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Evaluating the Effect of the Bank of Canada's Conditional Commitment Policy

by Zhongfang He

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Abstract

The author evaluates the effect of the Bank of Canada's conditional commitment regarding the target overnight rate on longer-term market interest rates by taking into account the relationship between interest rates, inflation, and unemployment rates. By using vector autoregressive models of monthly interest rates, month-over-month inflation, and unemployment rates for Canada and the United States, the author finds that the Canadian 1-year treasury bill rates and 1-year forward 3-month rates have generally been lower than their model-implied values since April 2009, while the difference between the U.S. realized rates and their model-implied values has been much smaller. The author also studies the effect of the conditional commitment on longer-term government bond yields with maturities of 2, 5, and 10 years, and finds lower actual Canadian longer-term interest rates than their model-implied values, though their difference diminishes as the maturities become longer. The evidence appears to suggest that the Bank of Canada's conditional commitment likely has produced a persistent effect in lowering Canadian interest rates relative to what their historical relationship with inflation and unemployment rates would imply. However, this finding is not statistically strong and is subject to caveats such as possible in-sample model instability and the dependence of the results on the choice of inflation variable.

JEL classification: E4, E5, E6
Bank classification: Interest rates; Monetary policy implementation; Transmission of monetary policy

Résumé

L'auteur tente d'évaluer l'incidence que l'engagement conditionnel de la Banque du Canada à l'égard du taux cible du financement à un jour a pu avoir sur les taux du marché à plus long terme. Pour ce faire, il examine la relation entre les taux d'intérêt, l'inflation et le taux de chômage au moyen de modèles vectoriels autorégressifs formalisant l'évolution mensuelle des taux d'intérêt, de l'inflation et des taux de chômage au Canada et aux États-Unis. Il constate qu'au Canada, les taux des bons du Trésor à un an et les taux à trois mois anticipés à l'horizon d'un an ont en général été inférieurs depuis avril 2009 à ceux que génèrent les modèles, alors qu'aux États-Unis, la différence entre les taux réalisés et les valeurs issues des modèles est beaucoup plus faible. L'auteur étudie aussi l'effet de l'engagement conditionnel des autorités sur les rendements des obligations d'État à 2, 5 et 10 ans. Les taux d'intérêt canadiens à moyen et long terme sont plus bas que ceux prévus par les modèles, mais l'écart se rétrécit à mesure que l'échéance s'éloigne. Il semble donc que l'engagement conditionnel pris par la Banque se

soit traduit par une diminution durable des taux canadiens par rapport à ce que leur relation passée avec les taux d'inflation et de chômage laissait présager. Ce résultat n'est cependant pas très significatif. Il pourrait être dû à une instabilité du modèle sur échantillon et est sensible au choix de la variable relative à l'inflation.

Classification JEL : E4, E5, E6
Classification de la Banque : Taux d'intérêt; Mise en œuvre de la politique monétaire; Transmission de la politique monétaire

1 Background and Motivation

On 21 April 2009, the Bank of Canada lowered its target for the overnight rate to the effective lower bound of 0.25 per cent and made an explicit commitment that, conditional on the outlook for inflation, the target rate could be expected to remain at 0.25 per cent until the end of the second quarter of 2010. The intention of this unusually explicit guidance regarding the future path of the target overnight rate was to provide additional monetary policy stimulus by influencing rates at longer maturities. By comparison, the U.S. Federal Reserve has been less explicit about the timing of the future path of the federal funds rate, but has communicated that it would remain low for "an extended period."[1] The key difference is that the Bank of Canada's commitment has an explicit timing attached to it, while the Fed's guidance does not. This difference leads to the question of whether the Bank's more explicit statement about future monetary policy has generated a different impact on the behaviour of market interest rates compared with the less explicit statement of the U.S. Federal Reserve.

A recent study by Chehal and Trehan (2009) compares the market-expected policy rates of the two countries at 9- and 12-month maturities by using measures derived from the overnight index swap (OIS) rates. They find that the Canadian expected policy rates dropped initially after the announcement of the conditional commitment but then rose and subsequently moved similar to the U.S. expected policy rates. They interpret this as evidence that the Bank of Canada's explicit commitment has not produced a persistent effect that is different from the effect of the Fed's "extended period" policy guidance. To illustrate the problem, Figure 1 plots the daily 1-year treasury bill rates of Canada and the United States since January 2009. It can be seen that the Canadian 1-year treasury bill rate fell in April, when the conditional commitment was made, but rose subsequently to levels similar to those before the conditional commitment. It is

[1]The U.S. Federal Open Market Committee first established the target range of 0 to 25 basis points for the federal funds rate on 16 December 2008. It stated that the federal funds rate would remain low for "some time" in its December 2008 and January 2009 monetary policy releases, and for "an extended period" in its subsequent 2009 and 2010 monetary policy releases.

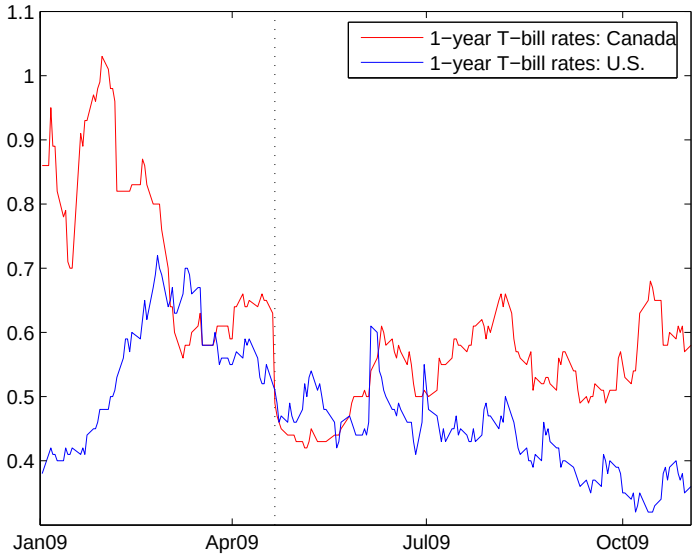


Figure 1: Data for 1-Year Treasury Bill Rates

tempting to conclude, based on the observed pattern of interest rates, that the conditional commitment produced only a transitory effect on the market interest rates. However, the limitation of this conclusion is that the relation between interest rates and macro variables such as inflation and unemployment rates is not taken into account. For example, a rise in Canadian interest rates relative to the U.S. rates could be due to a heightened inflation risk in Canada, even if the conditional commitment has a persistent downward impact on Canadian interest rates, since the commitment is conditional on the outlook for inflation.

