

The term structure of interest rates and the conduct of monetary policy in Canada

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Introduction

The aim of this paper is to put into perspective the empirical results obtained at the Bank of Canada and elsewhere with regard to the information content of the term structure of interest rates, and to describe how this information is currently used in the conduct of monetary policy in Canada.

There are three main reasons for central banks' interest in financial asset prices. First, since monetary policy influences the economy through the financial markets, the central banks wish to understand the role played by the prices of different financial assets in the monetary policy transmission mechanism. Secondly, financial asset prices may contain useful information for the conduct of monetary policy, irrespective of whether they play an important role in the transmission mechanism. This is because such data may contain more up-to-date information on the economic situation than that otherwise available to the central bank. Moreover, they reflect the expectations of market participants with respect to future economic developments. Since expectations are derived from market transactions, they are often considered to be more representative than the figures obtained from surveys. Finally, changes in financial asset prices can signal market imbalances, which may spill over into the real economy and thus have consequences for monetary policy.

Unfortunately, certain financial data have only been available in Canada for a few years and the markets on which these securities are traded are extremely narrow. This is the case for inflation-indexed bonds and short-term interest rate options. On the other hand, the data making up the term structure of interest rates are readily available and, generally, of good quality. It is partly for this reason that this study is confined to the information content of the term structure. Furthermore, it is a source of information which has been the subject of numerous studies using Canadian data and which has proved to be one of the most conclusive. The existence of a close correlation between the yield curve spread and economic activity raises questions concerning the monetary policy transmission mechanism. This will be the topic of the next section. In Section 2, we examine the way in which the information in the term structure is used at the Bank as part of simple indicator models for real output, inflation and market expectations with regard to future interest rates. Given that the expectations hypothesis of the term structure (EH) plays a dominant role in the analysis of the monetary policy transmission mechanism, Section 3 tests this hypothesis. We then examine the possibility that the presence of a risk premium on internationally-traded Canadian securities, as a result of Canada's high level of indebtedness, partly explains the variability of the term premium and the fairly frequent statistical rejection of the EH. Section 4 describes our main avenues of research.

1. The role of the term structure of interest rates in the monetary policy transmission mechanism

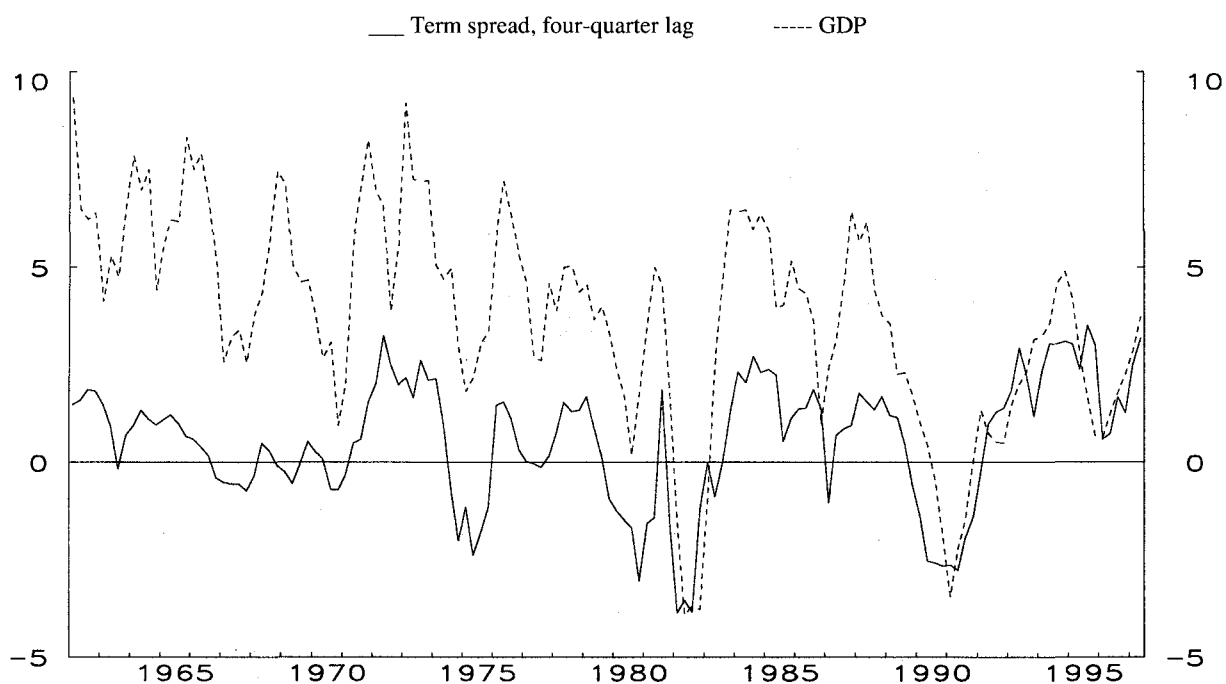
In this section, we review the various hypotheses proposed in the literature to explain the correlation observed between the yield curve spread (for short, the yield spread) and economic activity. We also discuss the empirical results obtained at the Bank, which led the researchers to choose the yield spread as the key monetary variable in the Quarterly Projection Model (QPM).

1.1 Background

Over the last few years, research carried out both at the Bank of Canada and elsewhere has revealed the existence of a strong positive correlation between the yield spread and the subsequent growth of economic activity (Graph 1).¹ In itself, this correlation is not very surprising: according to the traditional model of monetary policy transmission, the central bank affects economic activity through real interest rates. The central bank influences monetary conditions by modifying the amount of liquidity in circulation in the banking system, which has an immediate impact on nominal and real very short-term interest rates. The movements in these rates in turn affect the whole interest rate spectrum and the exchange rate, depending on lenders' and borrowers' expectations with regard to subsequent changes in rates. Since the expectation formation process is a complex one, the response of real long rates cannot be determined a priori, but one would expect it to be smaller than that of short rates since monetary policy measures can have only a temporary effect on real interest rates. In the long run, real interest rates are chiefly determined by expectations as to the productivity of capital and the underlying forces affecting saving globally. In fact, for a small open economy like Canada, world real interest rates provide a stable anchor for domestic real rates.

Graph 1

Lagged yield spread and four-quarter growth rate of real GDP



Thus, the correlation observed between the yield spread and real economic activity could quite simply reflect the endogenous response of these two variables to monetary policy actions. For example, a monetary tightening leads to a narrowing of the yield spread, followed a few quarters later by an economic slowdown. Conversely, a monetary easing results in a widening of the yield spread and faster growth.

¹ See, in particular, Laurent (1988), Cozier and Tkacz (1994), Estrella and Hardouvelis (1991), Hu (1993), Plosser and Rouwenhorst (1994), Estrella and Mishkin (1995, 1997), Haubrich and Dombrosky (1996), Harvey (1997) and Dueker (1997).

What appears less compatible with the traditional point of view is the size of the correlation observed between these two variables and the fact that the yield spread appears to be better than other monetary policy indicators - especially the real interest rate - at forecasting the growth of real economic activity. As Table 1 shows, certain yield spreads are capable, on their own, of explaining approximately 65% of the variance of the future rate of growth (four quarters) of Canadian real GDP in the period 1972-90. The explanatory power of both the level of and changes in short-term interest rates, whether nominal or real, is substantially lower over the same period.

Table 1

**Comparison of different interest rate variables in an indicator model of real GDP
for the period 1972Q1-1990Q4**

$$G4Y_t = a + b(R)_{t-4}$$

<i>R</i>	<i>b</i>	\bar{R}^2
(1-3 years) – 90 days	1.6 (4.3)	0.38
(3-5 years) – 90 days	1.5 (5.5)	0.50
(5-10 years) – 90 days	1.4 (6.8)	0.58
(10 years+) – 90 days	1.3 (7.9)	0.64
(3-5 years) – (1-3 years)	6.2 (6.7)	0.58
(5-10 years) – (1-3 years)	3.6 (8.5)	0.66
(10 years) – (1-3 years)	2.7 (8.0)	0.66
(5-10 years) - (3-5 years)	7.1 (8.4)	0.62
(+10 years) - (3-5 years)	3.9 (6.7)	0.60
(+10 years) - (5-10 years)	6.0 (3.5)	0.40
4Q moving average (1-day rate)	-0.5 (3.2)	0.31
4Q moving average (real 90-day rate)	-0.3 (2.4)	0.16
Δ_4 4Q moving average (1-day rate)	-0.8 (4.6)	0.38
Δ_4 4Q moving average (real 90-day rate)	-0.7 (3.1)	0.26

Notes: *t*-statistics in parenthesis. $G4Y_t$ = rate of growth of real GDP over four quarters in period *t*. Δ_4 = four-quarter difference operator. 90-day rate refers to commercial paper; other rates correspond to Canadian government bond rates; real 90-day rate is calculated as the nominal rate less the change in the GDP deflator.

