0.16	0.75 (0.27)**	0.08	0.52 (0.20)**	0.05
Non-durables	0.50 (0.25)*	0.02	0.51 (0.17)*	0.06	0.57 (0.15)**	0.13	0.65 (0.15)**	0.21	0.61 (0.15)**	0.24	0.49 (0.16)**	0.16	0.36 (0.17)	0.09	0.27 (0.16)	0.06	0.27 (0.12)*	0.06
Business investment	0.88 (0.57)	0.01	1.30 (0.58)*	0.04	1.46 (0.68)	0.07	1.59 (0.75)*	0.10	1.63 (0.77)	0.14	1.72 (0.62)*	0.19	1.69 (0.34)**	0.26	1.43 (0.24)**	0.34	1.14 (0.28)**	0.36
Machinery and equipment	1.36 (0.82)	0.01	2.12 (0.78)**	0.07	2.43 (0.85)**	0.13	2.62 (0.89)**	0.18	2.58 (0.86)**	0.23	2.51 (0.68)**	0.26	2.28 (0.30)**	0.32	1.82 (0.22)**	0.38	1.31 (0.27)**	0.34
Non-residential construction	0.48 (0.61)	-0.01	0.65 (0.56)	0.00	0.67 (0.61)	0.00	0.78 (0.68)	0.01	0.91 (0.74)	0.04	1.12 (0.61)	0.09	1.21 (0.48)*	0.14	1.11 (0.34)**	0.21	1.04 (0.34)**	0.25
Housing	3.74 (1.05)**	0.10	4.05 (0.85)**	0.19	3.81 (0.81)**	0.25	3.25 (0.79)**	0.23	2.27 (0.64)**	0.19	1.37 (0.53)**	0.10	0.84 (0.46)	0.05	0.57 (0.29)	0.04	0.44 (0.17)**	0.03
Government expenditures	-0.24 (0.30)	0.00	-0.20 (0.21)	0.00	-0.14 (0.18)	0.00	-0.06 (0.15)	-0.01	-0.01 (0.14)	0.00	0.09 (0.14)	-0.00	0.16 (0.15)	0.01	0.17 (0.13)	0.02	0.23 (0.12)	0.04
Exports	2.14 (0.74)**	0.06	1.87 (0.54)**	0.11	1.80 (0.44)**	0.17	1.60 (0.39)**	0.18	1.32 (0.29)**	0.18	0.84 (0.27)**	0.09	0.13 (0.34)	0.00	-0.09 (0.31)	-0.00	-0.01 (0.22)	-0.01
Imports	2.62 (0.77)**	0.09	2.74 (0.66)**	0.18	2.91 (0.63)**	0.28	2.79 (0.62)**	0.33	2.37 (0.51)**	0.37	1.84 (0.34)**	0.32	1.30 (0.28)**	0.27	0.90 (0.16)**	0.23	0.59 (0.15)**	0.15

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 6: A closer look at S10M30

$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_0	α_1	$\bar{R}^2$	SEE
1	3.38 (0.34)**	1.31 (0.20)**	0.25	3.61
2	3.35 (0.29)**	1.37 (0.16)**	0.42	2.56
3	3,35 (0.26)**	1.37 (0.14)**	0.56	1.96
4	3.37 (0.26)**	1.29 (0.15)**	0.59	1.74
6	3.44 (0.29)**	1.08 (0.16)**	0.55	1.56
8	3.54 (0.33)**	0.83 (0.15)**	0.40	1.58
12	3.74 (0.39)**	0.50 (0.15)**	0.19	1.50
16	3.86 (0.39)**	0.35 (0.13)**	0.13	1,32
20	3.89 (0.37)**	0.30 (0.09)**	0.12	1.20

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 7: Significance of adding M4ARR90

$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 M4ARR90_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_1	α_2	$\bar{R}^2$	SEE
1	1.15 (0.20)**	-0.41 (0.13)**	0.30	3.49
2	1.21 (0.14)**	-0.38 (0.10)**	0.48	2.42
3	1.24 (0.11)**	-0.33 (0.08)**	0.62	1.81
4	1.17 (0.11)**	-0.31 (0.07)**	0.65	1.59
6	0.99 (0.11)**	-0.27 (0.08)**	0.61	1.45
8	0.78 (0.10)**	-0.23 (0.10)*	0.46	1.50
12	0.48 (0.14)**	-0.14 (0.10)	0.21	1.48
16	0.35 (0.13)**	-0.06 (0.09)	0.13	1.32
20	0.30 (0.09)**	-0.05 (0.12)	0.12	1.20

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 8: Significance of adding G4RM1

$GkY_t = \alpha_0 + \alpha_1 S10M30_{t\text{-}k} + \alpha_2 G4RM1_{t\text{-}k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_1	α_2	$\bar{R}^2$	SEE
1	0.81 (0.25)**	0.27 (0.10)**	0.30	3.49
2	0.95 (0.18)**	0.22 (0.09)**	0.47	2.44
3	1.16 (0.15)**	0.11 (0.08)	0.57	1.92
4	1.18 (0.16)**	0.06 (0.06)	0.59	1.74
6	1.10 (0.19)**	-0.01 (0.05)	0.54	1.57
8	0.84 (0.19)**	-0.00 (0.06)	0.39	1.59
12	0.51 (0.14)**	-0.00 (0.04)	0.18	1.51
16	0.42 (0.12)**	-0.03 (0.04)	0.13	1.32
20	0.26 (0.10)**	0.02 (0.02)	0.11	1.20

* Significantly different from zero at the 5 per cent level.
** Significantly different from zero at the 1 per cent level.

Table 9: Significance of adding G4RTSE

$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 G4RTSE_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, k quarters ahead	α_1	α_2	$\bar{R}^2$	SEE
1	1.15 (0.20)**	0.06 (0.02)**	0.29	3.50
2	1.25 (0.15)**	0.04 (0.02)*	0.45	2.49
3	1.31 (0.14)**	0.02 (0.01)	0.57	1.94
4	1.28 (0.15)**	0.00 (0.01)	0.58	1.75
6	1.13 (0.16)**	-0.02 (0.01)	0.56	1.54
8	0.90 (0.14)**	-0.02 (0.01)	0.43	1.54
12	0.57 (0.16)**	-0.02 (0.01)	0.23	1.46
16	0.43 (0.11)**	-0.02 (0.01)	0.19	1.28
20	0.33 (0.09)**	-0.01 (0.01)	0.11	1.20

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 10: Significance of adding S10M30US

$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 S10M30US_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, k quarters ahead	α_1	α_2	$\bar{R}^2$	SEE
1	1.75 (0.29)**	-0.62 (0.29)*	0.27	3.55
2	1.67 (0.24)**	-0.44 (0.22)*	0.44	2.52
3	1.60 (0.21)**	-0.33 (0.16)*	0.57	1.93
4	1.51 (0.20)**	-0.31 (0.15)*	0.60	1.71
6	1.28 (0.19)**	-0.27 (0.17)	0.56	1.54
8	1.01 (0.21)**	-0.22 (0.20)	0.41	1.57
12	0.67 (0.16)**	-0.21 (0.18)	0.20	1.49
16	0.55 (0.12)**	-0.25 (0.13)	0.16	1.30
20	0.60 (0.11)**	-0.36 (0.12)**	0.22	1.13

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 11: Significance of additional variables

$$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 M4ARR90_{t-k} + \alpha_3 G4RM1_{t-k} + \alpha_4 G4RTSE_{t-k} + \alpha_5 S10M30US_{t-k} + \varepsilon_t$$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_1	α_2	α_3	α_4	α_5	$\bar{R}^2$	SEE
1	1.02 (0.32)**	-0.38 (0.12)**	0.08 (0.10)	0.05 (0.02)**	-0.23 (0.28)	0.35	3.35
2	1.03 (0.23)**	-0.35 (0.09)**	0.08 (0.08)	0.04 (0.02)*	-0.09 (0.20)	0.53	2.31
3	1.20 (0.20)**	-0.34 (0.07)**	0.00 (0.07)	0.03 (0.01)*	-0.06 (0.15)	0.64	1.78
4	1.24 (0.18)**	-0.31 (0.07)**	-0.02 (0.05)	0.01 (0.01)	-0.11 (0.13)	0.65	1.60
6	1.20 (0.18)**	-0.24 (0.09)**	-0.03 (0.06)	-0.01 (0.01)	-0.16 (0.14)	0.62	1.43
8	0.94 (0.24)**	-0.19 (0.12)	0.01 (0.08)	-0.02 (0.02)	-0.14 (0.16)	0.48	1.48
12	0.71 (0.21)**	-0.09 (0.13)	0.01 (0.09)	-0.02 (0.02)	-0.20 (0.17)	0.25	1.44
16	0.68 (0.15)**	-0.01 (0.11)	-0.01 (0.07)	-0.02 (0.02)	-0.28 (0.11)*	0.22	1.26
20	0.61 (0.13)**	0.02 (0.11)	0.02 (0.04)	-0.01 (0.01)	-0.37 (0.10)**	0.22	1.13