This paper evaluates the effect of the Bank of Canada's conditional commitment in a framework relating market interest rates to inflation and unemployment rates, and examines whether the conclusion reached by Chehal and Trehan (2009) still holds. The central idea is that, if the effect of the conditional commitment is persistent, the model parameters should exhibit a "break" after its announcement, since the market's expectation of the path of future policy rates, which takes into account the effect of changes in inflation and unemployment rates, is changed by the conditional commitment. Conversely, if the effect of the conditional commitment is transitory, the model should be largely consistent before and after its announcement.

The rest of this paper is organized as follows. Section 2 explains the model. Section 3 provides the estimation results. Section 4 describes the robustness check and discusses the results. Section 5 concludes. Plots of the data and details of the model estimates are provided in the appendix.

2 The Model

In this paper, we use a reduced-form vector autoregressive (VAR) model of monthly interest rates, inflation, and unemployment rates[2]:

$$y_t = \mu + \Phi y_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \Sigma),$$

where y_t is a vector of the interest rate r_t, inflation π_t, and the unemployment rate x_t at month t, ϵ_t is the model innovation, and μ, Φ, and Σ are model parameters. Theoretically, one could test (e.g., by using a Chow statistic) whether the model parameters changed in April 2009, and view it as evidence of whether the conditional commitment has produced a persistent effect. But, given the few monthly data observations since April 2009, the statistical test is unlikely to produce reliable results. Instead, a forecasting-based approach is taken. The model parameters are first estimated by using data from before April 2009. Based on the parameter estimates, paths of interest rates since April 2009 are then generated from distributions implied by the VAR model. Specifically, let T be March 2009 and $T+h$ be h-month after March 2009. Paths of interest rates $\{r_{T+1}, ..., r_{T+h}\}$ are generated from the joint distribution:

$$p(r_{T+1}, r_{T+2}, ..., r_{T+h} | Y_T, \mu, \Phi, \Sigma),$$

where $Y_T = \{y_T, y_{T-1}, ..., y_1\}$ is the information set at month T. The mean of the simulations could be taken as the model-implied path of the interest rates. A confidence band for the path of interest rates can be constructed based on the simulations, to indicate the range of the likely values for these interest rates if the model parameters do

[2]We also considered more lags in the VAR model. Generally, we found that the parameters after the first lag were mostly insignificant, and that including them did not change the results qualitatively.

not change after April 2009. If the actual observed interest rates are inconsistent with the model-implied values and confidence bands, then that is considered to be evidence that the model parameters may have changed in April 2009, and hence that the effect of the conditional commitment is likely to have been persistent. Otherwise, it is considered to be evidence that the effect of the conditional commitment on interest rates has been transitory.

Since the reduced-form VAR model implies a contemporaneous relation of interest rates with inflation and unemployment rates, we also consider the following augmented conditional distribution of interest rates, which takes into account new developments in contemporaneous inflation and unemployment rates[3]:

$$p(r_{T+h}|\pi_{T+h}, x_{T+h}, Y_{T+h-1}, \mu, \Phi, \Sigma) = N(a, B),$$

where $a = e_1(\mu + \Phi y_{T+h-1}) + e_1\Sigma e_2'(e_2\Sigma e_2')^{-1}\left([\pi_{T+h}\ x_{T+h}]' - e_2(\mu + \Phi y_{T+h-1})\right)$, $B = e_1\Sigma e_1' - e_1\Sigma e_2'(e_2\Sigma e_2')^{-1}e_2\Sigma e_1'$, $e_1 = [1\ 0\ 0]$ and

$$e_2 = \begin{pmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}.$$

The parameters μ, Φ, and Σ are fixed at estimates derived from the data before April 2009. By comparing the actual observed interest rates with the augmented conditional distribution, we can infer whether the observed interest rates are likely to have been generated under the estimated parameters, and hence whether there is likely to have been a structural break in the model in April 2009. Since using the extra information about contemporaneous inflation and unemployment rates reduces the uncertainty of interest rate forecasts, there could be a potential gain in the power of detecting the structural break if there is one in the data.[4]

[3]Note that this augmented conditional distribution of interest rates does not imply a structural model of the contemporaneous relation between interest rates, inflation, and unemployment rates. It is a statistical result of the reduced-form VAR model and is derived by using the Bayes' rule $p(r_{T+h}|\pi_{T+h}, x_{T+h}, Y_{T+h-1}, \mu, \Phi, \Sigma) = p(r_{T+h}, \pi_{T+h}, x_{T+h}|Y_{T+h-1}, \mu, \Phi, \Sigma)/p(\pi_{T+h}, x_{T+h}|Y_{T+h-1}, \mu, \Phi, \Sigma)$.

[4]In the experiments, we also compared the actual interest rates with other alternative dis-

3 Data and Estimation

The Bank of Canada adopted an inflation-targeting regime in 1991, which likely led to a structural change in the relation between interest rates and inflation after 1991. Therefore, the data sample is selected to be from January 1991 to March 2010, with a total of 231 monthly observations. Our main estimation results focus on the 1-year Canadian treasury bill rates, since the 1-year horizon spans the months after March 2009 and the end of the conditional commitment period. We also study the 1-year forward rates on the 3-month Canadian treasury bill rates,[5] which reflects the expected 3-month interest rate one year from the date of observation, and longer-term government bond yields with maturities of 2, 5, and 10 years.[6] The inflation rate is computed as the monthly percentage change in the seasonally adjusted core CPI. The unemployment rate is also seasonally adjusted.

We obtain the U.S. Treasury rates and seasonally adjusted core inflation data from the U.S. St. Louis Fed's FRED database, and obtain the seasonally adjusted unemployment rate data from the U.S. Bureau of Labor Statistics. The U.S. 1-year forward rates are constructed in the same way as the Canadian rates. Plots of the data are provided in the appendix. The interest rates and inflation rates of the two countries are generally close and move in similar directions. Unemployment for the United States, however, is below that for Canada until October 2008.

We estimate five sets of the VAR models by using the different interest rates. For each model, we compare the forecasts of the Canadian and U.S. interest rates based on the parameter estimates using the data from before April 2009 with their realized values afterwards. Since the interest rates and unemployment rates are highly persistent,

tributions implied by the VAR models such as $p(r_{T+j}|Y_{T+j-1}, \mu, \Phi, \Sigma)$, $j = 1, ..., h$, and $p(r_{T+1}, ..., r_{T+h}|\pi_{T+h}, x_{T+h}, ..., \pi_{T+1}, x_{T+1}, Y_T, \mu, \Phi, \Sigma)$. The results were qualitatively similar.

[5]The forward rates are computed based on linear interpolations between the 1-year treasury bill and 2-year treasury note rates. Specifically, a 1.25-year rate is linearly interpolated from the 1-year and 2-year rates. Then, the 1-year and 1.25-year rates are used to derive 1-year forward rates on 3-month treasury rates.