According to the traditional point of view, the more closely the path of long rates tracks that of short rates, the greater will be the impact of the initial change of the latter on economic activity. The fact that the yield spread is the best advance indicator of output could be interpreted as signifying the opposite, a result which is obviously not compatible with economic theory and which has prompted researchers to suggest other explanations.

1.2 Suggested explanations

In order to examine the hypotheses put forward in the literature to explain the correlation observed between the yield spread and economic activity, we use the analytical framework of Cozier and Tkacz (1994). It is based on three key hypotheses, which are represented by the following equations:

$$i_t = r_t + E_t \pi_{t+1} \quad (1)$$

$$i_t^k = \frac{1}{k} \sum_{i=0}^{k-1} E_t i_{t+i} + \rho_t^k \quad (2)$$

$$r_t = r^* - l_t \quad (3)$$

where

- i = nominal short interest rate (one period)
- r = real interest rate
- E_t = expected value on the basis of the information available at time t
- π = inflation rate
- i_t^k = nominal long interest rate (k periods)
- ρ_t^k = term premium
- r^* = equilibrium real interest rate
- l = liquidity effect of monetary policy

Equation (1) corresponds to the Fisher relationship, which assumes that the nominal interest rate is equal to the sum of the real interest rate and the expected inflation rate. Equation (2) represents the expectations hypothesis of the term structure, according to which the yield on a long-term bond is a weighted average of the expected short rates plus a term premium. Finally, equation (3) states that the real interest rate is made up of two components: the equilibrium real rate, which reflects market forces, and the “disequilibrium” rate, which reflects monetary policy shocks, commonly referred to as the liquidity effect. From these three equations, we can derive the following expression for the yield spread:

$$i_t^k - i_t = \left[\gamma l_t - \frac{1}{k} E_t \sum_{i=1}^{k-1} l_{t+i} \right] - \left[\gamma r^* - \frac{1}{k} E_t \sum_{i=1}^{k-1} r^*_{t+i} \right] - \left[\gamma E_t \pi_{t+1} - \frac{1}{k} E_t \sum_{i=1}^{k-1} \pi_{t+1+i} \right] + \rho_t^k \quad (4)$$

where $\gamma = (k - 1)/k$.

Equation (4) shows that the yield spread comprises four elements: the liquidity effect of monetary policy via expectations; expectations about changes in the equilibrium real interest rate; expectations concerning future inflation; and the term premium. The fact that the yield spread is negative at cyclical peaks and high and positive during the troughs may therefore reflect one or other of the following factors: countercyclical monetary policy; the cyclical development of the demand for credit, of the return on capital and thus of the equilibrium real interest rate; and the cyclical pattern of inflation, which tends to fall during recessions and rise during periods of expansion.

In order for the yield spread to reflect mainly the monetary policy stance and *bring about* fluctuations in economic activity, its variability must be dominated by liquidity effects. This will be the case if the changes in the equilibrium real rate are either weak or show a high degree of persistence, if inflation expectations show a high degree of persistence and if the term premium is relatively stable over time or is influenced by the liquidity effect. As suggested by Laurent (1988), the yield spread may be a better indicator of monetary policy than the level of interest rates if it allows the monetary component of interest rate changes to be isolated. For this to happen, monetary policy would have to exert a fairly large influence on real short-term interest rates but a relatively small one on real long-term interest rates, which, for their part, would more accurately reflect market equilibrium forces.

On the other hand, certain economists, notably Hu (1993) and Harvey (1997), maintain that the correlation between the yield spread and future output reflects the endogenous response of the

term structure of real interest rates to the forecast evolution of economic activity, as predicted by the Capital Asset Pricing Model (CAPM). This model is based on the hypothesis that individuals are risk-averse and try to smooth their consumption over time. If they expect a recession, they will lengthen the term of their investments in order to secure a certain revenue during this period. This substitution of short-term securities with longer-term ones will bring down the price of the former and raise the price of the latter. Thus, the yield curve flattens or is inverted before the economy slows down. Harvey maintains that the same type of reasoning can be applied to the behaviour of firms. If they foresee an economic downturn, they will cut back their long-term investment projects and, as they try to balance the maturity structure of project loans, the supply of long-term securities will fall, which will also lead to an increase in their price and a flattening of the yield curve.

1.3 Empirical results

The three factors mentioned above can all contribute to the predictive power of the yield spread and, in practice, it is not easy to determine which of them is dominant, since expectation variables and equilibrium real rates are not directly observable and all the interest rates are strongly correlated amongst themselves. Estrella and Hardouvelis (1991) and Plosser and Rouwenhorst (1994) conclude that while monetary policy does have a role to play in the predictive power of the yield spread, other factors are important as well. This is because the yield spread remains significant in indicator models which that additional variables to represent monetary policy, such as the level of interest rates or the growth of a monetary aggregate.

At the Bank, we have a certain number of empirical results, which suggest that the predictive power of the yield spread chiefly reflects its role as an indicator of monetary policy:²

- the predictive power of the yield spread reaches a peak at a forecast horizon of around four to six quarters, which is fairly compatible with the traditional point of view on the length of the lags between monetary policy measures and real economic activity (Cozier and Tkacz (1994));
- among the components of aggregate demand, the yield spread forecasts consumption particularly well, and within this durable goods. Its link with investment is fairly weak over a one-year forecast horizon, but strengthens when the horizon is extended. These results are also compatible with the traditional transmission model, according to which monetary policy affects first consumption spending and then, via the accelerator effect, investment. In addition, the effect of the yield spread on the consumption of non-durables is rather low, which does not appear to be consistent with forecasts obtained using the CAPM (Cozier and Tkacz (1994));
- historically, the yield spread has proved on average to be a better advance indicator of output than of inflation, which suggests that the movements in the yield spread capture changes in real rates better than those in inflation expectations; moreover, for predicting inflation, the yield spread's maximum explanatory power is reached at a longer forecast horizon than for predicting real output. This is consistent with the chain of causality which runs from the yield spread to real economic activity and, finally, to inflation (Cozier and Tkacz (1994) and Day and Lange (1997)).

Furthermore, we have some results, which allow us to conclude that the yield spread may have been a better indicator of monetary policy than the traditional direct measures of the real interest rate:

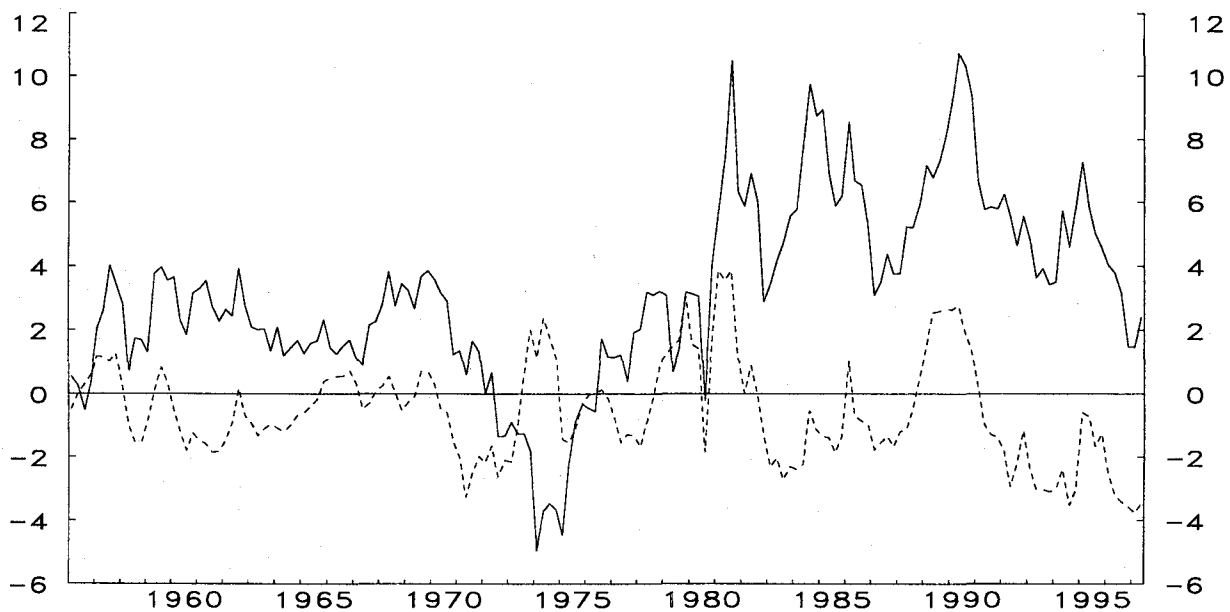
² Certain observers sometimes wrongly think that the monetary conditions index (MCI) is used by the Bank as an indicator of monetary policy. In fact, the MCI is used as an operating target, the equivalent of the short-term interest rate at other central banks. As an indicator of monetary policy, the MCI suffers from the same shortcomings as the level of interest rates, since the values for the interest rate and the exchange rate which ensure a balance between supply and demand are not constant over time.