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 12: G4Y estimation models using S10M30: a synopsis

In sample: 1962:1 to 1991:4

Out of sample: 1975:1 to 1991:4

Model	In-sample results								Out-of-sample
	Constant	S10M30	M4ARR90	G4RM1	G4RTSE	S10M30US	G4Y	$\bar{R}^2$	RMSE
1	3.37 (0.26)**	1.29 (0.15)**	...	...	...	...	...	0.59	2.03
2	4.38 (0.27)**	1.17 (0.11)**	-0.31 (0.07)**	...	...	...	...	0.65	1.84
3	3.34 (0.27)**	1.18 (0.16)**	...	0.06 (0.06)	...	...	...	0.59	2.05
4	3.37 (0.26)**	1.28 (0.15)**	...	...	0.01 (0.01)	...	...	0.58	2.06
5	3.37 (0.23)**	1.51 (0.20)**	...	...	...	-0.31 (0.15)*	...	0.60	2.17
6	3.40 (0.44)**	1.30 (0.14)**	...	...	...	...	-0.01 (0.07)	0.58	2.15
7	4.38 (0.28)**	1.24 (0.18)**	-0.31 (0.07)**	-0.02 (0.05)	0.01 (0.01)	-0.11 (0.13)	...	0.65	2.15
8	5.02 (0.42)**	1.24 (0.18)**	-0.33 (0.07)**	0.03 (0.05)	0.01 (0.01)	-0.14 (0.13)	-0.15 (0.07)*	0.66	2.36
9	4.87 (0.44)**	1.19 (0.11)**	-0.34 (0.07)**	...	...	...	-0.10 (0.06)	0.66	2.01

... : Variable not included in the model

* Significantly different from zero at the 5 per cent level

** Significantly different from zero at the 1 per cent level

Table 13: Out-of-sample forecasts of G4Y using S10M30

(Forecasts: 1975:1 to 1991:4)

$$G4Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Regressor_{t-k} + \varepsilon_t$$

Regressors	Statistic				
	RMSE	MAE	ME	t-stat for ME = 0	Stddev. of forecast
S10M30	2.03	1.54	-1.26	-6.45	1.61
S10M30 M4ARR90	1.84	1.32	-0.91	-4.65	1.61
S10M30 G4RM1	2.05	1.57	-1.30	-6.73	1.60
S10M30 G4RTSE	2.06	1.58	-1.29	-6.60	1.62
S10M30 S10M30US	2.17	1.71	-1.37	-6.64	1.70
S10M30 G4Y	2.15	1.64	-1.50	-7.99	1.55
S10M30 M4ARR90 G4RM1 G4RTSE S10M30US	2.15	1.65	-1.31	-6.29	1.72
S10M30 M4ARR90 G4RM1 G4RTSE S10M30US G4Y	2.36	1.89	-1.66	-8.08	1.69
S10M30 M4ARR90 Dummy*	1.64	1.21	0.05	0.25	1.65

*Dummy is defined as 0 before 1973:1 and 1 thereafter.

Table 14: G4YC Estimation models using S10M30: a synopsis

In-sample: 1962:1 to 1991:4

Out-of-sample: 1975:1 to 1991:4

Model	In-sample results								Out-of-sample
	Constant	S10M30	M4ARR90	G4RM1	G4RTSE	S10M30US	G4YC	$\bar{R}^2$	RMSE
1	-0.38 (0.21)	0.85 (0.12)**	...	...	...	...	...	0.45	1.61
2	-0.19 (0.24)	0.83 (0.12)**	-0.06 (0.05)	...	...	...	...	0.45	1.67
3	-0.37 (0.22)	0.87 (0.11)**	...	-0.01 (0.06)	...	...	...	0.45	1.65
4	-0.37 (0.20)	0.81 (0.12)**	...	...	0.01 (0.01)	...	...	0.46	1.60
5	-0.38 (0.21)	0.76 (0.15)**	...	...	...	0.13 (0.13)	...	0.45	1.73
6	-0.37 (0.20)	0.87 (0.11)**	...	...	...	...	-0.31 (0.05)**	0.54	1.53
7	0.11 (0.27)	0.71 (0.14)**	-0.14 (0.06)*	-0.07 (0.06)	0.02 (0.01)*	0.21 (0.13)	...	0.48	1.73
8	0.06 (0.21)	0.57 (0.13)**	-0.13 (0.06)*	0.00 (0.06)	0.03 (0.01)**	0.21 (0.11)	-0.40 (0.07)**	0.61	1.69
9	-0.06 (0.18)	0.74 (0.10)**	-0.09 (0.06)	...	0.03 (0.01)**	...	-0.40 (0.06)**	0.60	1.51

... : Variable not included in model.

*   Significantly different from zero at the 5 per cent level

** Significantly different from zero at the 1 per cent level

Table 15: Out-of-sample forecasts of G4YC using S10M30

(Forecasts: 1975:1 to 1991:4)

$$G4YC_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Regressor_{t-k} + \varepsilon_t$$

Regressors	Statistic				
	RMSE	MAE	ME	t-stat for ME = 0	Stddev. of forecast
S10M30	1.61	1.17	0.23	1.19	1.60
S10M30 M4ARR90	1.67	1.22	0.37	1.86	1.64
S10M30 G4RM1	1.65	1.17	0.16	0.78	1.65
S10M30 G4RTSE	1.60	1.16	0.24	1.24	1.59
S10M30 S10M30US	1.73	1.25	-0.04	-0.20	1.74
S10M30 G4YC	1.53	1.08	0.17	0.90	1.54
S10M30 M4ARR90 G4RM1 G4RTSE S10M30US	1.73	1.31	0.01	0.05	1.75
S10M30 M4ARR90 G4RM1 G4RTSE S10M30US G4YC	1.69	1.29	-0.12	-0.60	1.70
S10M30 G4RTSE G4YC	1.40	1.00	0.13	0.78	1.41

Table 16: Split term structure models for detrended output growth

$GkYC_t = \alpha_0 + \alpha_1 SPREAD1_{t-k} + \alpha_2 SPREAD2_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Spread	Annualized cumulative growth, *k* quarters ahead																	
	1		2		3		4		6		8		12		16		20	
	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$	α	$\bar{R}^2$
S10M1T3 S1T3M90	0.76 (0.46) 1.04 (0.41)*	0.12	0.88 (0.34)** 1.06 (0.24)**	0.26	0.93 (0.29)** 1.02 (0.15)**	0.40	0.96 (0.23)** 0.85 (0.13)**	0.45	0.74 (0.23)** 0.68 (0.16)**	0.47	0.64 (0.15)** 0.42 (0.11)**	0.38	0.50 (0.15)** 0.17 (0.07)**	0.30	0.35 (0.12)** 0.09 (0.06)	0.24	0.22 (0.05)** 0.07 (0.08)	0.15
S10M3T5 S3T5M90	0.51 (0.72) 1.06 (0.31)**	0.12	0.84 (0.55) 1.02 (0.20)**	0.26	0.89 (0.44)* 1.01 (0.14)**	0.40	1.09 (0.34)** 0.83 (0.14)**	0.45	0.94 (0.28)** 0.63 (0.13)**	0.47	0.87 (0.17)** 0.39 (0.08)**	0.39	0.65 (0.14)** 0.19 (0.06)**	0.30	0.45 (0.16)** 0.11 (0.05)*	0.25	0.34 (0.10)** 0.06 (0.07)	0.17
S10M1T3 S1T3M30	0.72 (0.43) 1.03 (0.37)**	0.14	0.90 (0.32)** 0.96 (0.22)**	0.27	0.96 (0.26)** 0.90 (0.15)**	0.40	0.99 (0.22)** 0.75 (0.14)**	0.45	0.78 (0.22)** 0.59 (0.13)**	0.46	0.68 (0.15)** 0.34 (0.09)**	0.37	0.54 (0.15)** 0.11 (0.06)	0.28	0.37 (0.12)** 0.05 (0.05)	0.23	0.23 (0.05)** 0.06 (0.06)	0.15
S10M3T5 S3T5M30	0.56 (0.68) 1.01 (0.29)**	0.14	0.95 (0.53) 0.93 (0.19)**	0.27	1.02 (0.42)* 0.90 (0.14)**	0.40	1.19 (0.33)** 0.74 (0.14)**	0.45	1.02 (0.28)** 0.55 (0.11)**	0.47	0.94 (0.18)** 0.33 (0.07)**	0.38	0.71 (0.15)** 0.14 (0.06)*	0.29	0.49 (0.16)** 0.08 (0.04)*	0.23	0.35 (0.10)** 0.05 (0.05)	0.17
S10M90 S90M30	0.82 (0.20)** 2.21 (1.30)	0.14	0.94 (0.15)** 0.89 (1.05)	0.27	0.96 (0.12)** 0.44 (0.97)	0.40	0.89 (0.12)** 0.22 (0.89)	0.45	0.71 (0.13)** -0.00 (0.71)	0.47	0.53 (0.09)** -0.49 (0.60)	0.38	0.34 (0.07)** -0.90 (0.32)**	0.33	0.22 (0.06)** -0.65 (0.22)**	0.27	0.14 (0.05)** -0.14 (0.26)	0.14