[6]Historical OIS rates are available from the middle of 2001, which is insufficient to estimate the model reliably.

estimates of the intercept parameter μ, which determines the long-run mean of interest rates and unemployment rates, will have large standard errors without any restriction. To improve efficiency, the stationarity condition $\mu = (I - \Phi)^{-1} E(y_t)$ is imposed in estimation. All parameter estimates are provided in the appendix.

To illustrate the effects of the inflation and unemployment rates on interest rates, Figure 2 plots the impulse responses of the 1-year treasury bill rates to inflation and unemployment rate shocks and their 90 per cent confidence intervals, based on the ordering of interest rates, inflation, and unemployment rates in the VAR model. The effect of the inflation shock on interest rates is insignificant and dies out quickly, which is likely due to the weak serial correlation in the month-over-month inflation rates. In contrast, the unemployment shock has a persistent effect on the 1-year treasury bill rates. Holding all other variables constant, a 1 per cent unexpected increase in the unemployment rate corresponds to about a 0.4 per cent rise in the 1-year treasury bill rate after 36 months. This finding can be explained by the fact that the 1-year interest rates contain both the expected future overnight rates and a risk premium. A rise in unemployment rates, though producing downward pressure on the expected overnight monetary policy rates, usually accompanies a heightened risk premium in longer-term interest rates. The positive impact of unemployment shocks on 1-year treasury bill rates suggests that the risk premium in interest rates is strongly affected by unemployment shocks.

3.1 Estimation results of using treasury bill rates

Figure 3(a) compares the observed Canadian treasury bill rate path since April 2009 with the simulations from their joint distribution based on parameter estimates using the data from before April 2009. The forecast mean and confidence bands are computed from 100,000 simulations of the interest rate path. As shown in the plot, the realized interest rate path is below, and flatter than, the mean of the simulated paths. But there is no strong statistical significance for their difference. The realized path of interest rates lies inside the 90 per cent confidence band of their joint distribution, but is below the 70 per cent lower bound for the August, September, and October interest rates. This wide

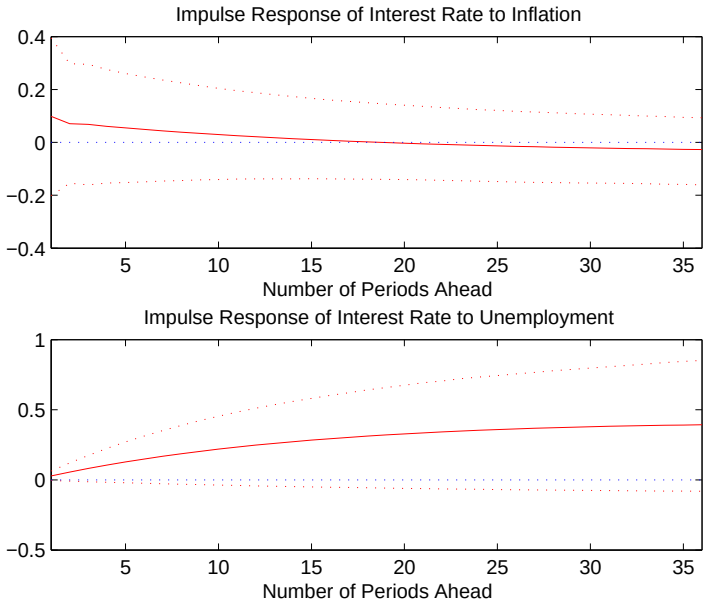
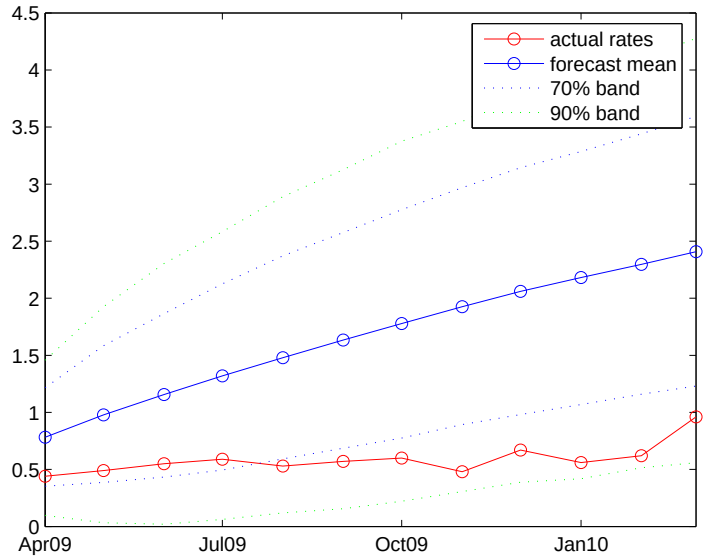


Figure 2: Impulse Responses of 1-Year Treasury Bill Rates: Canada

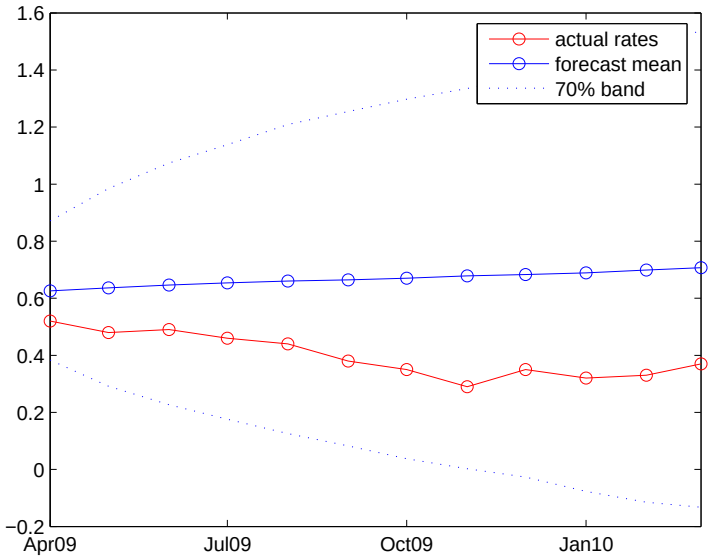
confidence band reflects the large amount of uncertainty about the future path of the 1-year treasury bill rates.

Figure 3(b) plots the results of an identical exercise for the U.S. interest rate path since April 2009. The joint distribution of interest rates implies an almost flat path since April 2009. The realized path lies below the model-implied one and is downward sloping. The difference between the paths is not significant, since the realized path of interest rates lies inside the 70 per cent confidence band of the simulated path. Interestingly, the magnitude of the difference between the realized and the simulated paths is much smaller for the United States than for Canada. The average of the difference is about 76 basis points in the Canadian case, while for the United States, the average is about 21 basis points.