- historically, Canada's real short-term interest rate deviates from its average long-term value for prolonged periods (Graph 2), whereas the yield spread tends to return to its average value, as might be expected if it reflects the temporary effects of monetary factors (Clinton (1994-95));³
- the yield spread appears to partly solve the problem related to the use of traditional measures based on retrospective inflation expectations. The best example is that of the mid-1970s, where it seems improbable that ex ante real rates were so strongly negative;
- the yield spread gives better results than the real interest rate in an aggregated household consumption model, and provides good results for identifying monetary shocks in VAR models (Macklem (1995b) and Macklem, Paquet and Phaneuf (1996)).

Graph 2

Real short-term interest rate and spread between short and long rates

— Real short-term interest rate (90-day commercial paper rate minus year-on-year growth rate of GDP deflator)
 ---- 90-day commercial paper rate minus 10yr+ government bond rate



Based on these observations, the yield spread was chosen as the key monetary variable in QPM.⁴ As well as isolating the monetary component of the changes in interest rates, the yield spread can serve as a guide with regard to the vigour with which short rates need to be raised in order to control the inflationary consequences of a shock. For example, a positive demand shock will provoke a rise in expected future real interest rates, and possibly in expected inflation. The extent to which long rates increase can thus provide information on the markets' perception of the authorities' determination to control inflation shocks.

³ It should be noted, however, that the formal tests do not allow us to reject that the yield spread is non-stationary (see Section 3).

⁴ In QPM, this variable is used to capture the impact of interest rates on "consumption", which includes household consumption as defined in the national accounts, residential construction spending and changes in stocks. Obviously, the exchange rate also plays an important role in the model. See Coletti et al. (1996) for a description of the model.

1.4 Implications for the transmission mechanism

The fact that the yield spread is statistically superior to other interest rate measures suggests that monetary policy has little effect on real long-term rates, which would appear to be confirmed by the estimation results of Clinton and Zelmer (1997). Using a small-scale VAR, they find that short-term interest rate shocks brought about by Canadian monetary policy have very weak, indeed insignificant, effects on Canadian long rates.⁵ However, economists generally maintain that it is long rates that most affect spending by households, given the structure of their balance sheets.⁶ How, therefore, can one reconcile the above estimation results, which accord a major role to monetary policy in the explanation of economic fluctuations, with the negligible effect of monetary policy on long interest rates?

Table 2
VAR model results
 August 1972 - December 1996

Terms for RL	Maximum response of RL to a 100 b.p. innovation of R90	Probability Σ coefficient (R90 - R90US) = 0
1 year	0.56	0.00
2 years	0.42	0.00
3 years	0.32	0.00
5 years	0.24	0.00
10 years	0.20	0.00
Long term	0.08	0.19

Note: The model is based on 90-day (R90) and long-term (RL) interest rate differentials between Canada and the United States.

Two factors are important in this regard. First, monetary policy influences household spending through various channels, notably via intertemporal substitution effects. This effect is independent of the balance-sheet structure. For example, if real short rates rise in relation to expected future rates (the yield spread narrows), this tends to dampen the demand for credit and delay consumption spending. Secondly, even if monetary policy has no major influence on long-term rates, its impact on medium-term rates is nevertheless substantial. A study by Montplaisir (1996-97) shows that contracts at three and five years currently account for the majority of households' financial liabilities. The rates associated with these maturities are therefore most likely to influence that sector's liquidity constraints and, when re-estimating the Clinton and Zelmer model, a shock to Canadian short-term rates has a significant effect on the rates for three and five-year bonds (Table 2).⁷ Monetary policy may therefore also exert considerable cash-flow effects.

⁵ These results must not be interpreted as signifying the existence of a weak correlation between the Canadian short and long rates. The tests presented in Section 3 in fact reveal an extremely close correlation between these rates. What the VAR indicates is simply that the independent effects of Canadian monetary policy on Canadian long rates are very weak.

⁶ The same could be said of firms' spending. However, it has always been very difficult to estimate significant interest rate effects for firms.

⁷ It is interesting to note that the results of the VAR indicate that the effects of a monetary policy shock on implied one-year forward rates are greater than might have been expected if the expectations hypothesis of the term structure of

1.5 Unanswered questions

Although we selected the yield spread for the projection model, questions remain as to its predictive power. More research is needed to develop a more solid theory to explain the cause-and-effect relationships at work. Certain results in particular raise questions:

- the yield spread fails to predict the growth of a particular spending category as precisely as the growth of global spending. Since monetary policy directly affects households' expenditure on durable goods, one would expect the yield spread to be able to forecast this more precisely than aggregate spending (Cozier and Tkacz (1994));
- over the period 1972-90, the predictive power of the spread between medium-term rates is just as high as that of the spread between short and long rates in the indicator models for the growth of real GDP (Table 1). One might expect, however, that the latter spread would yield better results as an indicator of monetary policy, since the short rate is controlled more closely by the Bank, while the long rate should represent the equilibrium rate better.

In addition, over the last few years, the indicator models based on the yield curve have substantially overpredicted the growth of economic activity. Since other economic models have also overpredicted growth, it is too early to tell whether these errors are symptomatic of a break in the relationship between the yield spread and economic activity. Can the move to low inflation and lower interest rates worldwide have affected the predictive power of the yield spread? Does this power vary according to the monetary policy stance? It is interesting to note that, in research aimed at testing the asymmetry effects of monetary policy, the conclusions vary depending on whether or not the yield spread is used as a measure of monetary policy. Using the spread, the results are more favourable to the asymmetry hypothesis.⁸ It has yet to be demonstrated whether these results really do reflect the asymmetry in the effects of monetary policy, or whether they instead capture the asymmetry in the determination of long rates.⁹

According to Clinton and Zelmer (1997), one possible explanation for the forecast errors of the yield spread is the increase in the risk premium on Canadian long-term securities during the 1990s. When they include a variable in the indicator model to capture this risk premium, it has the expected sign and is significant, although it should be noted that this addition improves the forecasts obtained only slightly. At this stage of our research, however, we are not able to say whether this results from the fact that the variations in the term premium are not very important in explaining the forecast errors, or whether it simply reflects the difficulty in measuring this term premium precisely. Work is currently under way to improve our understanding of the determinants of the term premium and we will return to this topic in Section 3.¹⁰

2. The indicator role of the term structure of interest rates

In this section, we briefly examine how the information content of the term structure of interest rates is used by the Bank, from both a strategic and a tactical point of view.

interest rates had been confirmed. These results are compatible with Shiller's hypothesis of the overreaction of long-term rates, or they may indicate that the liquidity effect influences the term premia.

⁸ See, in particular, Macklem (1995a) and Macklem, Paquet and Phaneuf (1996).

⁹ Remolona, Dziwura and Pedreza (1995) maintain, for example, that long-term rates contain more information when agents expect a tightening of monetary policy than when they expect an easing. In the first case, the changes in short rates dominate those in long rates, whereas, in the second case, the movements in the term premium are predominant.

¹⁰ In the context of the projection, adjustments are made to the equilibrium values for the yield spread in order to capture the variations in the term premium. This allows us to cancel out their effects in the model.

2.1 Real economic activity and inflation

Since monetary policy in Canada is oriented towards the achievement of inflation targets, the staff's economic projection and the constant monitoring of economic developments using different indicator variables are of prime importance. At the Bank, projections are made using a formal model, QPM. In addition, we have for some years been using indicator models based on financial variables in order to obtain alternative short-term forecasts of the path of real GDP and inflation. However, since monetary policy measures are aimed at influencing the inflation rate approximately six to eight quarters ahead, recent work on the indicator models has attempted chiefly to develop models with a forecast horizon of this length, with the purpose of cross-checking the projections made using QPM and thereby rapidly detecting potential errors.

As noted in the previous section, the research at the Bank has allowed us to conclude that the yield spread has, in the past, been an excellent advance indicator of real output growth. Its predictive power remains high even over a horizon of eight quarters, which makes it a particularly attractive indicator.¹¹ Since the indicator models have systematically overpredicted during the last few years, they have not played a front-line role in the conduct of monetary policy. We are continuing our research in order to improve our understanding of the source of these errors.

We also examined the relative performance of different financial variables in probit models aimed at determining the probability of a recession. The interest in this type of model lies, among other things, in the fact that it avoids the problem of illusory precision associated with point estimates. It is also possible that the yield spread is better at forecasting major variations in output growth, such as recessions. In studies currently under way, Atta-Mensah and Tkacz (1997) conclude that, among the indicators examined, the yield spread (from bonds at ten years and above to those at 90 days) is the best for forecasting recessions over a horizon of one to five quarters. It outperforms, *inter alia*, various measures of the level of nominal and real interest rates as well as equity indices and the monetary aggregate M1. The results of this model for a forecast horizon of four quarters are shown in Graph 3. These results are fairly consistent with those obtained in the United States by Estrella and Mishkin (1995) and for the Group of Seven countries by Bernard and Gerlach (1996).