* Significantly different from zero at the 5 per cent level

** Significantly different from zero at the 1 per cent level

Table 17: A look at the term structure and inflation (CPI)

$$GkPC_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 G1PC_{t-k} + \alpha_3 G1PC_{t-k-1} + \alpha_4 G1PC_{t-k-2} + \alpha_5 YGAPT_{t-k} + \varepsilon_t$$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_1	α_2	α_3	α_4	α_5	$\bar{R}^2$	SEE
1	0.10 (0.16)	0.53 (0.10)**	0.19 (0.10)	0.14 (0.10)	0.39 (0.18)*	0.70	1.88
2	0.15 (0.16)	0.48 (0.08)**	0.16 (0.09)	0.21 (0.09)*	0.42 (0.16)**	0.71	1.73
3	0.22 (0.16)	0.39 (0.09)**	0.23 (0.08)**	0.20 (0.09)*	0.47 (0.16)**	0.71	1.67
4	0.27 (0.18)	0.43 (0.08)**	0.20 (0.07)**	0.19 (0.06)**	0.47 (0.16)**	0.72	1.60
6	0.44 (0.23)	0.43 (0.07)**	0.24 (0.07)**	0.13 (0.06)*	0.52 (0.18)**	0.69	1.64
8	0.59 (0.26)*	0.42 (0.08)**	0.22 (0.06)**	0.12 (0.05)*	0.53 (0.19)**	0.62	1.76
12	0.75 (0.27)**	0.36 (0.08)**	0.20 (0.05)**	0.11 (0.07)	0.50 (0.21)*	0.52	1.87
16	0.75 (0.21)**	0.30 (0.06)**	0.17 (0.05)**	0.12 (0.07)	0.43 (0.25)	0.43	1.90
20	0.74 (0.19)**	0.22 (0.05)**	0.16 (0.05)**	0.15 (0.08)	0.41 (0.25)	0.39	1.83

* Significantly different from zero at the 5 per cent level.
**Significantly different from zero at the 1 per cent level.

Table 18: A look at the term structure and inflation (GDP deflator)

$GkP_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 G1P_{t-k} + \alpha_3 G1P_{t-k-1} + \alpha_4 G1P_{t-k-2} + \alpha_5 YGAPT_{t-k} + \varepsilon_t$

Sample: 1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, *k* quarters ahead	α_1	α_2	α_3	α_4	α_5	$\bar{R}^2$	SEE
1	0.29 (0.14)*	0.37 (0.08)**	0.30 (0.08)**	0.20 (0.08)*	0.51 (0.12)**	0.64	2.08
2	0.40 (0.15)**	0.39 (0.07)**	0.28 (0.06)**	0.18 (0.08)*	0.54 (0.11)**	0.71	1.72
3	0.46 (0.17)**	0.39 (0.08)**	0.27 (0.06)**	0.18 (0.07)*	0.53 (0.11)**	0.71	1.66
4	0.53 (0.21)**	0.39 (0.08)**	0.27 (0.06)**	0.16 (0.06)*	0.54 (0.14)**	0.70	1.66
6	0.71 (0.27)**	0.36 (0.06)**	0.25 (0.05)**	0.18 (0.06)**	0.58 (0.18)**	0.66	1.71
8	0.82 (0.32)*	0.37 (0.06)**	0.24 (0.05)**	0.15 (0.05)**	0.56 (0.20)**	0.60	1.78
12	0.87 (0.39)*	0.31 (0.06)**	0.19 (0.05)**	0.14 (0.06)*	0.49 (0.24)*	0.45	1.93
16	0.88 (0.31)**	0.23 (0.05)**	0.18 (0.05)**	0.13 (0.06)*	0.47 (0.23)*	0.38	1.90
20	0.91 (0.22)**	0.18 (0.04)**	0.15 (0.05)**	0.18 (0.05)**	0.41 (0.21)*	0.37	1.77

* Significantly different from zero at the 5 per cent level.
** Significantly different from zero at the 1 per cent level.

Table 19: Output growth prediction equations using YGAPT

1961:1 + k to 1991:4 (124 - k observations)

Forecasting horizon, k quarters ahead	$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 YGAPT_{t-k} + \varepsilon_t$			$GkY_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 YGAPT_{t-k} + \alpha_3 M4ARR90_{t-k} + \varepsilon_t$			
	α_1	α_2	$\bar{R}^2$	α_1	α_2	α_3	$\bar{R}^2$
1	1.20 (0.26)**	-0.22 (0.25)	0.25	1.00 (0.24)**	-0.29 (0.24)	-0.43 (0.13)**	0.30
2	1.20 (0.21)**	-0.34 (0.21)	0.43	1.01 (0.17)**	-0.39 (0.18)*	-0.40 (0.11)**	0.51
3	1.18 (0.19)**	-0.38 (0.15)*	0.59	1.01 (0.13)**	-0.43 (0.12)**	-0.35 (0.09)**	0.66
4	1.04 (0.19)**	-0.49 (0.14)**	0.64	0.90 (0.13)**	-0.52 (0.11)**	-0.32 (0.08)**	0.72
6	0.78 (0.18)**	-0.56 (0.15)**	0.65	0.69 (0.12)**	-0.57 (0.11)**	-0.27 (0.07)**	0.72
8	0.52 (0.15)**	-0.59 (0.17)**	0.55	0.46 (0.11)**	-0.59 (0.14)**	-0.23 (0.09)**	0.61
12	0.24 (0.17)	-0.50 (0.20)*	0.35	0.22 (0.15)	-0.51 (0.19)**	-0.15 (0.08)	0.38
16	0.18 (0.13)	-0.32 (0.14)*	0.21	0.17 (0.12)	-0.33 (0.13)*	-0.08 (0.08)	0.22
20	0.17 (0.10)	-0.25 (0.09)**	0.18	0.15 (0.09)	-0.26 (0.09)**	-0.06 (0.12)	0.18

* Significantly different from zero at the 5 per cent level
** Significantly different from zero at the 1 per cent level

Table 20: Out-of-sample forecasts of G4Y using spreads and YGAPT

Forecasts: 1975:1 to 1991:4

$$G4Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Regressor_{t-k} + \varepsilon_t$$

Regressors	Statistic				
	RMSE	MAE	ME	t-stat for ME = 0	Stddev. of forecast
S10M90 YGAPT	2.16	1.62	-1.52	-8.12	1.55
S10M90 YGAPT M4ARR90	2.12	1.59	-1.28	-6.22	1.70
S10M30 YGAPT	2.05	1.54	-1.40	-7.59	1.52
S10M30 YGAPT M4ARR90	2.03	1.53	-1.18	-5.89	1.66

Table 21: Detrended output growth prediction equations using YGAPT

1961:1 + *k* to 1991:4 (124 - *k* observations)