Turning to the augmented conditional distribution of interest rates, Figures 4(a) and 4(b) plot the results for the Canadian and U.S. treasury bill rates, respectively. Figure 4(a) confirms the findings from the joint distribution that the realized Canadian 1-year treasury bill rates are generally lower than their VAR model-implied values, except in March 2010. By comparison, the realized U.S. Treasury bill rates are very close to, and

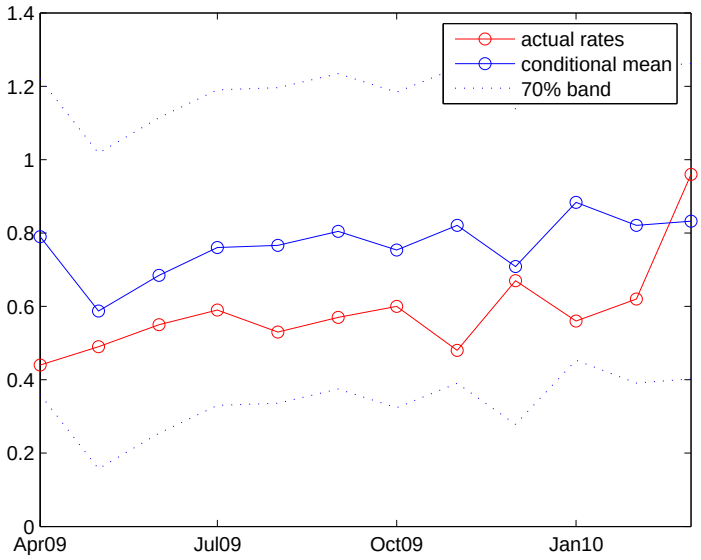


(a) Canada

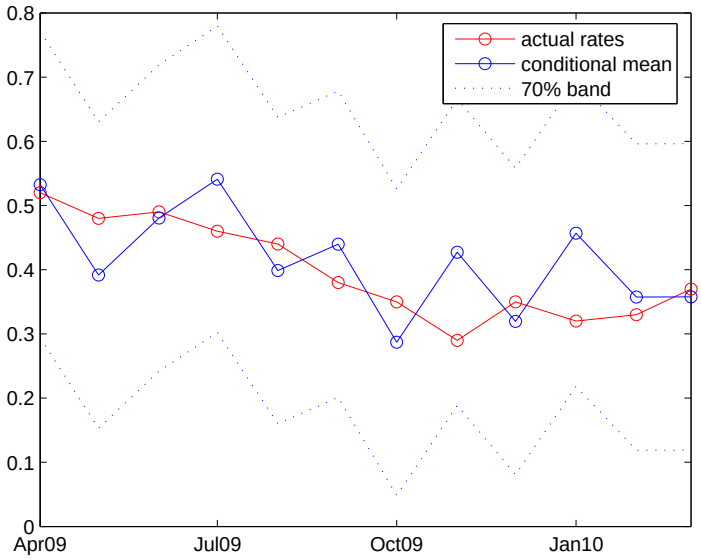


(b) United States

Figure 3: Forecast of Treasury Bill Rates from the Joint Distribution



(a) Canada



(b) United States

Figure 4: Forecast of Treasury Bill Rates from the Augmented Conditional Distribution

fluctuate around, their model-implied values. Combined with the results from the exercise using the joint distribution, the Canadian 1-year treasury bill rates since April 2009 appear to be lower than the implied values from the model using pre-April data, while there is a much smaller difference in the realized U.S. Treasury bill rates and their model-implied values. This evidence appears to suggest that the Canadian conditional commitment may have produced a persistent reduction in the 1-year Canadian interest rates since April 2009 relative to what might have been expected given the inflation and unemployment rates and their historical relationship. The statistical significance, however, is not strong.

It is worth noting that, in Figures 3 and 4, both the realized and model-implied Canadian interest rate paths are upward sloping, while for the United States they are almost flat or downward sloping. The model-implied interest path from the augmented conditional distribution is particularly interesting, since it takes into account the new developments in inflation and unemployment after March 2009. Recall that, for the augmented distribution, the model-implied interest rates are based on estimates of the VAR parameters, interest rates in March 2009, and inflation and unemployment after March 2009. The difference between the interest rate paths in Canada and the United States suggests that, based on the historical relationship of interest rates with inflation and unemployment, the new development in inflation and unemployment since March 2009 implies an earlier rise of interest rates in Canada than in the United States. This is consistent with the market belief that Canada is likely to recover out of the recession faster than the United States.

Given that the U.S. Federal Reserve first lowered the federal funds rate to the lower bound in December 2008 before beginning to use the "extended period" language in March 2009, the VAR model for the United States might have had a structural break in December 2008. Therefore, the forecasts of the U.S. interest rates based on parameter estimates using the sample through March 2009 might be biased. To determine whether this is the case, we re-estimate the VAR model for the United States by using the data up to November 2008 and generate forecasts of the U.S. 1-year Treasury bill rates from December 2008 to March 2010. Figure 5 plots the observed U.S. 1-year Treasury bill rates

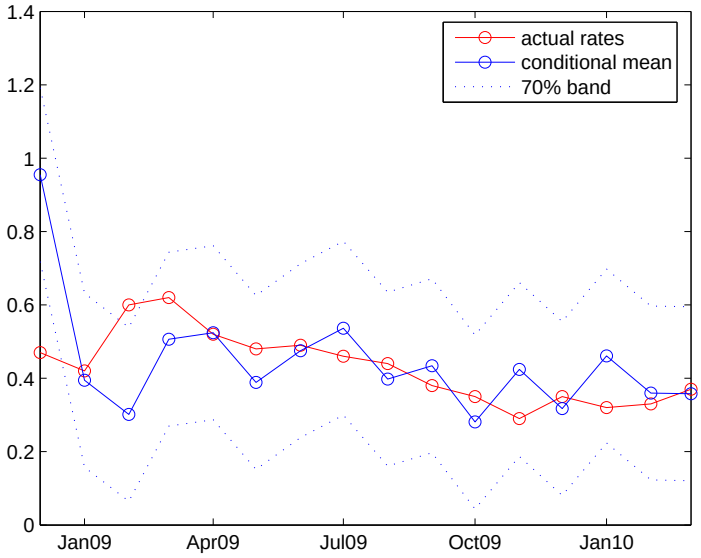


Figure 5: Forecasts of the U.S. Treasury Bill Rates Since December 2008

since December 2008 along with the means and 70 per cent confidence intervals of their augmented conditional distributions. It can be seen that the actual 1-year U.S. Treasury bill rate of 0.47 per cent in December 2008 is much lower than the model-implied value of 0.95 per cent. But, subsequently, the actual U.S. Treasury bill rates move very closely to the model-implied values. The average of the difference between the actual U.S. Treasury bill rates and the model-implied values is less than 2 basis points. Therefore, there is no evidence that the VAR model for the U.S. 1-year Treasury bill rates has a structural break in December 2008.