Since what ultimately interests the Bank is determining the size of inflationary pressures in advance, we also examined the relative efficiency of different financial variables in forecasting periods of overheating. If we arbitrarily define such periods as those in which the output gap exceeds 2%, very preliminary studies suggest that the equity index would be a better predictor of these periods than the yield spread, which appears to have a fairly low predictive power. It is, however, too early to draw firm conclusions from these results; in particular, we have to test their robustness by using other definitions of periods of overheating.

Finally, Day and Lange (1997) have evaluated the ability of the yield curve to forecast future changes in inflation in Canada. They conclude that the slope of the yield curve for maturities of one to five years is a relatively reliable indicator of the future path of inflation at these horizons and that it contains different information to other indicators, such as the broad money aggregate M2+ and the output gap.¹² Nevertheless, the authors stress that, in the short term, the yield curve can vary as a result of temporary changes in real interest rates or term premia. Only lasting changes in the yield curve will be associated with similar changes in future inflation. Their results show that the explanatory power of the yield curve has increased considerably since the mid-1980s, probably because there have been no major supply shocks during this period. However, forecasts have

¹¹ It is important to emphasise that, even if the yield spread is included in the projection model, it can also be used in indicator models since the projection model is much more complex and the results partly reflect expert judgement.

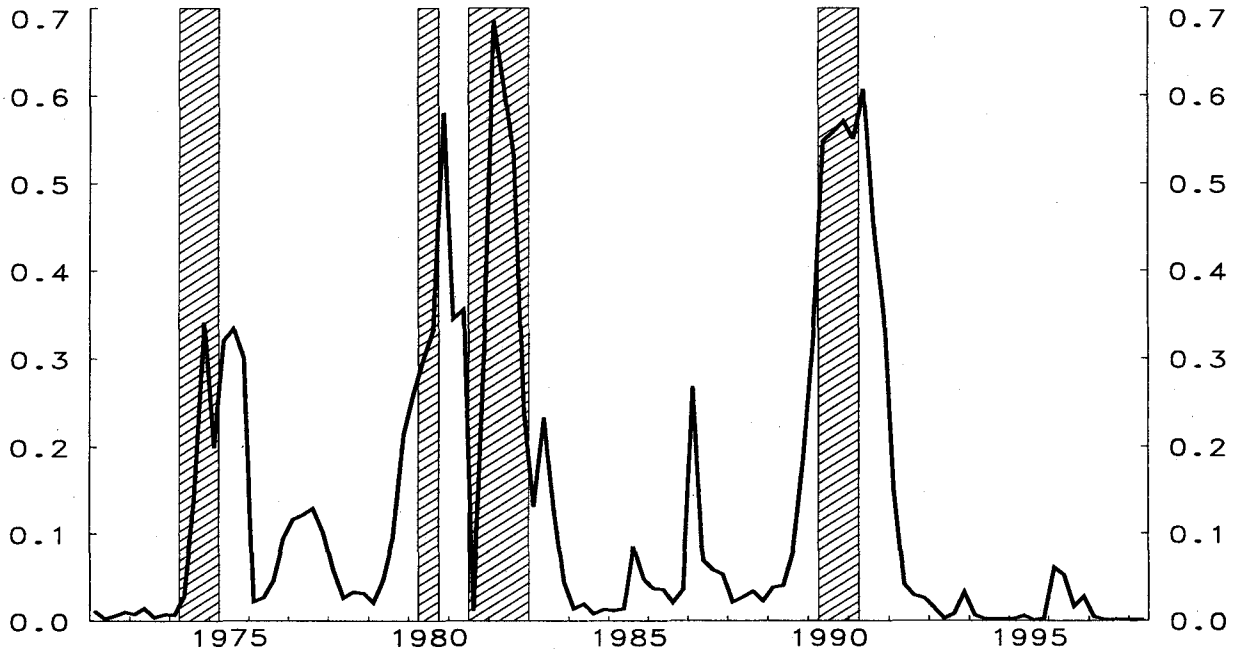
¹² The findings of Day and Lange are compatible with those of Mishkin (1990) for the United States and Gerlach (1995) for Germany. These last two authors conclude that the medium-term segment of the yield curve contains a great deal of information on future inflation.

deteriorated during the last few years, as can be seen from Graph 4. According to this model, inflation should accelerate by ½ to 1 percentage point from the end of 1998.

Graph 3

Four-quarter ahead probability of recession

Out-of-sample forecast using 10yr+ bond rate less 90-day CP rate

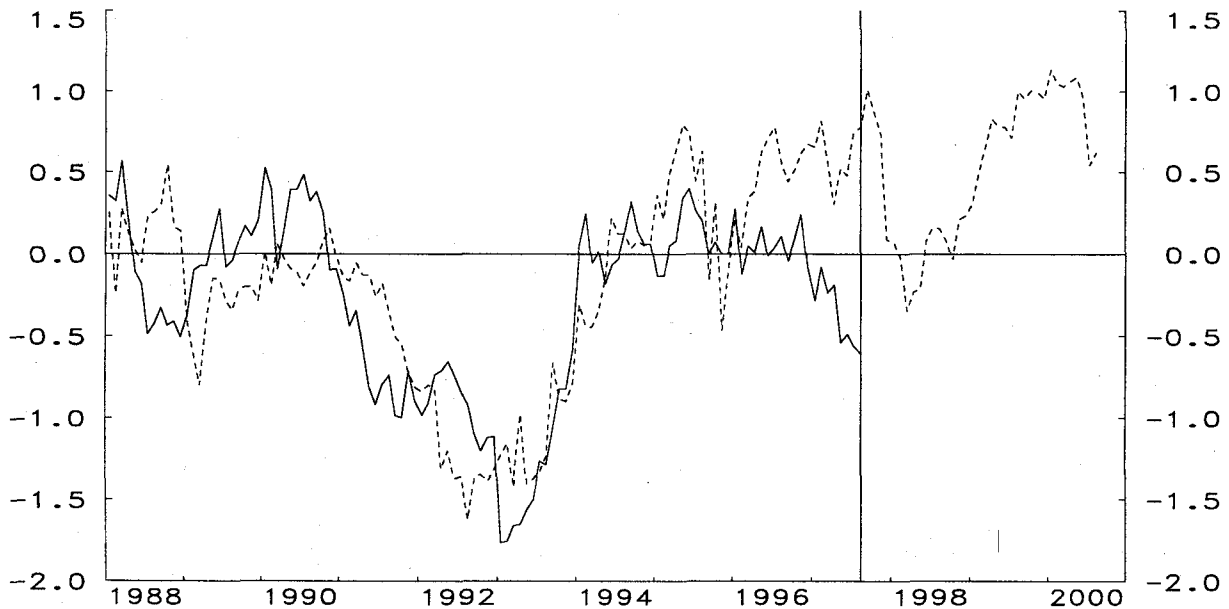


Graph 4

Change in actual and predicted inflation

Three-year minus one-year inflation

— Actual change in CPI excluding food, energy and effect of indirect taxes
 ---- Forecast using a model in which the term structure coefficient is restricted to equal 1



2.2 The expected level of monetary conditions

At the Bank we also use the short interest rate segment of the term structure to measure the financial markets' expectations with regard to future three-month interest rates. The process consists of calculating the expected profile of three-month rates on the basis of the interest rates corresponding to forward interest rate agreements maturing in four, six, nine and 12 months, from which we subtract a representative term premium which varies according to the maturity of the agreement. The term premia are calculated using the average value of interest rate spreads over a long period that excludes certain episodes of high interest rate variability. The term premia also contain a variable (zero-centred) component obtained by estimating the cointegrating vectors linking the three-month rates with each of the forward rate agreements.

Together with the expected measure of the Canadian dollar exchange rate obtained from forward contracts, the measure of interest rate expectations is compared with that resulting from the Bank staff's economic projection, with the aim of evaluating the forecast level of monetary conditions relative to that expected by the financial markets. This comparison can be useful to the monetary authorities in their tactical decisions as to the appropriate moment to change the official interest rate.¹³

3. Tests of the term structure of interest rates

As we saw in Section 1, the different interpretations which can be placed on the role of the term structure of interest rates in the monetary policy transmission process are based in part on the expectations hypothesis (EH) of the term structure of interest rates. In its most general form, the EH states that each long-term interest rate represents the average of current and expected short-term interest rates over the life of the long-term security, plus a relatively stable term premium. In this section, we review the work recently undertaken to verify this hypothesis using Canadian data. We also examine the possibility that the presence of a risk premium on Canadian securities in international markets, as a result of Canada's high level of indebtedness, partly explains the variability of the term premium and the statistical rejection of the EH.