Forecasting horizon, k quarters ahead	$GkYC_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 YGAPT_{t-k} + \varepsilon_t$			$GkYC_t = \alpha_0 + \alpha_1 S10M30_{t-k} + \alpha_2 YGAPT_{t-k} + \alpha_3 M4ARR90_{t-k} + \varepsilon_t$			
	α_1	α_2	$\bar{R}^2$	α_1	α_2	α_3	$\bar{R}^2$
1	0.69 (0.24)**	-0.41 (0.24)	0.16	0.63 (0.25)**	-0.43 (0.24)	-0.14 (0.12)	0.16
2	0.69 (0.19)**	-0.48 (0.18)**	0.32	0.64 (0.18)**	-0.50 (0.18)**	-0.12 (0.10)	0.33
3	0.69 (0.15)**	-0.49 (0.11)**	0.48	0.64 (0.14)**	-0.50 (0.11)**	-0.09 (0.08)	0.48
4	0.58 (0.14)**	-0.53 (0.08)**	0.57	0.55 (0.13)**	-0.54 (0.09)**	-0.07 (0.06)	0.58
6	0.39 (0.12)**	-0.52 (0.06)**	0.66	0.38 (0.11)**	-0.52 (0.06)**	-0.05 (0.04)	0.66
8	0.21 (0.07)**	-0.49 (0.04)**	0.65	0.20 (0.07)**	-0.49 (0.05)**	-0.03 (0.03)	0.65
12	0.08 (0.06)	-0.37 (0.04)**	0.61	0.08 (0.06)	-0.37 (0.04)**	0.00 (0.04)	0.61
16	0.03 (0.04)	-0.27 (0.04)**	0.54	0.03 (0.04)	-0.27 (0.05)**	0.01 (0.04)	0.54
20	-0.01 (0.04)	-0.25 (0.03)**	0.57	-0.01 (0.04)	-0.25 (0.03)**	-0.01 (0.02)	0.56

* Significantly different from zero at the 5 per cent level
** Significantly different from zero at the 1 per cent level

Table 22: Out-of-sample forecasts of G4YC using spreads and YGAPT

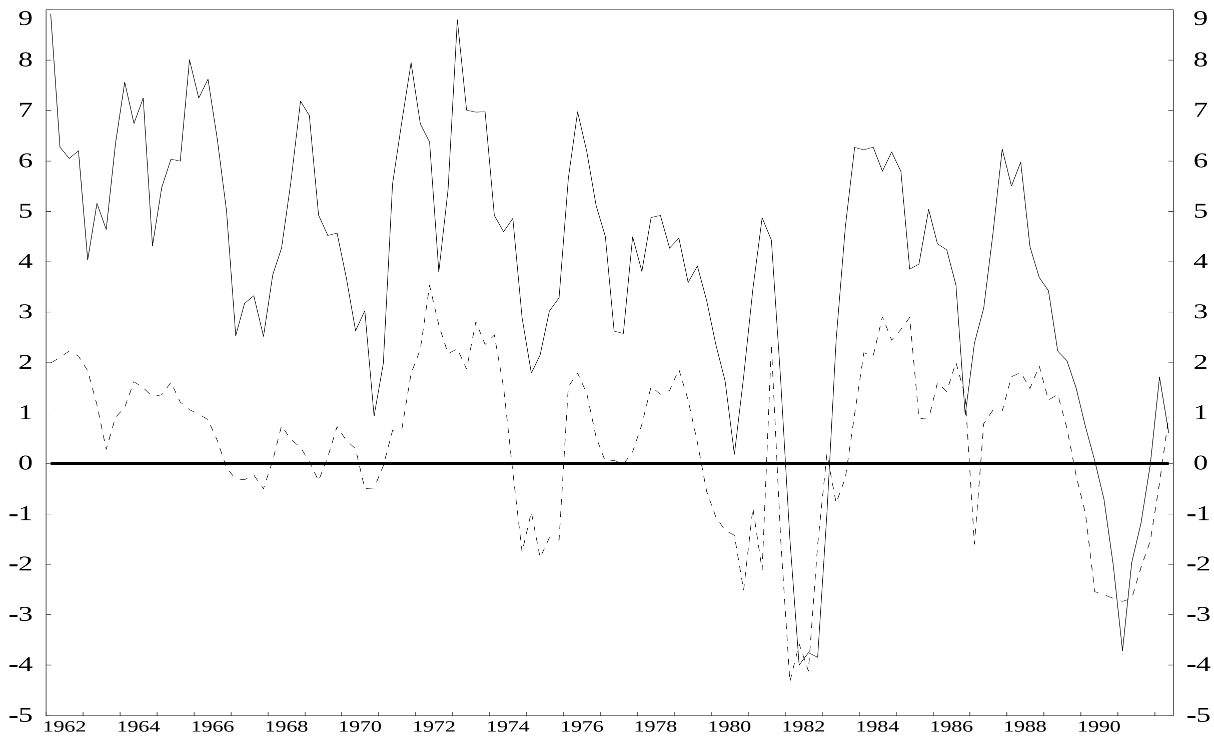
Forecasts: 1975:1 to 1991:4

$$G4YC_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Regressor_{t-k} + \varepsilon_t$$

Regressors	Statistic				
	RMSE	MAE	ME	t-stat for ME = 0	Stddev. of forecast
S10M90 YGAPT	1.56	1.15	0.07	0.35	1.57
S10M90 YGAPT M4ARR90	1.86	1.43	0.07	0.32	1.87
S10M30 YGAPT	1.55	1.13	0.14	0.72	1.55
S10M30 YGAPT M4ARR90	1.85	1.42	0.13	0.56	1.85

Figure 1: Four-quarter real output growth and lagged S10M30

(1962:1 to 1992:2)

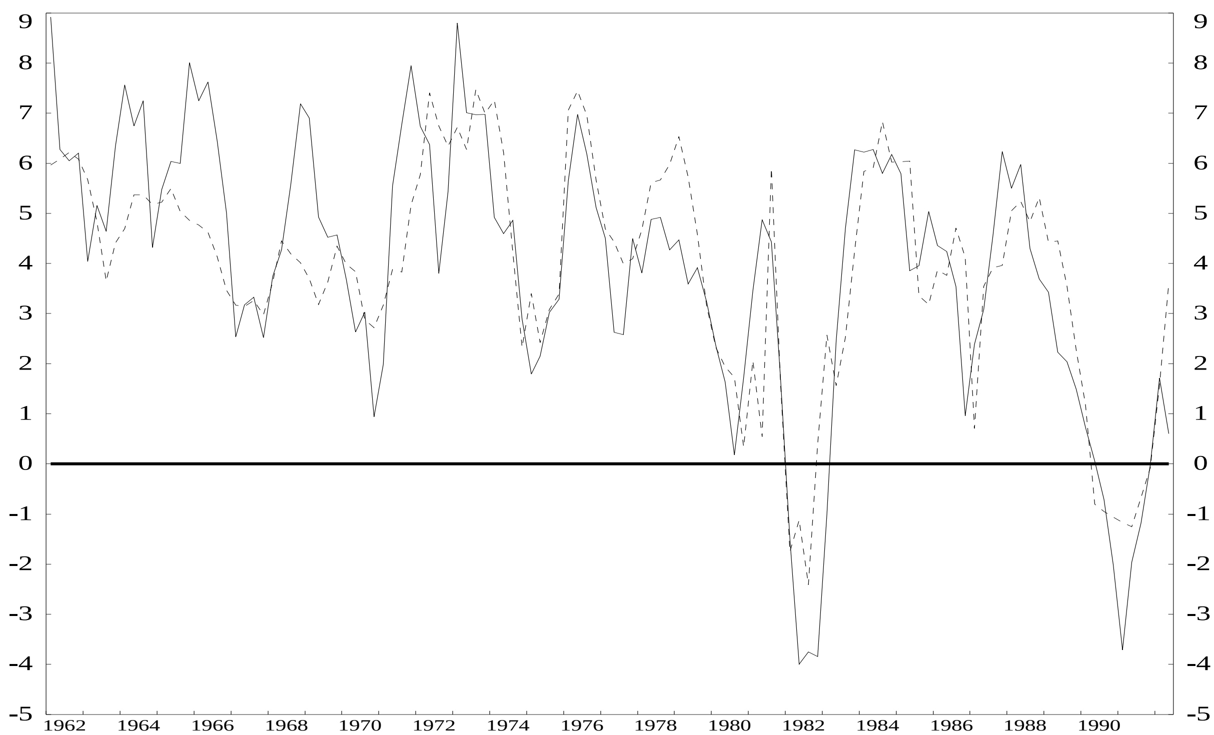


——— = G4Y

--------- = $S10M30_{t-4}$

Figure 2: Actual and fitted output growth (augmented prediction model)
(1962:1 to 1992:2)

$$G4Y_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \alpha_2 M4ARR90_{t-4} + \varepsilon_t$$