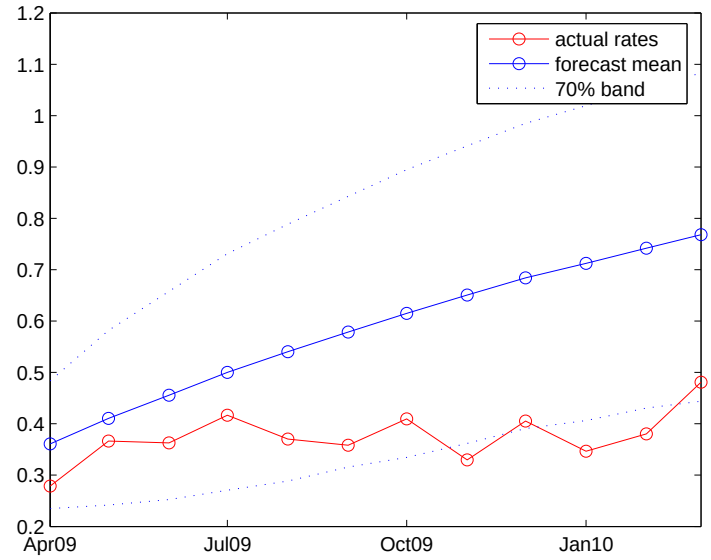
3.2 Estimation results of using forward rates and longer-term interest rates

We perform the same exercises by using the 1-year forward 3-month rates instead of the treasury bill rates. While the 1-year treasury bill rates contain information about the expected short-term interest rates over the future 1-year period, the 1-year forward 3-month rate reflects the expected 3-month interest rate at the end of the period. The

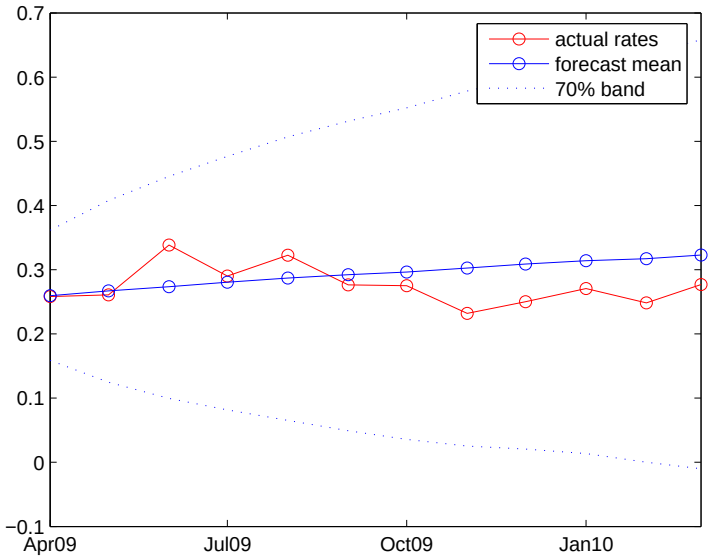
results of using the joint distribution of interest rates are plotted in Figure 6(a) and 6(b) for Canada and the United States, respectively. The qualitative conclusions are generally the same as those from the exercises using the 1-year treasury bill rates. The actual Canadian forward rates are lower than the mean of their simulated values, while the U.S. forward rates fluctuate around their simulated path. However, the difference for both the Canadian and the U.S. estimates is not statistically strong.

Results of using the augmented conditional distribution of interest rates are plotted in Figure 7(a) and 7(b) for Canada and the United States, respectively. For the Canadian exercise, the actual forward rates are mostly below their model-implied values. The actual U.S. forward rates fluctuate around their model-implied values with small differences. This pattern is largely consistent with the exercise of using treasury bill rates and suggests evidence, albeit not strong, that the Bank's conditional commitment likely had a persistent effect in lowering future expected rates relative to their historical relationship with the inflation and unemployment rates before April 2009.

We also consider longer-term government bond yields with maturities of 2, 5, and 10 years. Though the maturities of these longer-term interest rates are well beyond the end of the conditional commitment in June 2010, the conditional commitment is likely to have had an impact on these interest rates by influencing the risk premiums embedded in them as well as the interest rate expectations within the conditional commitment period. We find that actual Canadian longer-term government bond yields are mostly below their model-implied values. However, the differences between them are smaller than those for the 1-year interest rates, and diminish as the maturities become longer. For example, the average difference between the actual rates and the means of their augmented conditional distributions is 14 basis points for the 2-year government bond yields and less than 5 basis points for the 5- and 10-year government bond yields, while for the 1-year treasury bill rates, the average difference is about 18 basis points. These results suggest that the effect of the conditional commitment is most significant on Canadian interest rates at horizons of 1 to 2 years. For the United States, the results of using longer-term interest rates are largely similar to those of using the 1-year interest rates. There is no persistent difference

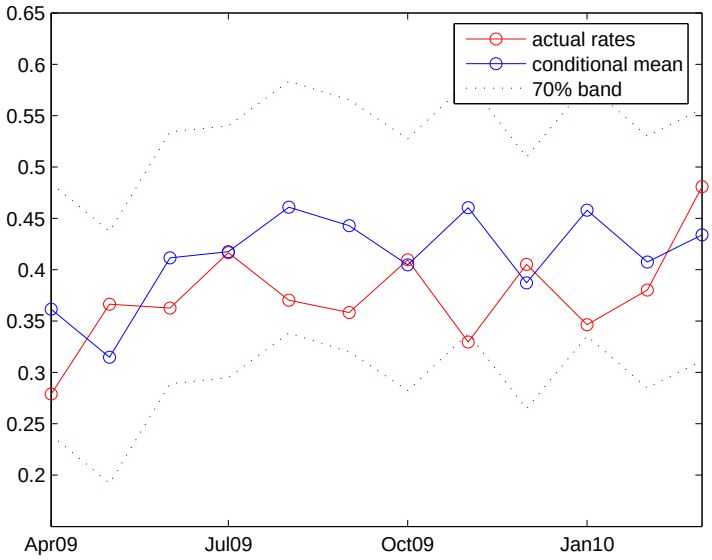


(a) Canada

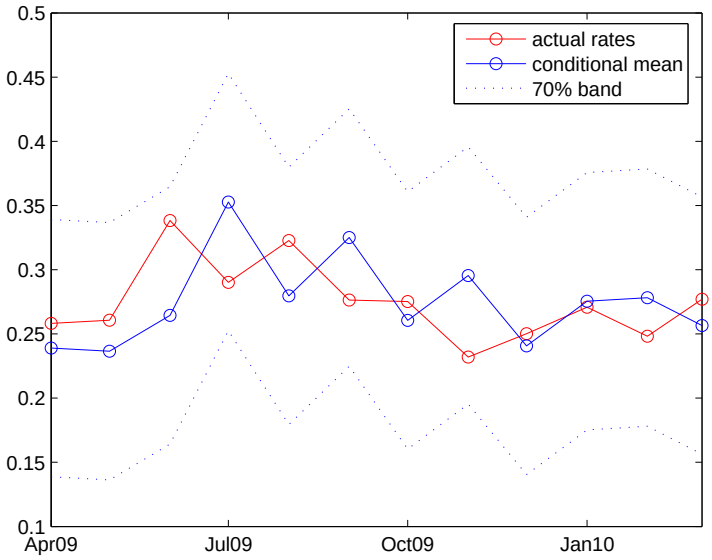


(b) United States

Figure 6: Forecast of Forward Rates from the Joint Distribution



(a) Canada



(b) United States

Figure 7: Forecast of Forward Rates from the Augmented Conditional Distribution

between the actual longer-term U.S. interest rates and their model-implied values.[7]