3.1 Tests of the expectations hypothesis of the term structure of interest rates

A number of tests were carried out to verify the EH using Canadian data. We divide these tests into three main groups, aimed at verifying: (i) whether long-term interest rates are unbiased predictors of future short-term interest rates; (ii) whether the long-term interest rate forecasts calculated using a model in which the EH is imposed permit adequate explanation of the long-term interest rates observed in the markets; and (iii) whether there is a long-term common trend between short and long interest rates. The third type of test does not constitute a direct verification of the EH, but the presence of a long-term common trend between the interest rates, which are non-stationary variables, is a necessary condition for the EH.

The type (i) tests of the EH start with estimating the following equation:

$$\frac{1}{k} \left[\sum_{k=0}^{k-1} i_{t+k} \right] - i_t = \alpha + \beta (i_t^k - i_t) + v_t \quad (5)$$

¹³ For a discussion of tactical considerations, see Zelmer (1995).

To verify the EH, it is necessary to test the hypothesis $\beta = 1$; that is, that the spread between long and short rates is an unbiased predictor of the average of future short-term rates during the k periods to come, where k corresponds to the life of the long-term security.¹⁴ We can also test the EH using the interest rates on forward agreements instead of long spot rates. In this case, the estimated equation takes the form:

$$i_{t+k} - i_t = \alpha + \beta(i(k)_t - i_t) + v_t \quad (6)$$

where $i(k)$ is the short-term interest rate on a forward rate agreement starting in k periods.

Table 3
HASTI tests in the short-term interest rate segment

	β	Test: $\beta = 1$ (<i>p</i> -value)	Source; data
One-day average interest rate forecast using changes in:			
1-month rate	0.86	0.26	Stréliski (1997); 1992:11:23-1996:10:07
2-month rate	1.03	0.83	Stréliski (1997); 1992:11:23-1996:10:07
3-month rate	1.02	0.94	Stréliski (1997); 1992:11:23-1996:10:07
One-month average interest rate forecast using changes in:			
3-month rate	0.86	0.33	Gerlach, Smets (1997); 1979:3:12-1996:7:15
6-month rate	0.72	0.19	Gerlach, Smets (1997); 1979:3:12-1996:7:15
12-month rate	0.62	0.01	Gerlach, Smets (1997); 1979:3:12-1996:7:15
Three-month interest rate forecast using changes in:			
3-month futures rate (maturing in 6 months)	0.73	0.48	This paper; 1990:01:01-1997:07:07
3-month futures rate (maturing in 9 months)	0.95	0.84	This paper; 1990:01:01-1997:04:07
3-month futures rate (maturing in 12 months)	1.10	0.68	This paper; 1990:01:01-1997:01:06

The results of the type (i) tests sometimes favour the EH, but they apply only to the short end of the term structure, with a maturity of less than 12 months. As Table 3 shows, the results of Stréliski (1997) indicate that one, two and three-month rates are unbiased predictors of the average call-money rate during the coming 30, 60 or 90 days, with the β coefficients linking the short and long rates varying between 0.86 and 1.02 and not statistically different from unity. However, as Stréliski points out, these coefficients are not stable over time. The results of Gerlach and Smets (1997) show that three-month interest rates are fairly good predictors of average one-month rates over the subsequent three months. However, the ability of the six and twelve-month rates to predict one-month rates is fairly imprecise, with the β coefficients deviating further and further from unity. Finally, our results indicate that the rates of future agreements are unbiased predictors of three-month interest

¹⁴ It should be noted that the error term v_t is a moving average representation, the order of which depends on k and on the frequency of the data used. When testing the hypothesis $\beta = 1$, we must take this characteristic of the error term into account. The results presented use the Newey-West procedure, which corrects the variance-covariance matrix.

rates up to nine months in advance. However, like Strélski we found that the β coefficients are unstable over time. For example, simply adding the year 1989 to our base sample reduces the value of the β coefficients by approximately 0.4 points. This instability is perhaps a reflection of the fragility of the EH.¹⁵

The type (ii) tests were developed by Campbell and Shiller (1987) and applied to Canadian data, inter alia, by Hardouvelis (1994) and Gerlach (1996). According to this methodology, one must first estimate a VAR with two variables, namely the change in short-term interest rates and the spread between the long and short interest rates. The VAR is then used to forecast future short-term interest rates, and these forecasts serve to calculate the *theoretical* values of the long-term interest rates under the EH with a constant term premium. Finally, statistical tests are used to compare the theoretical values for long-term interest rates with their observed values. Overall, the results of Hardouvelis (1994) and Gerlach (1996) tend to support the EH with Canadian data. However, the authors admit that the tests of the EH are not very powerful. Indeed, using an alternative hypothesis under this methodology, Sutton (1997) obtains results which tend if anything to reject the EH.¹⁶

The type (iii) tests for common trends are, in the first instance, aimed at testing the hypothesis of cointegration between short and long-term interest rates, and then, if there is cointegration, testing for the presence of a common relation [1, -1] between these rates.¹⁷ In Table 4, we present the results of these tests applied to a large range of Canadian interest rate pairs, ranging from one and three-month rates to those at one, two, three, four, five and ten years.¹⁸ We use monthly data covering the period 1972-96. The tests are obtained from estimating VECMs (vector error correction models) according to the methodology proposed by Johansen (1988) and Johansen and Juselius (1990). It should, however, be noted that the majority of the equations estimated in the VECMs, and shown in Table 4, suffer from a fairly severe ARCH-type error heteroskedasticity problem. This means that the cointegration tests and the hypothesis tests [1, -1] must be interpreted with caution.

The two tests used, *MV* and *Trace*, do not jointly support the presence of cointegration. Indeed, of the 28 interest rate pairs, there are only four for which both tests reject the absence of cointegration. Cointegration is present at the short end of the yield curve (between 30 and 90-day rates), but the hypothesis of a common relation [1, -1] in this segment is rejected.¹⁹ Cointegration is also found in a section of the medium-term rate segment (between two, three and four-year rates), but there are no cointegration links between this segment and that of short rates, or with the long segment. As regards the long-term coefficients linking the different interest rate pairs, these are not too far from unity and lie between 0.79 and 0.99. In sum, fairly close relationships exist between short and long-term interest rates, but the absence of cointegration suggests that the term premium is variable and non-stationary.

¹⁵ Some may maintain that this instability reflects that the sample periods are too short to produce reliable statistical results rather than the fragility of the base hypothesis.

¹⁶ According to Sutton (1997), the existence of a significant excess correlation between long-term bond yields in different countries is an indication that the EH is rejected, at least in terms of the formulation proposed by Campbell and Shiller.

¹⁷ With interest rates often being regarded as non-stationary, the cointegration hypothesis [1, -1] signifies, on the one hand, that permanent shocks affecting short-term interest rates (and, consequently, expectations of future short rates) will be reflected in corresponding changes in long-term interest rates. On the other hand, if there is cointegration [1, -1], permanent shocks to long rates (which reflect the changes in expectations) should ultimately be reflected in changes in future short rates. Thus, cointegration [1, -1] is a necessary condition for the EH.

¹⁸ Table 4 is taken from Tkacz (1997).

¹⁹ Gravelle (1997) arrives at similar conclusions when examining the relationships between three-month rates and the rates on forward agreements maturing in four, six, nine and twelve months.