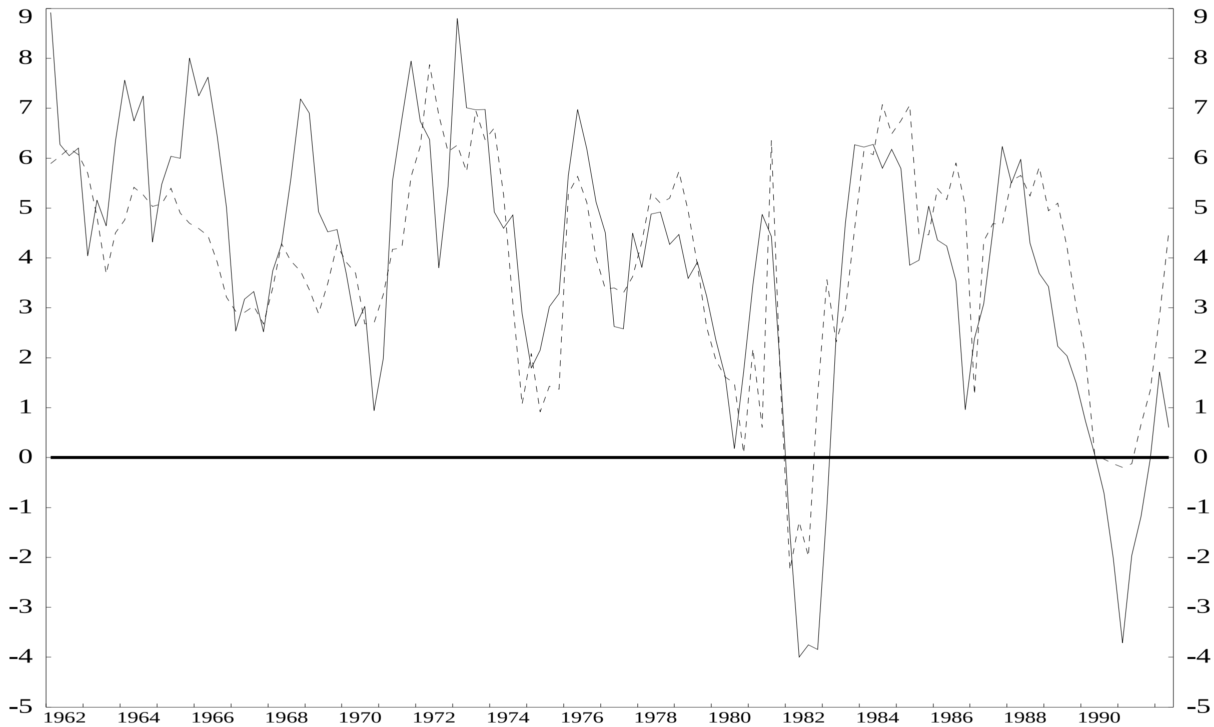


_______ = Actual
--------- = Fitted

Figure 3: Actual and fitted output growth (simple prediction model)

(1962:1 to 1992:2)

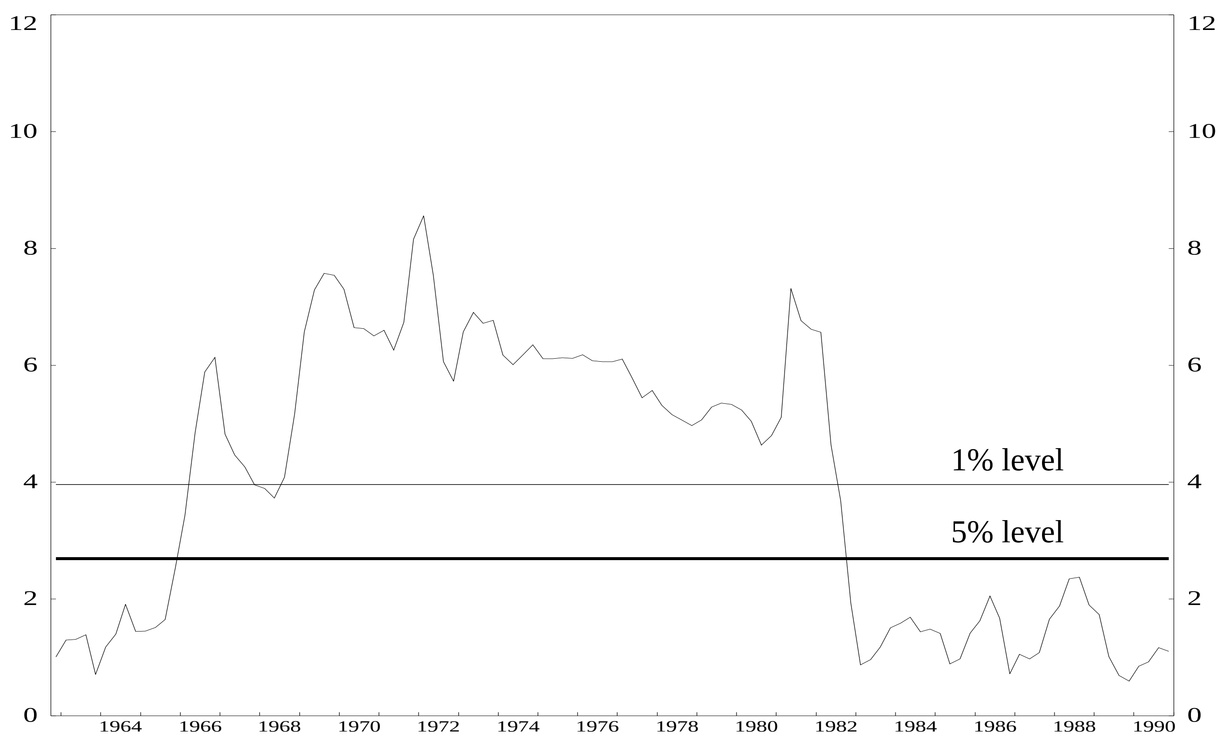
$$G4Y_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \varepsilon_t$$



_______ = Actual
--------- = Fitted

Figure 4: Rolling Chow test for real output growth (G4Y)

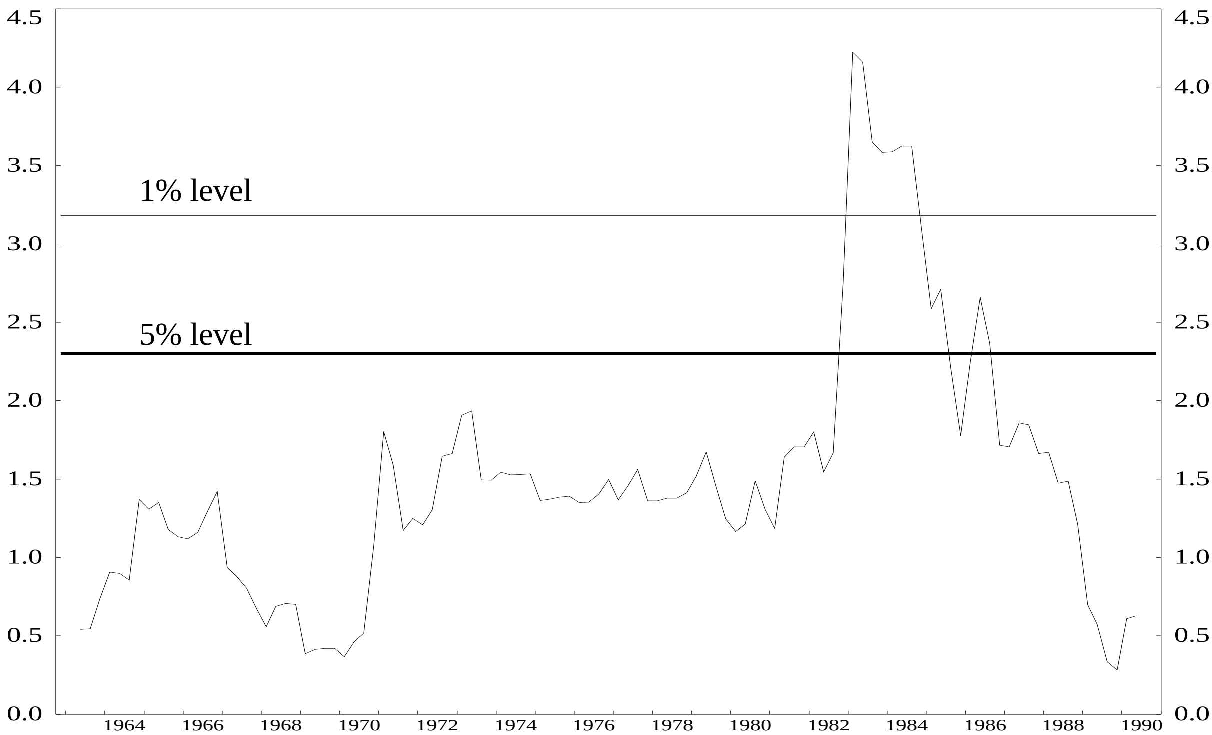
$$G4Y_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \alpha_2 M4ARR90_{t-4} + \varepsilon_t$$