4 Robustness Check and Discussion

Given the strong influence of the U.S. economy on the Canadian financial markets, we expand the VAR model of the Canadian interest rates to include the Can$/US$ exchange rates and the growth rates of the U.S. real industrial production index to account for the U.S. effect. The coefficients of the exchange rates and the U.S. industrial production growth, however, are insignificant at the 95 per cent confidence level. The resulting simulated path of Canadian interest rates is similar to that of the VAR model without exchange rates and U.S. industrial production growth. Figure 8 plots the augmented conditional distribution of the 1-year Canadian treasury bill rates along with the actual rates. The model-implied path of 1-year treasury bill rates is mostly above the actual rates. The qualitative conclusions remain unchanged.

The estimation results in this paper are subject to important caveats. For example, Cogley and Sargent (2005) and Primiceri (2005), among many others, find that parameters of VAR models for the U.S. short-term interest rates, inflation, and unemployment rates are not time invariant. This suggests that, for the longer-term 1-year interest rate and Canadian data, the in-sample stability of the VAR models could be a concern, especially when considering the various monetary policy and lending initiatives introduced in both Canada and the United States during the recent economic crisis. Moreover, the estimation results depend on the choice of inflation variable included in the VAR model. For example, when we use the year-over-year, instead of the month-over-month, inflation rates, the realized 1-year treasury bill rates since December 2008 in both Canada and the United States are below their VAR model-implied values, which suggests that there is likely a structural break in the VAR models of using the year-over-year inflation rates in both countries in December 2008, when the U.S. Federal Reserve first lowered the federal funds rate to the lower bound. Given the few data points between December 2008 and April

[7]The full set of results using the longer-term interest rates is not produced in this paper, but is available upon request.

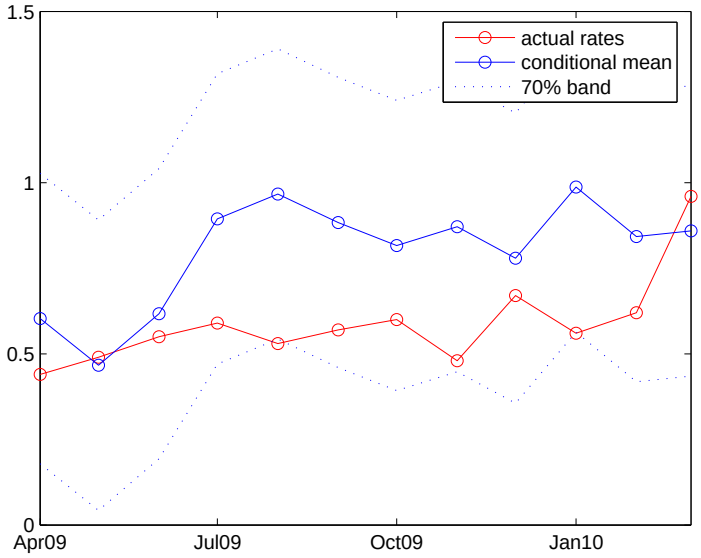


Figure 8: Forecasts of the Canadian Treasury Bill Rates: Including Exchange Rates and U.S. Industrial Production Growth

2009, the VAR models of using the year-over-year inflation rates could not identify the relative impact of the Canadian conditional commitment.

5 Conclusions

This paper evaluates the effect of the Bank of Canada's conditional commitment policy on market interest rates by using VAR models of monthly interest rates, month-over-month inflation, and unemployment rates for Canada and the United States. We find that the Canadian 1-year treasury bill rates and 1-year forward 3-month rates have generally been lower than their model-implied values since April 2009, while the difference between the U.S. realized rates and their model-implied values has been much smaller. We also study the effect of the conditional commitment on longer-term government bond yields with maturities of 2, 5, and 10 years, and find lower actual Canadian longer-term interest rates than their model-implied values, though their difference diminishes as the maturities become longer. These findings appear to suggest that the Bank of Canada's conditional

commitment likely has produced a persistent effect in lowering the Canadian interest rates since April 2009 relative to what their historical relationship with inflation and unemployment rates would have implied. The effect on interest rates is most significant at horizons of 1 to 2 years. The results are robust to the inclusion of variables accounting for the effect of the U.S. economy on Canadian financial markets. However, the statistical significance of the finding is not strong. Important caveats such as model instability and the dependence of the results on the choice of inflation variable should be taken into account when interpreting our findings.

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Appendix

The appendix provides plots of some of the data used in the paper and the parameter estimates of the VAR models. The estimates are based on monthly data from January 1991 to March 2009. The stationarity condition $\mu = (I - \Phi)^{-1}E(y_t)$ is imposed in estimation to improve efficiency.