Table 4
Cointegration test between interest rate pairs

System	<i>MV</i>	<i>Trace</i>	Long-term vector	Test [1, -1] (<i>p</i> -value)
[90 days, 30 days]	25.81*	30.84*	[1, -0.979]	0.03
[1 year, 30 days]	11.02	14.38+	[1, -0.943]	0.59
[2 years, 30 days]	10.44	14.64+	[1, -0.868]	0.35
[3 years, 30 days]	10.16	14.17+	[1, -0.831]	0.31
[4 years, 30 days]	10.15	13.97+	[1, -0.813]	0.31
[5 years, 30 days]	10.28	14.25+	[1, -0.804]	0.32
[10 years, 30 days]	9.36	13.78+	[1, -0.792]	0.43
[1 year, 90 days]	9.74	13.07	[1, -0.996]	0.97
[2 years, 90 days]	9.23	13.54+	[1, -0.919]	0.62
[3 years, 90 days]	9.38	13.57+	[1, -0.880]	0.52
[4 years, 90 days]	9.69	13.74+	[1, -0.862]	0.49
[5 years, 90 days]	9.91	14.12+	[1, -0.850]	0.48
[10 years, 90 days]	9.12	13.73+	[1, -0.836]	0.56
[2 years, 1 year]	9.57	13.43+	[1, -0.904]	0.05
[3 years, 1 year]	7.71	12.02	[1, -0.865]	0.16
[4 years, 1 year]	8.54	12.99	[1, -0.865]	0.24
[5 years, 1 year]	9.78	14.44+	[1, -0.860]	0.25
[10 years, 1 year]	10.29	15.07+	[1, -0.787]	0.16
[3 years, 2 years]	11.67	15.83*	[1, -0.958]	0.16
[4 years, 2 years]	13.19+	17.04*	[1, -0.939]	0.20
[5 years, 2 years]	12.37+	16.46*	[1, -0.933]	0.30
[10 years, 2 years]	10.53	15.91*	[1, -0.867]	0.28
[4 years, 3 years]	12.68+	16.26*	[1, -0.976]	0.28
[5 years, 3 years]	11.31	15.39+	[1, -0.968]	0.45
[10 years, 3 years]	9.56	14.82+	[1, -0.892]	0.30
[5 years, 4 years]	10.99	15.41*	[1, -0.988]	0.55
[10 years, 4 years]	9.45	14.20+	[1, -0.899]	0.19
[10 years, 5 years]	11.49	16.05*	[1, -0.928]	0.15

Notes: The systems are estimated on monthly data for the period 1972-96. The order of the system, or the *p*-value, equals 12. The statistics for *MV* and *Trace* allow testing for cointegration, using the null hypothesis of no cointegration (for more details see the notes to Table 5).

Among the reasons for the difficulties in accepting the EH (or in identifying the presence of a common trend between short and long rates), the possibility that the term premium is time-

varying is the one which has aroused the most interest at the Bank recently. We have a large number of results that tend to support the hypothesis of a variable term premium, but little evidence of the underlying factors that might influence it. Thus, there are a number of results which show that the term premium depends on the conditional variability of interest rates themselves, which can be characterised by the distribution function of the shocks affecting the interest rates and by the rate determination process. In addition, as demonstrated by Lee (1995), in a general equilibrium model of the structure of interest rates with a monetary constraint, the term premium may depend on the conditional variability of the growth of economic activity and on the growth of the money supply. The empirical findings by Lee on the basis of US data appear to support his theoretical model. However, in a similar study Hejazi and Lai (1996) were not able to identify such a relationship using Canadian data. According to their results, the term premium is linked to the conditional variability of both interest rates themselves and the exchange rate. This last result surely deserves particular attention in future research.

When the premium is variable, rejection of the EH can also depend on the difficulty of forecasting future interest rate changes. In this regard, the work of Gerlach and Smets (1997) has shown that the tests tend not to reject the base hypothesis in countries where short-term interest rates are more easily forecastable, particularly those using a fixed exchange rate regime, which is, of course, not the case for Canada and the United States. According to their results, Canada is the country in which short-term interest rates are the most difficult to predict after the United States. Furthermore, it is well known that the EH is frequently rejected for the United States.

By the same token, it is possible that the difficulty of forecasting the future stance of monetary policy explains the rejection of the EH. The Bank of Canada has made considerable efforts in recent years to make monetary policy objectives and actions more transparent to the public.²⁰ In addition, research is currently under way to verify the potential effects of transparency on the forecastability of short and long-term interest rates in Canada.

To sum up, even if the EH is often rejected by Canadian data on the basis of statistical criteria, the fact remains that it constitutes an important economic hypothesis for explaining the path of long-term interest rates. Thus, the base model is not so much faulty as incomplete. In itself, the rejection of the EH does not, perhaps, pose a very serious problem for the monetary authorities. What presents a greater challenge, however, is understanding the reasons for the rejection of the base hypothesis. If the determining process of long-term interest rates changes over time, this would explain the rejection of the EH, while at the same time complicating the analyses of the monetary policy transmission process as well as the information content of the term structure of interest rates. This is why research is still in progress on testing the EH and understanding the reasons for its rejection. In the next section, we examine one potential cause.

3.2 The risk premium linked to public sector debt, the term premium and the common trend between short and long rates

Along with the difficulty of establishing stable links between short and long-term interest rates in Canada, various studies have shown the very strong substitutability between Canadian and US bonds, and the very close links which exist between the interest rates of these two countries.²¹ More recently, studies have revealed that a *variable* risk premium could be attached to long-term Canadian bonds on the international markets, possibly because of the rise in Canada's public and external debt during the second half of the 1980s and the first half of the 1990s.²² This risk premium, which we will

²⁰ See the paper by Clinton and Zelmer (1997) on this subject.

²¹ See, inter alia, the studies carried out at the Bank of Canada by Caramazza et al. (1986) and Murray and Khemani (1989).

²² See the studies by Orr et al. (1995) and Fillion (1996).

refer to here as the debt premium, arises in part out of the uncertainty that often attaches to the value of the currency of a heavily indebted country. In the light of these results, it would seem of interest to examine the hypothesis that the debt premium also influences the term premium. Tests of the EH (or tests for a common trend) which do not take account of this situation might tend to reject, spuriously, the base model.

The hypothesis we wish to examine derives from the following three long-run relations:²³

$$i^k = if^k + \Delta^e z(l) + \Omega_l \quad (7)$$

$$i = if + \Delta^e z(s) + \Omega_s \quad (8)$$

$$if^k = if + \varphi \quad (9)$$

Equation (7) represents the hypothesis of uncovered interest parity between long-term rates in Canada and the United States. It states simply that long-term interest rates in Canada (i^k) are equal to long-term interest rates in the United States (if^k), plus the expected changes in the exchange rate over the life of long-term bonds ($\Delta^e z(l)$), plus a risk premium (Ω_l) which may correspond to the debt premium. Equation (8) represents the hypothesis of uncovered interest parity between short-term interest rates in Canada and the United States (i and if). It takes a similar form to equation (7). Equation (9) states that there is a long-run unit root between long and short-term interest rates in the United States, plus a term premium φ . Thus, the model is based on the hypothesis of a common trend between short and long rates in the United States, a hypothesis that is not necessarily accepted unanimously.²⁴

By substituting equation (9) into (7) and subtracting (8), we obtain the following equation:

$$i^k - i = \varphi + [\Delta^e z(l) - \Delta^e z(s)] + [\Omega_l - \Omega_s] \quad (10)$$

Thus, we find in equation (10) that short and long-term interest rates have a unit root. We note that the spread between long and short rates can depend on a number of factors. For simplicity's sake, we assume that the expected short and long-term exchange rate changes are equal, in other words, $\Delta^e z(l) = \Delta^e z(s)$.²⁵ In addition, we assume that the term premium in the yield curve for the United States (φ) is predetermined and stationary, as is the risk premium incorporated in short-term interest rates in Canada (Ω_s).²⁶ These hypotheses allow us to obtain a stationary component for the term premium, which we define as $\Phi = \varphi - \Omega_s$. Finally, we assume that the risk premium in long-term

²³ The approach which follows is an approximation. It serves to illustrate the hypothesis we wish to examine rather than to obtain an exact formulation of the term structure. The time indices have been omitted in order to facilitate the notation.

²⁴ Engsted and Tanggaard (1994) do not reject the hypothesis of a common trend between short and long-term interest rates in the United States on the basis of cointegration tests obtained from the estimation of VECMs. However, Gerlach (1996) and Gerlach and Smets (1997) strongly reject the EH using type (i) and (ii) tests applied to US data. The fact that the EH does not hold in the United States may well explain why it is not accepted in Canada either, given the strong substitutability between Canadian and US bonds, but we do not address this possibility in this paper.

²⁵ This hypothesis may seem fairly extreme, but it is probably correct given the difficulty in finding an appropriate exchange rate forecast model.

²⁶ We have certain reasons for believing that the spread between Canadian and US short-term interest rates is not stationary, and that this spread is linked to Canada's public and external debt ratios. However, this relationship appears to be unstable. This is why we favour the hypothesis that the risk premium incorporated in short-term bonds is stationary.

interest rates in Canada is variable and, more particularly, that it depends on Canada's public sector debt ratio $\Omega_l(D)$, where D is the ratio of public sector debt to nominal GDP.

Under these hypotheses, we obtain the following formulation for the term structure of Canadian interest rates:

$$i^k = i + \Phi + \Omega_l(D) \quad (11)$$

To test this formulation, we use a set of cointegration and hypothesis tests obtained from the estimation of VECMs similar to those previously discussed. We apply these VECMs to interest rate measures from which we have previously subtracted the inflation rate for the preceding year, because this transformation reduces the problem of error heteroskedasticity we described earlier. The main estimation results are presented in Table 5. The estimation period runs from the first quarter of 1972 to the last quarter of 1994.