_______ = F-stats

Figure 5: Rolling Chow test for detrended real output growth (G4YC)

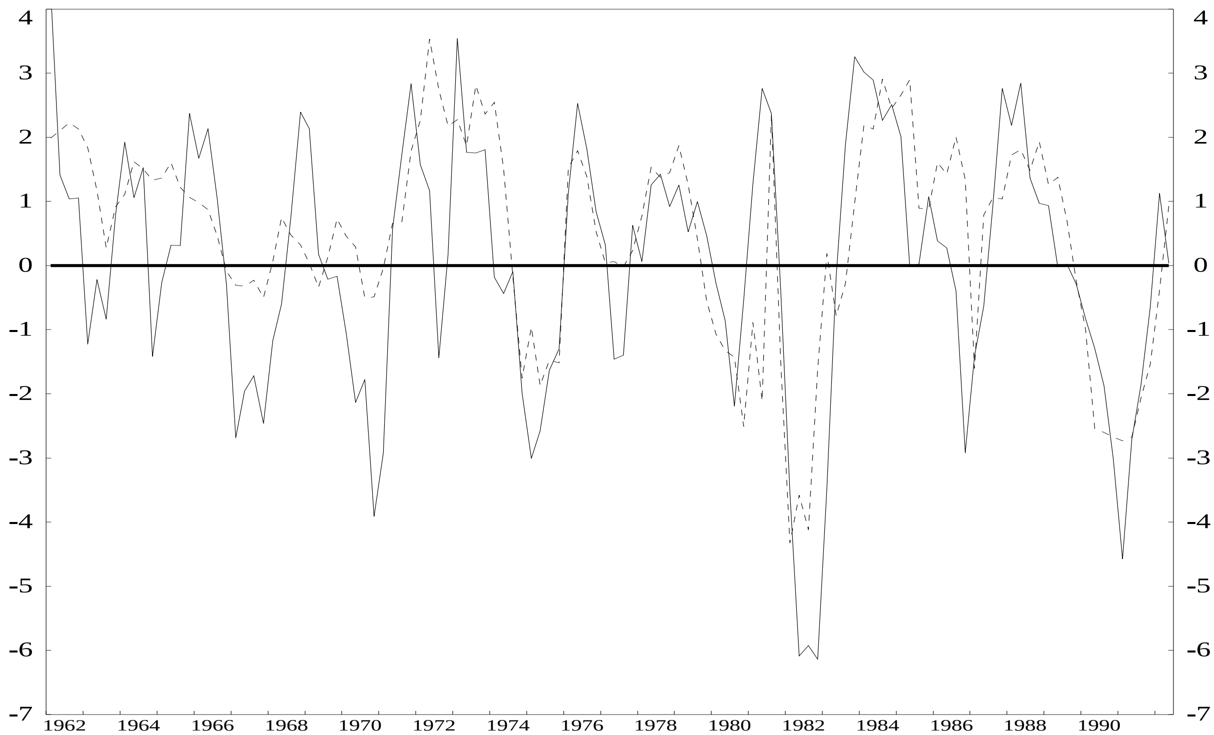
$$G4YC_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \alpha_2 M4ARR90_{t-4} + \alpha_3 G4RTSE_{t-4} + \alpha_4 G4YC_{t-4} + \varepsilon_t$$



______ = F-stats

Figure 6: Detrended four-quarter real output growth and lagged S10M30

(1962:1 to 1992:2)



——— = G4YC

--------- = $S10M30_{t-4}$

Figure 7: Actual and fitted detrended output growth (augmented model)

(1962:1 to 1992:2)

$$G4YC_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \alpha_2 M4ARR90_{t-4} + \alpha_3 G4RTSE_{t-4} + \alpha_4 G4YC_{t-4} + \varepsilon_t$$

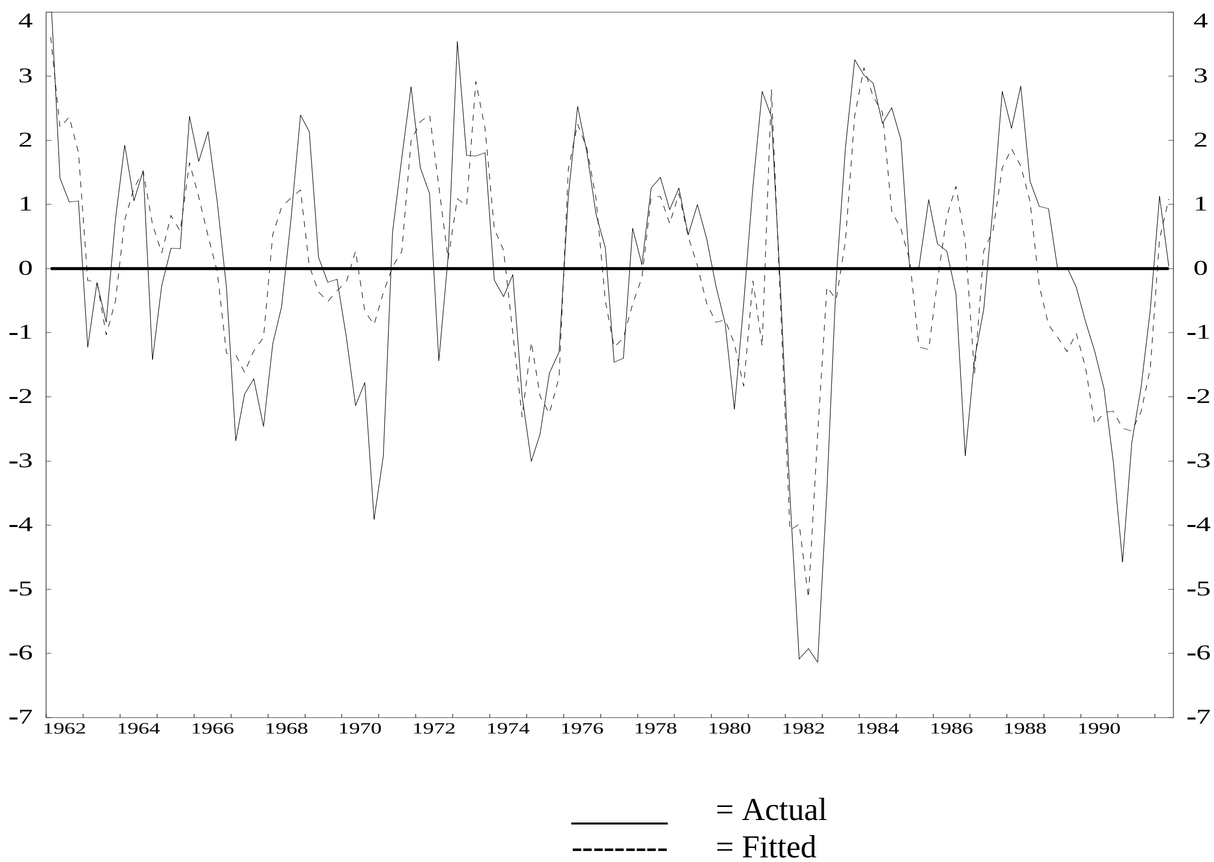
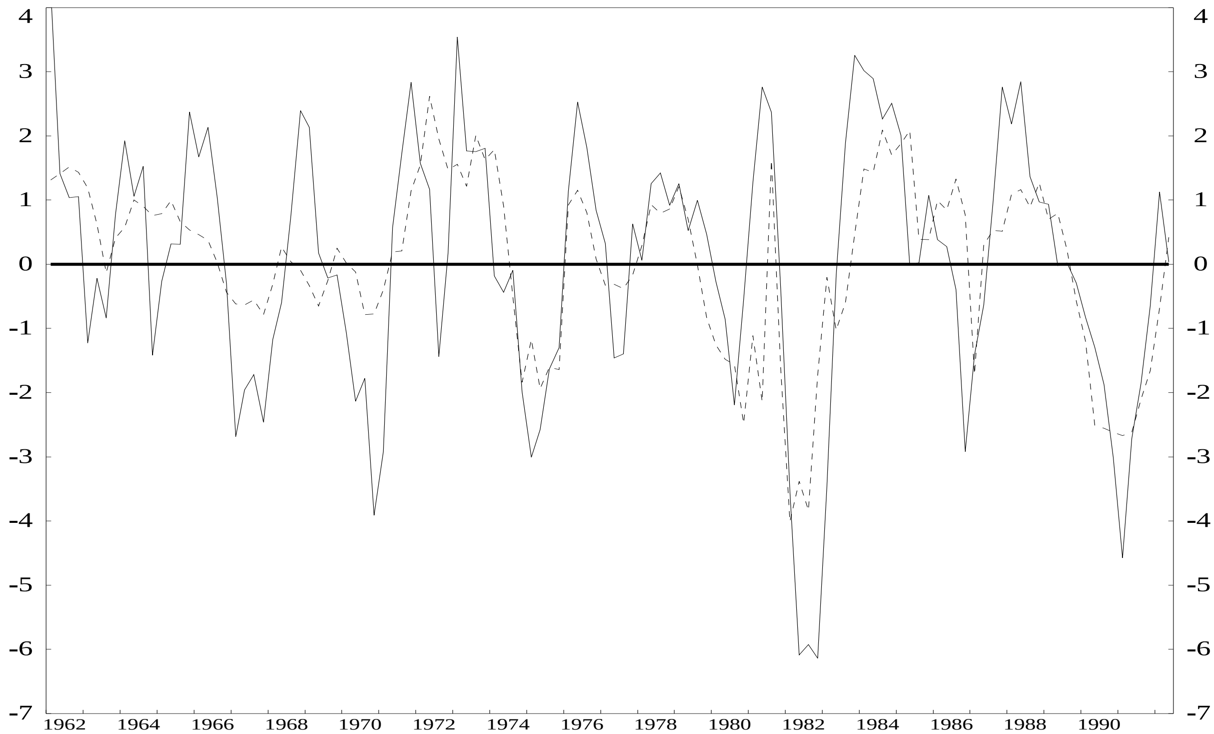