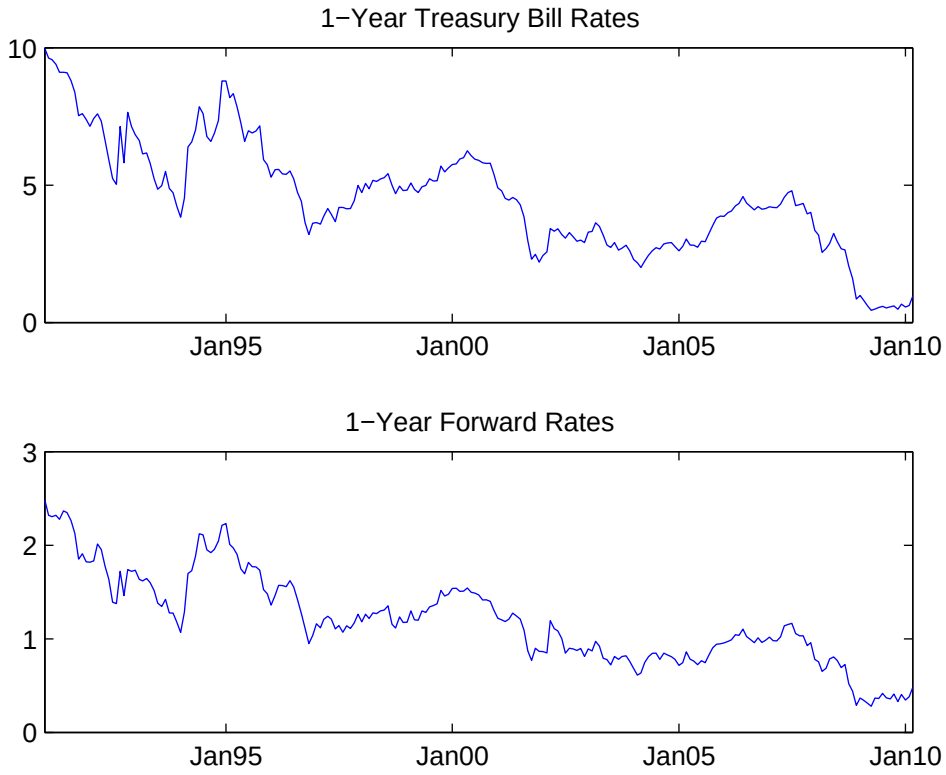

Figure A1: Canadian Interest Rates: January 1991 to March 2010

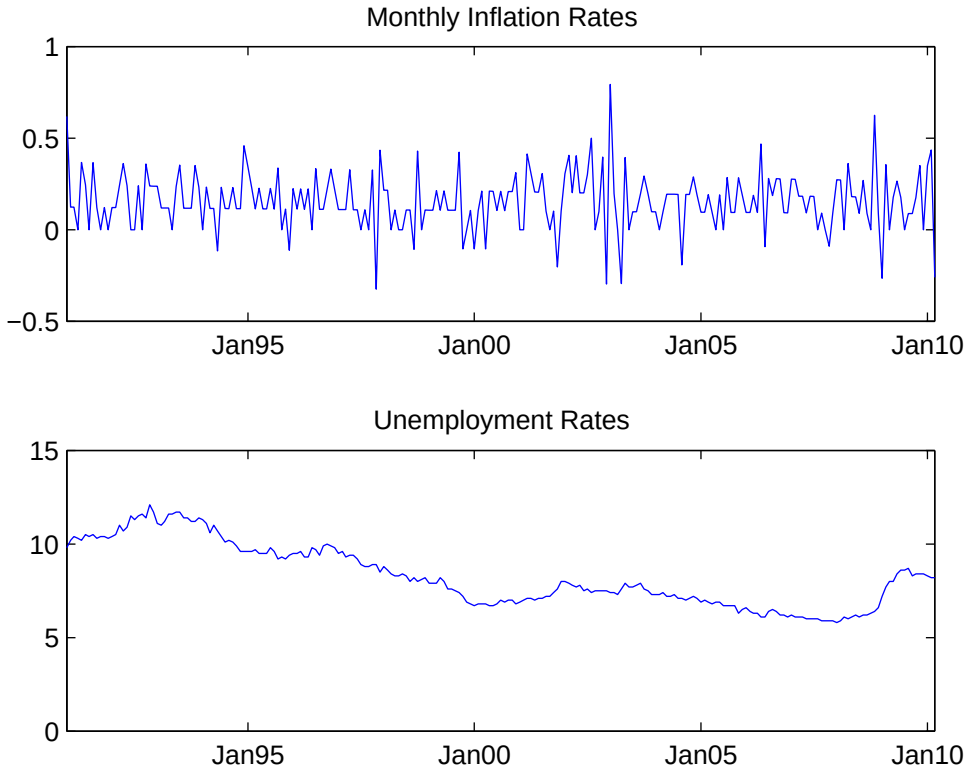

Figure A2: Canadian Inflation and Unemployment: January 1991 to March 2010

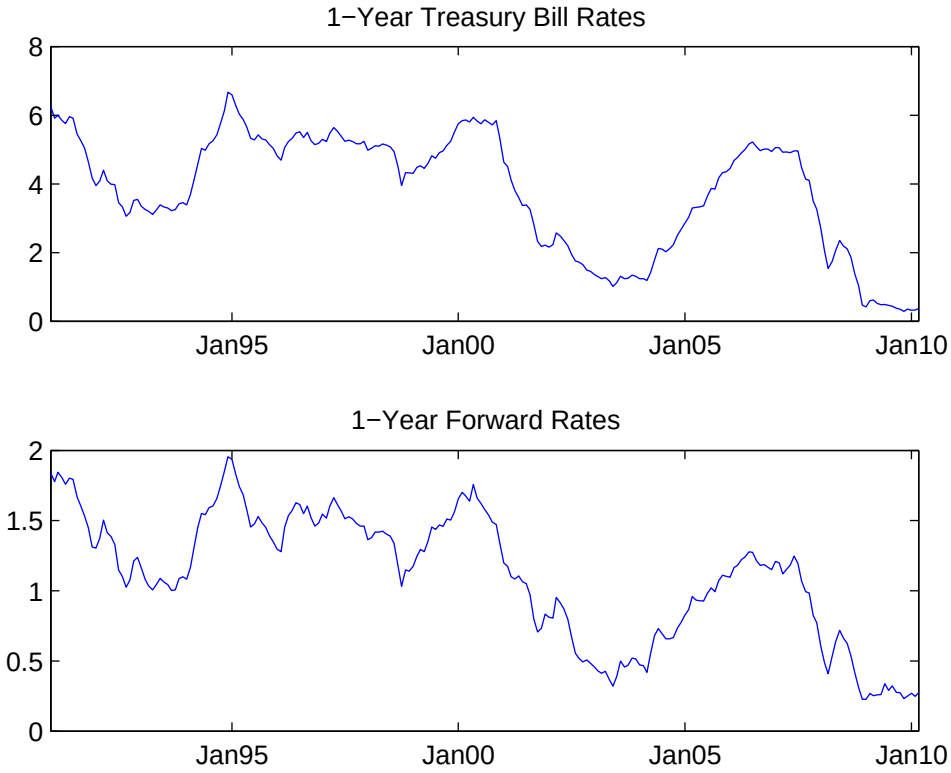

Figure A3: U.S. Interest Rates: January 1991 to March 2010

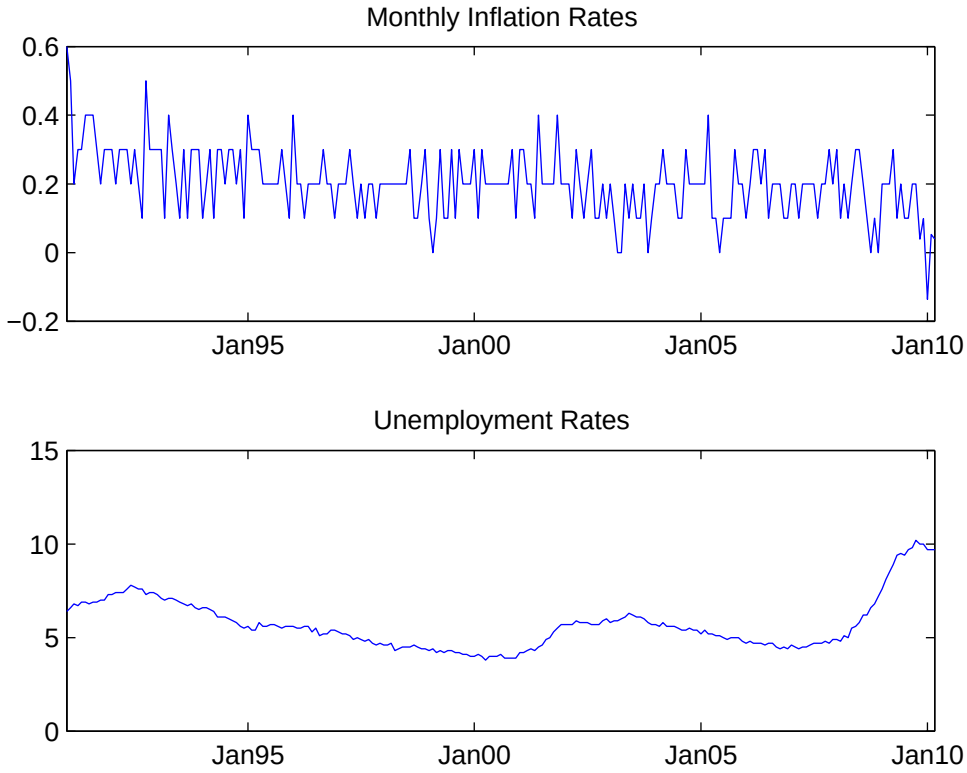

Figure A4: U.S. Inflation and Unemployment: January 1991 to March 2010

Table A1: Parameter Estimates of Using Treasury Bill Rates: Canada

$$\mu = \begin{pmatrix} -0.0243 \\ (0.1376) \\ 0.1515 \\ (0.0545) \\ 0.0669 \\ (0.0703) \end{pmatrix}$$

$$\Phi = \begin{pmatrix} 0.9515 & 0.1021 & 0.0289 \\ (0.0190) & (0.1805) & (0.0205) \\ -0.0002 & -0.1942 & 0.0039 \\ (0.0074) & (0.0718) & (0.0079) \\ -0.0007 & 0.0244 & 0.9918 \\ (0.0098) & (0.0931) & (0.0104) \end{pmatrix}$$

$$\Sigma = \begin{pmatrix} 0.1733 & & \\ (0.0164) & & \\ 0.0020 & 0.0267 & \\ (0.0046) & (0.0026) & \\ -0.0074 & -0.0037 & 0.0447 \\ (0.0060) & (0.0024) & (0.0043) \end{pmatrix}$$

This table reports the estimates of the model $y_t = \mu + \Phi y_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0, \Sigma)$, where y_t=(treasury bill rate, inflation rate, unemployment rate), for the monthly Canadian data from January 1991 through March 2009. Numbers in parentheses are standard errors.

Table A2: Parameter Estimates of Using Treasury Bill Rates: United States

$$\mu = \begin{pmatrix} 0.0352 \\ (0.1176) \\ -0.0511 \\ (0.0542) \\ 0.1169 \\ (0.0818) \end{pmatrix}$$

$$\Phi = \begin{pmatrix} 0.9963 & -0.0687 & -0.0011 \\ (0.0120) & (0.1822) & (0.0181) \\ 0.0221 & 0.0356 & 0.0298 \\ (0.0056) & (0.0843) & (0.0082) \\ -0.0235 & 0.0778 & 0.9928 \\ (0.0084) & (0.1281) & (0.0126) \end{pmatrix}$$

$$\Sigma = \begin{pmatrix} 0.0552 & & \\ (0.0052) & & \\ 0.0001 & 0.0116 & \\ (0.0017) & (0.0011) & \\ -0.0077 & 0.0007 & 0.0264 \\ (0.0027) & (0.0012) & (0.0025) \end{pmatrix}$$