Table 5

Cointegration tests between interest rates (data adjusted for the previous year inflation rate)

System	Cointegration tests			Univariate specification tests		Hypothesis tests	
	H0	MV	Trace	LB(24)	ARCH (5)	Non-constrained/constrained long-term vector coefficients	p-value
Tests of common trend							
(1) <i>rlcd, rscd</i>	$r=0$	9.81	12.82	0.51	0.21	1a. [1, -1.18]/[1, -1]	0.32
	$r \leq 1$	3.01+	3.01+	0.87	0.27		
(2) <i>rlcd, rscd, ngl</i>	$r=0$	19.77+	28.49+	0.34	0.08	2a. [1, -0.69, -0.03]/[1, -1, 0.01]	0.03
	$r \leq 1$	8.44	8.71	0.44	0.04	2b. [1, -1, -0.01]/[1, -1, 0]	0.78
				0.30	0.46	2c. [1, -0.69, -0.03]/[1, -0.75, 0]	0.18
(3) <i>rlcd, rscd, prime</i>	$r=0$	18.83+	30.30+	0.66	0.13	3a. [1, -0.69, -1.80]/[1, -1, 0.88]	0.04
	$r \leq 1$	9.51	11.47	0.99	0.46	3b. [1, -0.69, -1.80]/[1, -0.87, 1]	0.11
				0.31	0.62	3c. [1, -0.87, -1]/[1, -1, -1]	0.20
Tests of non-covered interest parity hypothesis (see Annex)							
(4) <i>rlcd, rleu</i>	$r=0$	6.68	8.22	0.63	0.06	4a. [1, -1.17]/[1, -1]	0.40
	$r \leq 1$	1.53	1.53	0.82	0.90		
(5) <i>rlcd, rleu, ngl, nfl</i>	$r=0$	31.20*	53.59*	0.42	0.19	5a. [1, -1.02, 0.01, -0.17]/[1, -1, 0.01, -0.17]	0.87
	$r \leq 1$	12.43	22.39	0.63	0.45	5b. [1, -1, 0.01, -0.17]/[1, -1, 0, -0.15]	0.76
				0.05	0.33	5c. [1, -1, 0.01, -0.17]/[1, -1, -0.03, 0]	0.03
				0.47	0.91		

Notes: The systems are estimated on data from 1972Q1–1994Q4. The order of the system, or the p -value, equals 5. All equations are estimated including a constant term. The statistics for MV and $Trace$ allow testing for cointegration, with $H_0: r = 0$ indicating that we are testing the null of no cointegrated vectors. If the null cannot be rejected, i.e. there is at least one vector of cointegration, a step-wise procedure is used to verify that there is no more than one vector. Thus, if $H_0: r \leq 1$ cannot be rejected and $H_0: r = 0$ has already been rejected, there is at most one cointegrating vector. On the other hand, if $H_0: r \leq 1$ is rejected, there is more than one vector. “+” indicates statistical significance at a confidence level of more than 90% while “*” indicates a confidence level above 95%, with critical values taken from Osterwald and Lenum (1992). The statistics LB(24) and ARCH(5) test for, respectively, autocorrelation and heteroskedasticity in the error terms, using a Chi-square test. The first hypothesis tested is that there is a unitary relationship between pairs of interest rates (indicated by 1, -1, d1), with bold figures referring to the hypotheses being tested. We also test the hypothesis that other variables may have a significant influence different from 0 or 1 (indicated by (1, -1, 0) or 1, -1, -1)).

We first use system (1) to examine the simple relation between long-term (i^k) and short-term (i) interest rates in Canada. The results of the *MV* and *Trace* tests do not allow the absence of cointegration to be rejected. As with the results presented in the previous section, this indicates that the short and long-term interest rates are not cointegrated, even though there appears to be a fairly close relation between i^k and i .

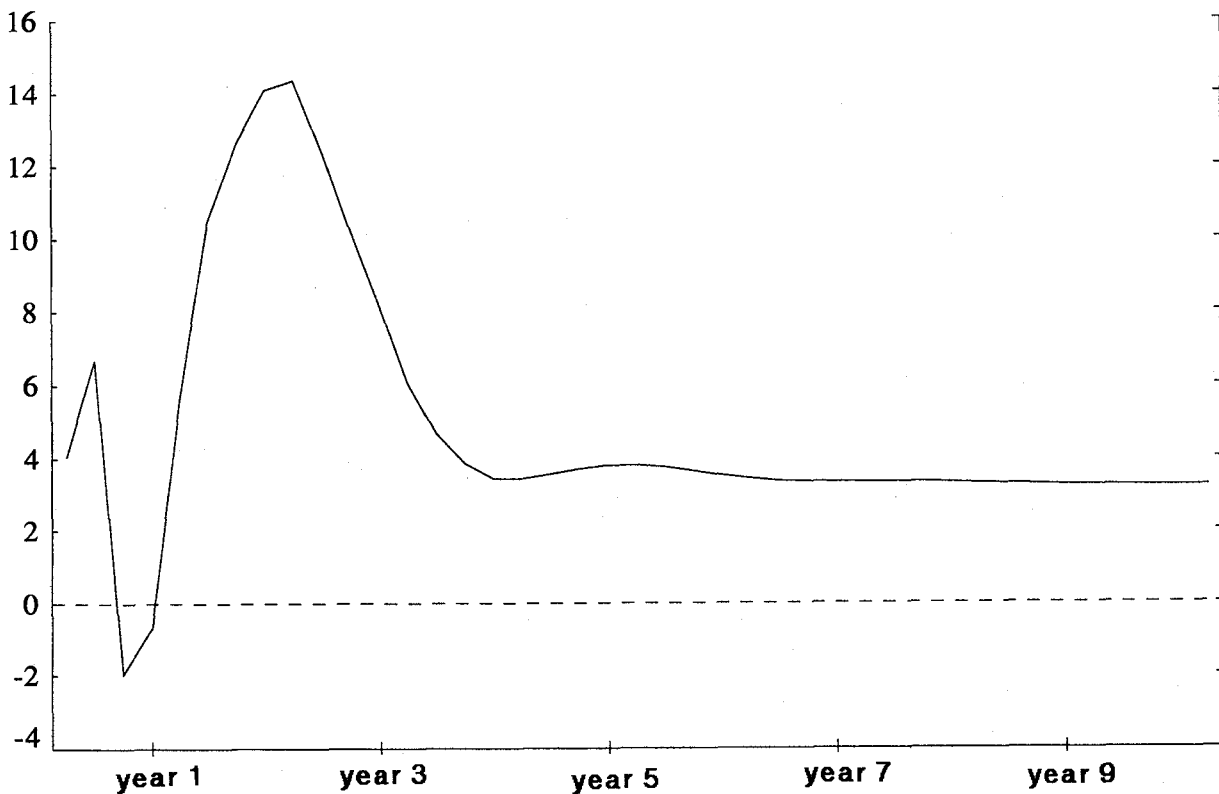
The results of system (2) show a cointegrating relation between i^k , i and the public sector debt ratio *ngl*. However, we can easily reject the hypothesis of a unit root between i^k and i in this model (system (2a)). In addition, in the system in which the unit root between i^k and i is imposed, the public sector debt ratio has no significant effect (system (2b)). Although the public sector debt effect is also insignificant in the system in which the unit root between i^k and i is not imposed (system (2c)), it is not negligible economically, since each 1 percentage point increase in the public sector debt ratio causes real interest rates to rise by 3 basis points in the long term (Graph 5).

These results suggest that there is a non-stationary component of the term premium which is linked to the public sector debt ratio. However, as we have just seen, the effect of this component is difficult to measure precisely. By the same token, the work recently carried out by Fillion (1996) suggests that, in order to evaluate the effects of the public sector debt ratio on the risk premium incorporated in Canadian long-term interest rates, account must be taken of: (a) the effects of the public sector debt on Canada's external indebtedness; and (b) the close cointegrating relation which exists between long-term interest rates and external debt in Canada.