Figure 8: Actual and fitted detrended output growth (simple model)

(1962:1 to 1992:2)

$$G4YC_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \varepsilon_t$$

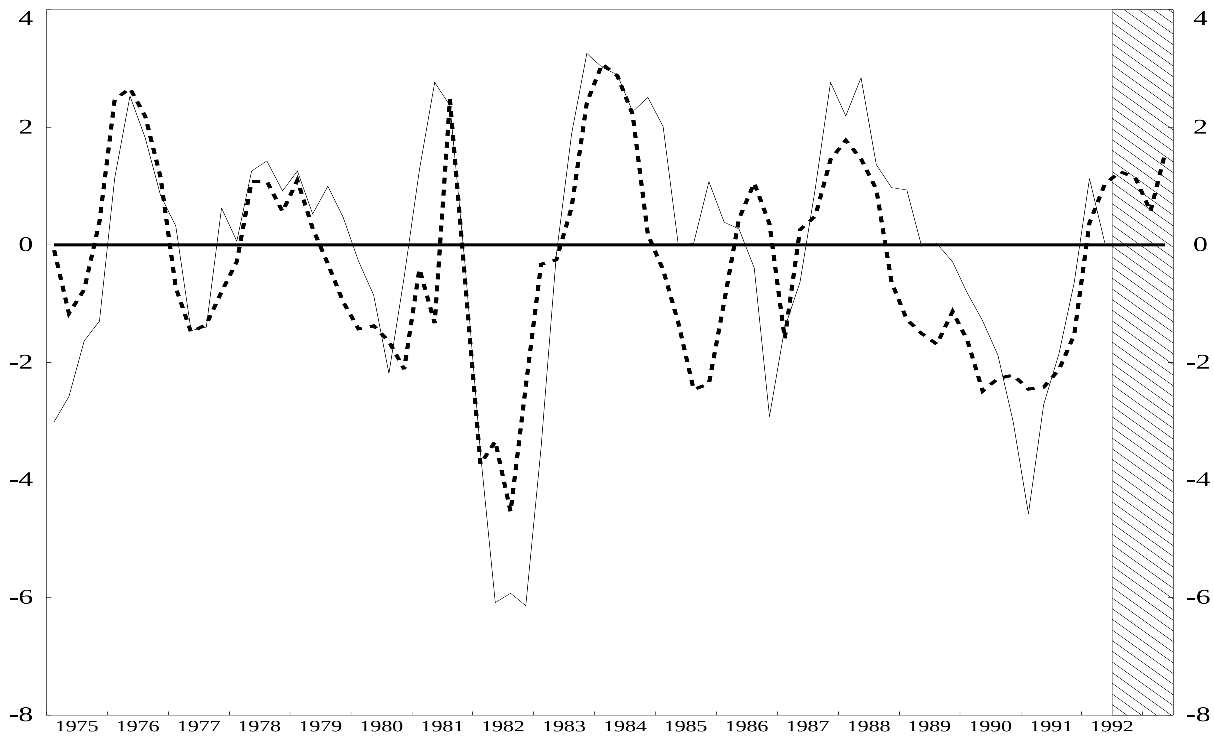


______ = Actual

--------- = Fitted

Figure 9: Out-of-sample forecasts for detrended real output growth (G4YC)
(Forecasts: 1975:1 to 1993:2)

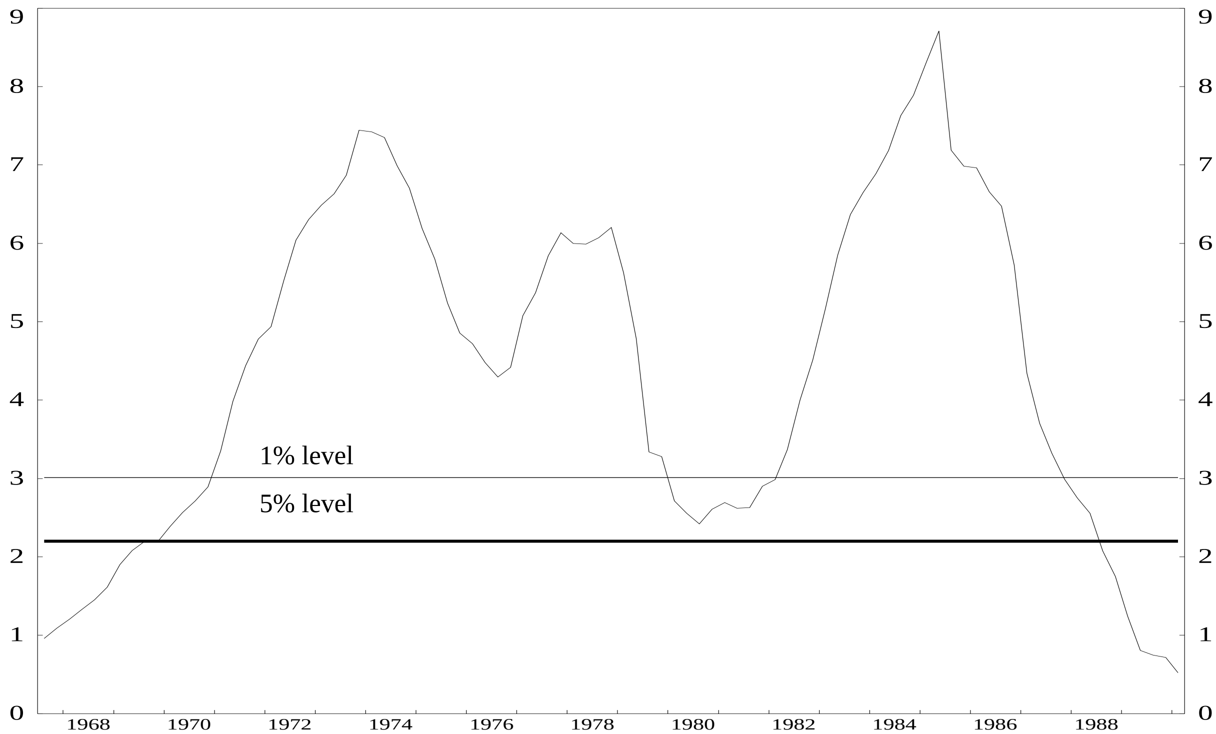
$$G4YC_t = \alpha_0 + \alpha_1 S10M30_{t-4} + \alpha_2 M4ARR90_{t-4} + \alpha_3 G4RTSE_{t-4} + \alpha_4 G4YC_{t-4} + \varepsilon_t$$