This table reports the estimates of the model $y_t = \mu + \Phi y_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0, \Sigma)$, where y_t=(treasury bill rate, inflation rate, unemployment rate), for the monthly U.S. data from January 1991 through March 2009. Numbers in parentheses are standard errors.

Table A3: Parameter Estimates of Using Forward Rates: Canada

$$\mu = \begin{pmatrix} -0.0111 \\ (0.0394) \\ 0.1525 \\ (0.0548) \\ 0.0669 \\ (0.0706) \end{pmatrix}$$

$$\Phi = \begin{pmatrix} 0.9428 & 0.0148 & 0.0097 \\ (0.0243) & (0.0514) & (0.0063) \\ 0.0039 & -0.1947 & 0.0030 \\ (0.0331) & (0.0718) & (0.0086) \\ -0.0025 & 0.0244 & 0.9918 \\ (0.0437) & (0.0932) & (0.0113) \end{pmatrix}$$

$$\Sigma = \begin{pmatrix} 0.0141 & & \\ (0.0013) & & \\ 0.0002 & 0.0267 & \\ (0.0013) & (0.0026) & \\ -0.0020 & -0.0036 & 0.0447 \\ (0.0017) & (0.0024) & (0.0043) \end{pmatrix}$$

This table reports the estimates of the model $y_t = \mu + \Phi y_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0, \Sigma)$, where y_t=(forward rate, inflation rate, unemployment rate), for the monthly Canadian data from January 1991 through March 2009. Numbers in parentheses are standard errors.

Table A4: Parameter Estimates of Using Forward Rates: United States

$$\mu = \begin{pmatrix} 0.0159 \\ (0.0442) \\ -0.0232 \\ (0.0492) \\ 0.0897 \\ (0.0741) \end{pmatrix}$$

$$\Phi = \begin{pmatrix} 0.9905 & -0.0024 & -0.0008 \\ (0.0175) & (0.0757) & (0.0070) \\ 0.0813 & 0.0266 & 0.0240 \\ (0.0197) & (0.0845) & (0.0076) \\ -0.0881 & 0.0902 & 0.9987 \\ (0.0297) & (0.1284) & (0.0117) \end{pmatrix}$$

$$\Sigma = \begin{pmatrix} 0.0094 & & \\ (0.0009) & & \\ 0.0001 & 0.0115 & \\ (0.0007) & (0.0011) & \\ -0.0016 & 0.0008 & 0.0263 \\ (0.0011) & (0.0012) & (0.0025) \end{pmatrix}$$

This table reports the estimates of the model $y_t = \mu + \Phi y_{t-1} + \epsilon_t$, $\epsilon_t \sim N(0, \Sigma)$, where y_t=(forward rate, inflation rate, unemployment rate), for the monthly U.S. data from January 1991 through March 2009. Numbers in parentheses are standard errors.