Graph 5

Effect of a 1% increase in the public sector debt/GDP ratio on long-term interest rates

In basis points



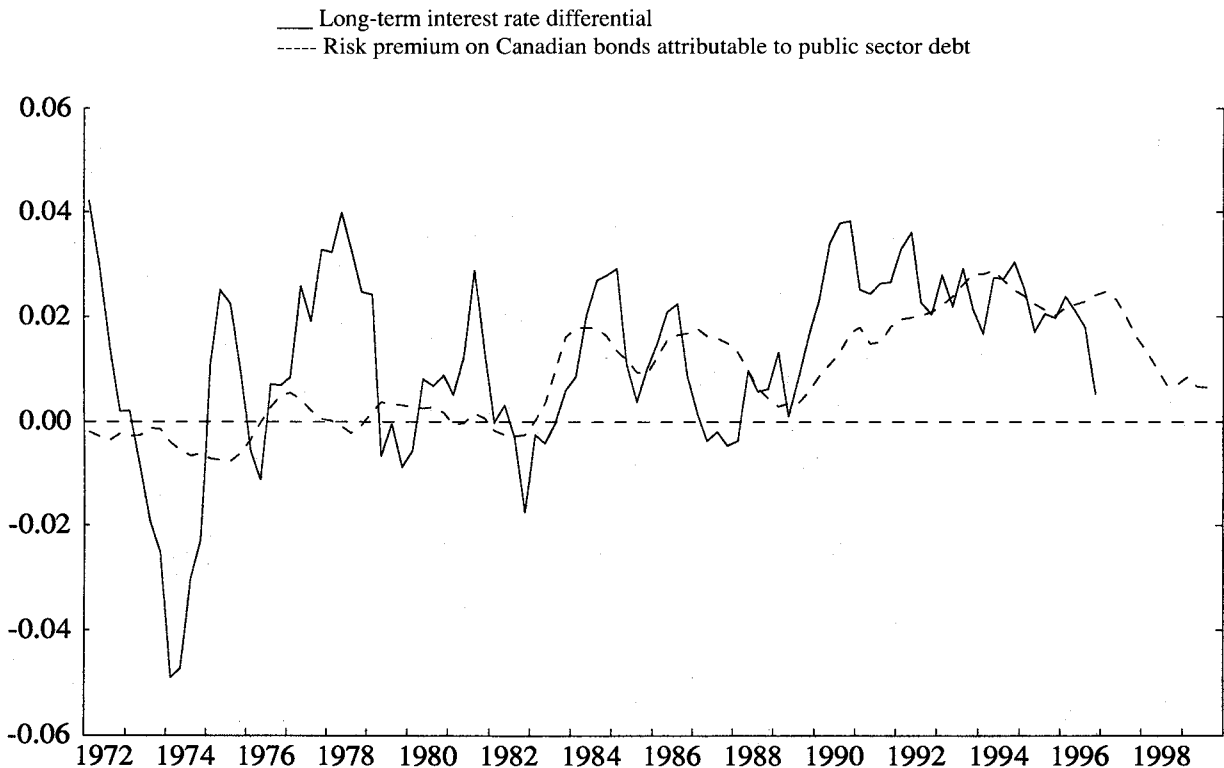
We simulated the VECM estimated by Fillion in order to evaluate the effect of the change in the public sector debt ratio on the risk premium since the beginning of the 1970s, after which we introduced this measure of the debt premium into the relation for the term structure of

Canadian interest rates.²⁷ The results of this simulation are shown in Graph 6. (We assume that the debt ratio during the period 1997-99 will decrease at the same pace as it increased during the three years prior to its 1996 peak.) We note first of all that the risk premium attributable to the public sector debt coincides fairly well with the major changes in the spread between Canadian and US interest rates, in particular since the beginning of the 1980s. For example, the spread between Canadian and US rates narrowed by approximately 150 points during the second half of 1996. However, according to our simulations, the fall in the debt premium ought to have been observed in 1997, when the public sector debt ratio effectively started to decrease.

In the last stage of this study, we introduce the measure of the debt premium (*premium*) presented in Graph 6 into the relation for the term structure of Canadian interest rates. The results (Table 5 (system (3)) indicate the presence of a cointegrating relation. We note, however, that the unit root between short and long-term interest rates is rejected (system (3a)).²⁸ When we modify the sequence of hypothesis tests, we observe that we cannot reject the hypothesis that the debt premium has a one-for-one effect on long-term interest rates (system (3b)), nor can we reject the unit root between short and long-term interest rates (system (3c)).

Graph 6

Long-term interest rate differential between Canada and the United States (adjusted for inflation differential) and estimated risk premium on Canadian bonds



This last set of results shows that a common trend exists between short and long-term interest rates when we take into account the presence, in the long rate segment, of a variable risk

²⁷ For interested readers, a brief overview of Fillion's (1996) results are provided at Annex 1.

²⁸ In the system in which the unit root between short and long rates is imposed, the variable *premium* shows an effect significantly different from zero, but not different from one (results not reported here).

premium linked to Canada's public sector debt ratio. This suggests that the existence of the risk premium might also help explain the rejection of the EH on the basis of the usual tests.

Conclusions

The aim of this paper has been to put into perspective the empirical results obtained at the Bank of Canada and elsewhere on the subject of the information content of the term structure of interest rates and to describe how this information is currently used in the conduct of monetary policy in Canada. From the wealth of financial instruments whose prices may contain useful information for a central bank, we have confined ourselves to examining the term structure of interest rates because this is currently the most important source of information for the Bank of Canada and has been the subject of a number of studies using Canadian data.

A large amount of research is currently being carried out at the Bank aimed at extracting information from the prices of other financial assets. This research, and the relevant research undertaken elsewhere in Canada, will be presented in May 1998 at a conference organised by the Bank. Among the questions which need to be examined is that of the information on the distribution of probabilities relating to exchange rate expectations that can be extracted from the prices of option contracts, plus the information on inflation expectations that can be extracted from long-term interest rates.

Annex: Canadian debt and its effects on long-term interest rates

This annex provides an overview of the results in Fillion (1996) which were used in Section 3 of this paper to calculate a measure of the risk premium on Canadian bonds linked to the development of the public sector debt ratio.

The results from system (4), presented in the second half of Table 5, show that we cannot reject the absence of cointegration between real long-term interest rates in Canada i^k and the United States if^k . System (5), on the other hand, indicates a close cointegrating relation between i^k , if^k , the public sector debt ratio ngl and the Canadian external debt ratio nfl . This result in favour of cointegration is obtained because the system contains two important endogenous variables, i^k and nfl .²⁹ Indeed, it would appear crucial to take account of the endogenous character of external debt in order to identify a cointegrating relation between interest rates in Canada and the debt variables used to approximate the risk on Canadian bonds. Furthermore, the results show that if^k and ngl are exogenous variables, in the weak sense, in this system.³⁰ The results also reveal a very close relationship between Canadian and US long-term interest rates (system (5a)). In addition, they indicate that ngl has no significant effect (system (5b)), whereas nfl is significant at a confidence level of over 95% (system (5c)).

²⁹ The endogenous or exogenous character is identified using tests of significance of the adjustment parameters which are attached to the cointegrating vector in each equation.

³⁰ While the public sector debt may be exogenous in the weak sense, it is a little difficult to believe that it is strictly exogenous, if only because of the effect that interest rate changes can have on the servicing of public sector debt and, consequently, on deficits and indebtedness. This relation is found in our systems of equations, but these systems are not well adapted to examining this particular question. See Fillion (1996) for more details on this subject.

It would therefore appear that a cointegrating relation exists between Canada's external debt ratio and Canadian interest rates. However, since the external debt variable is endogenous, it is difficult to quantify the role of this variable in the measure of the risk premium. On the other hand, the public sector debt ratio, which is more exogenous, does not seem to have a significant direct effect on the risk premium. Nevertheless, this ratio may have a major effect on the risk premium to the extent that it influences the development of the external debt ratio. In order to evaluate the effect of public sector debt on the risk premium for Canadian bonds, we estimated the VECM including the variables i^k , if^k , ngl and nfl by postulating that ngl and if^k are exogenous, and we simulated it for the values observed for the public sector debt ratio since the beginning of the 1970s.³¹ The results of this simulation are presented in Graph 6. We discuss them in more detail in the paper.

Another way of evaluating the effect of the public sector debt ratio on the risk premium is to submit the system of equations to a representative shock of 1 percentage point of ngl (see Graph 5 of this paper).³² In this system, each 1 percentage point rise in ngl has the long-run effect of increasing the external debt ratio by 0.22 percentage points. On the basis of the estimated cointegrating relation, it is easy to establish that the 1-point shock to the public sector debt ratio, given its effect on nfl , causes an increase in the risk premium for Canadian long-term bonds of 3.1 basis points after a certain time has elapsed. The dynamic profile of this effect is shown in Graph 5. Although the impact on the risk premium is imprecise during the first year, it is particularly high during the second and third years. After the third year, the simulations converge rapidly towards the long-run value. The strong rise in the risk premium during the intermediate period may reflect the reaction of financial market participants to the uncertainty surrounding the links between a rise observed in the debt ratio and its expected future path.

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³¹ The estimated system thus contains only two equations, that of the first difference of $rlcd$ and that of the first difference of nfl . Both estimated equations contain the first four lags of each of the four system variables, as well as the contemporaneous change in the two exogenous variables. In addition, both equations contain the long-term vector linking the levels of $rlcd$, $rleu$, ngl and nfl . In this vector, the unit root between $rlcd$ and $rleu$ is imposed during the estimation.

³² In order to create a representative shock, we estimated an equation Δngl , the formulation of which is similar to that of the two other equations of the VECM, and submitted it to a 1% shock. Thus, this shock takes account of the dynamics of the equation Δngl , as well as the presence of lags of $\Delta rlcd$ and Δnfl in this equation.

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