————	= Actual
---------	= Forecasts using spread-based model
\\\\\\\\\\\\\\\\\\\\\\	= Forecasts: 1992:3 to 1993:2

Figure 10: Rolling Chow test for G20PC

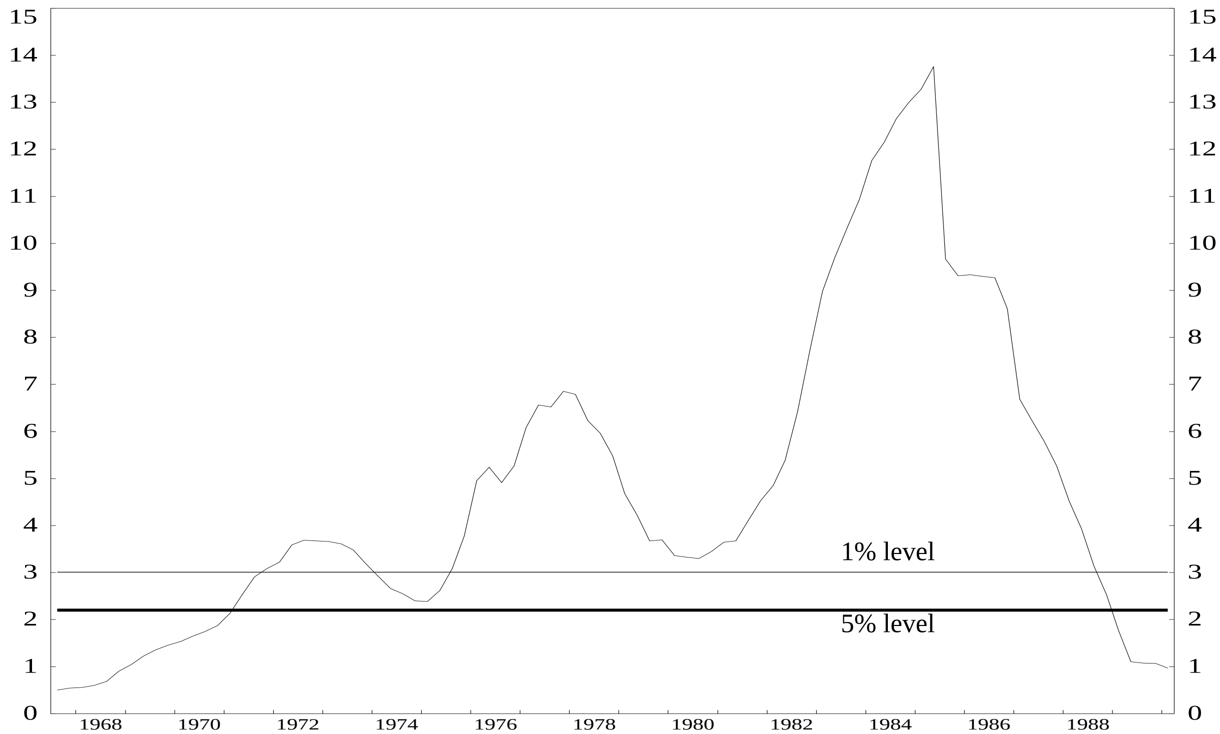
$$G20PC = \alpha_0 + \alpha_1 S10M30_{t-20} + \alpha_2 G1PC_{t-20} + \alpha_3 G1PC_{t-21} + \alpha_4 G1PC_{t-22} + \alpha_5 YGAPT_{t-20} + \varepsilon_t$$



______= F-stats

Figure 11: Rolling Chow test for G20P

$$G20P = \alpha_0 + \alpha_1 S10M30_{t-20} + \alpha_2 G1P_{t-20} + \alpha_3 G1P_{t-21} + \alpha_4 G1P_{t-22} + \alpha_5 YGAPT_{t-20} + \varepsilon_t$$



______= F-stats

Notes to the tables and figures

Values in parentheses below estimated coefficients are the Newey and West (1987) standard errors corrected for serial correlation.

The graphs report actual observations up to the most recent quarter for which complete data is available, 1992:2. Forecasts are extended to 1993:2 in the graphs using these most recent observations, although the forecasts beyond 1991:4 are not included in the out-of-sample performance statistics presented in the tables.

Abbreviations used in tables:

SEE	standard error of estimate
RMSE	root mean square error
MAE	mean absolute error
ME	mean error

Data appendix

The numerical results reported in this paper were generated using quarterly data from 1961:1 to 1991:4. Series with monthly observations were converted to quarterly data by taking the mean of the monthly observations for a given quarter. Unless otherwise indicated, monthly interest rate data are on an average-of-Wednesday basis. Quarterly national accounts series are seasonally adjusted at annual rates in 1986 dollars. CANSIM databank identification numbers are in parentheses.

Series with monthly observations:

R90	90-day commercial paper rate (B14017)
R30	30-day commercial paper rate (B14039)
RCALL	Call loan rate (daily average). (B14044)
RG10Y	Average yields of 10-year-plus Government of Canada marketable bonds (B14013)
RG1T3Y	Average yields of 1- to 3-year Government of Canada marketable bonds (B14009)
RG3T5Y	Average yields of 3- to 5-year Government of Canada marketable bonds (B14010)
T90	90-day treasury bill rate, average yield of Thursday auction (B14007)
R90US	90-day commercial paper rate, United States (daily average) (ETS: cp.usa.90d.cy.oper, daily observations)
R30US	30-day commercial paper rate, United States (daily average) (ETS: cp.usa.30d.cy.oper, daily observations)
R10US	Yield on 10-year U.S. government bonds (ETS: m.rmgfcm@10ns)
TSE	Toronto Stock Exchange 300 composite index, end-of-month close (B4237)
M1	Monetary aggregate M1, seasonally adjusted (B1627)
P	GDP deflator, seasonally adjusted, 1986=100 (D20556)
PC	Consumer price index, seasonally adjusted, 1986=100 (P484549)

<u>Series with quarterly observations:</u>

Y	Total output (D20463)
C	Total consumption (D20488)
CD	Durable consumption (D20489)
CND	Non-durable consumption (D20498)
IBUS	Business investment: non-residential construction (D20470) + machinery and equipment expenditures (D20471)
IRC	Investment in residential construction (D20469)
G	Government expenditures: Current expenditures (D20465) + gross fixed capital investment (D20466)
EX	Exports of goods and services (D20476)
IM	Imports of goods and services (D20480)

<u>Computation of spread variables:</u>

S10M90 = *RG10Y - R90*

S10M30 = *RG10Y - R30*

S10MC = *RG10Y - RCALL*

S10M1T3 = *RG10Y - RG1T3Y*

S10M3T5 = *RG10Y - RG3T5Y*

S1T3M90 = *RG1T3Y - R90*

S1T3M30 = *RG1T3Y - R30*

S1T3MC = *RG1T3Y - RCALL*

S3T5M90 = *RG3T5Y - R90*

S3T5M30 = *RG3T5Y - R30*

S3T5MC = *RG3T5Y - RCALL*

S10MT90 = *RG10Y* - *T90*

S90M30 = *R90* - *R30*

S10M90US = *R10US* - *R90US*

S10M30US = *R10US* - *R30US*

Deflated variables:

RTSE = *TSE* / *PC*

RM1 = *M1* / *PC*

Detrended variable:

YGAPT = 100 * (*LY* - *LYTREND*)

Where:

LY = log of output

LYTREND = log of the Hodrick-Prescott trend of output

Computation of growth variables:

$$GkX_t = \left(\frac{400}{k}\right) \times \log\left(\frac{X_t}{X_{t-k}}\right)$$

where:

k = quarter (1, 2, 3, 4, 6, 8, 12, 16 and 20)

X_t and X_{t-k} = Levels of variables *Y, C, CD, CND, IBUS, EX, IM, G, PC, P, RTSE, RM1* and *LYTREND* at time *t* and *t* - *k* respectively

GkX_t = *k*-quarter growth rate of variable *X* at time *t*.

Additional variables:

RR90 = *R90* - *G4PC*

M4ARR90 = $(RR90_t + RR90_{t-1} + RR90_{t-2} + RR90_{t-3}) / 4$

GkYC = *GkY* - *GkLYTREND*

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