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The Canadian macroeconomy and the yield curve: A dynamic latent factor approach

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ABSTRACT

This study estimates a dynamic latent factor model of the yield curve for Canada using a newly constructed data series on the term structure of constant-maturity, zero-coupon interest rates. The state-space representation of the model is used to assess the dynamic interaction between three latent yield-curve factors (level, slope, and curvature) and key macroeconomic variables (real activity, inflation, and the monetary policy instrument). The estimates support both strong macroeconomic effects on the future yield curve and yield-curve effects on future macroeconomic developments. The bidirectional causality is much stronger than that found in the research for the United States.

1. Introduction

The empirical research for Canada suggests an important role for the term structure of interest rates in the macroeconomy. In the spirit of earlier research on indicator models for the U.S. (e.g., Estrella & Hardouvelis, 1991; Estrella & Mishkin, 1997, 1998), interest rates along the term structure in Canada are found to have relatively good information about expectations of future economic activity, medium-term inflation, and interest rates.[1] In fact, the slope of the yield curve has been such a good measure of the stance of monetary policy in Canada that it was the primary interest rate variable in the demand side of the Bank of Canada's quarterly projection model for a period of time (e.g., Poloz, Rose, & Tetlow, 1994). One explanation for the success of the term spread as an indicator of both output growth and the stance of monetary policy is that it reflects the relation between short-term interest rates influenced mainly by monetary policy and the equilibrium rate of return on real investment (e.g., Bernanke & Blinder, 1992).

On the other hand, there is also some recent research that finds aggregate demand shocks have large and persistent effects on longer term yields in Canada (e.g., Lange, 2005). The results are similar to those found for the U.S. (e.g., Evans & Marshall, 2001; Wu, 2003). Overall, the research for Canada suggests relatively strong feedback effects from the yield curve to the macroeconomy and from the economy to the term structure of interest rates.

In recent years, a new approach has evolved that captures the possible interactions between the macroeconomy and the yield curve. There are essentially two contributions to the new methodology. In the first, Diebold and Li (2006) provide essentially a time-series extension of the exponential components framework by Nelson and Siegel (1987) that assume the term structure of interest rates was a

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[1] See Venetis, Paya, and Peel (2003), Hassapis (2003), Harvey (1997), Clinton (1995), and Cozier and Tkacz (1994) for real activity; Hejazi, Lai, and Yang (2000) and Lange (1999) for future interest rates; and Day and Lange (1997) for medium-term inflation.

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function of three unobservable components. The framework is extended by computing the values of the exponential factor loadings and using ordinary least squares to obtain three time-varying parameters that are interpreted as factors corresponding to the level, slope, and curvature of the yield curve. They also estimate autoregressive models for the factors and forecast the yield curve by forecasting the factors.

In the second contribution, Diebold, Rudebusch, and Aruoba (2006) extend the model in a state-space form with the Kalman filter and a VAR transition equation. The extension allows for a simultaneous fit of the yield curve at each point and maximum-likelihood estimates, as well as optimal filtered and smoothed estimates of the underlying factors. They find that the three time-varying parameters in the state-space form of the Nelson–Seigel model can be estimated efficiently for the U.S. and also interpret as latent factors corresponding to level, slope, and curvature of the yield curve.

Diebold et al. (2006) also extend the dynamic latent factor framework further by complementing the empirical Nelson–Seigel model with a nonstructural VAR model for real activity, inflation, and the monetary policy instrument. This modelling strategy overcomes one of the limitations of previous research that explicitly incorporates macroeconomic determinants into multi-factor yield-curve models, but restricts the linkage to be unidirectional from macroeconomic variables to the yield curve.[2] In addition, the model overcomes the one-way linkage from the yield curve to the macroeconomy that is inherent in the research mentioned above on the predictive content of the term structure for macroeconomic variables. Overall, they find that causality from macroeconomic variables to the yield curve is much stronger than from the yield curve to the macroeconomy for the U.S., which is more consistent with the VAR research on the macroeconomic determinants of the yield curve than that on the predictive power of the term structure for the macroeconomy.

This study estimates a dynamic latent factor model of the yield curve for Canada using a newly constructed data series on the term structure of constant-maturity, zero-coupon interest rates. Similar to the U.S., the model was able to characterize the average Canadian yield curve very well in terms of the statistical properties of the average yields for each maturity and in terms of the properties of three latent yield-curve factors (level, slope, and curvature). However, surprises to the yield curve factors appear to have a much larger influence on each other in Canada than that found for the U.S.

There is also evidence for Canada of both strong macroeconomic effects on the future yield curve and yield curve effects on future macroeconomic developments. The bidirectional causality is much stronger than that found for the U.S., especially a symmetrical bilateral relationship between the overnight rate, the instrument of monetary policy, and the slope factor. The stronger results for Canada may reflect that monetary policy in Canada has been systematically more pre-emptive in preventing 'inflation scare' shocks that distort the information content of the yield curve. Overall, the results indicate significant and persistent responses of the overnight policy rate to all three yield-curve factors and suggest that market yields contain important macroeconomic information that is useful for monetary policy. The strong response of the monetary policy rate to the yield curve is consistent with the research that finds the Bank of Canada reacts to financial variables, such as the short- and long-term yields, and the exchange rate (e.g., Lange, 2010).

The following section briefly outlines the state-space representation of the Nelson–Seigel factor model and the macroeconomic extension by Diebold et al. (2006). Section 3 discusses the data on constant-maturity, zero-coupon Government of Canada bonds and the estimation results for the dynamic latent-factor model of the yield curve. The estimation results, variance decompositions, and impulse response functions for an extended yield-curve model with macroeconomic factors are discussed in Section 4. The final section briefly interprets the empirical results and discusses future research that is important for a small open economy.

2. Empirical methodology

The foundation for the dynamic latent factor model used in this study is the Nelson and Siegel (1987) functional form, which is a convenient and parsimonious 3-component exponential algorithm. Diebold and Li (2006) reformulate the original Nelson–Seigel exponential expression for the yield curve as

$$y_t(\tau) = \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right), \tag{1}$$

where $y_t(\tau)$ is the continuously compounded nominal yield at maturity τ. The Nelson–Seigel yield curve corresponds to a discount curve that begins at zero maturity and approaches zero at infinite maturity. The β_{1t}, β_{2t}, and β_{3t} are time-varying parameters, and the parameter λ controls the exponential decay rate.[3] Small values of the decay parameter λ produce slow decay that better fit the longer term maturities, while large values produce fast decay that better fit the shorter maturities. The decay parameter also governs where the loading on β_{3t} reaches a maximum.

The three time-varying parameters can be construed as dynamic latent factors. The loading on β_{1t} is 1, a constant that does not decay to zero in the limit. An increase in β_{1t} increases on all yields equally since the loading is identical on all maturities. Consequently, it is viewed as a long-term factor and is typically interpreted as the level (L_t) factor. The loading on β_{2t} is $((1 - e^{-\lambda\tau}))/(\lambda\tau)$, a function that starts at 1 and decays monotonically to zero. An increase in β_{2t} increases short yields more than long yields since the short rates load more heavily on β_{2t}, resulting in a change in the slope of the yield curve, defined as short- minus long-term yield. It is viewed as a short-term factor and is interpreted as the slope (S_t) factor. The loading on β_{3t} is $((1 - e^{-\lambda\tau})/\lambda\tau) - e^{-\lambda\tau}$, which starts at zero, increases,

[2] See, for example, the VAR models of Ang and Piazzesi (2003), Evans and Marshall (1998, 2001), and Wu (2003).

[3] The estimation approach assumes that there is a single constant decay parameter λ for all maturities τ.