

**Forecasting Canadian Recessions Using Qual VAR Model**

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## **Abstract**

This paper applies the Qual VAR method developed recently by Dueker (2005) to search for the ideal macroeconomic indicator(s) that fully fit the in-sample movements of business cycle fluctuations and accurately predict the out-of-sample recession probability in Canada. Compared to previous works, I apply a more comprehensive dynamic forecasting model on the most updated Canadian macroeconomic dataset. The results are threefold: First, consistent with the findings by Estrella and Mishkin (1998), the term spread<sup>1</sup> between 10-year and 3-month marketable bonds on its own provides a reliable in-sample goodness of fit. Introducing additional leading financial variables, such as the bank rate and major stock market indices, does not entirely distort the forecasting performance of the term spread. Second, coupling the term spread with the US-Canada noon-spotted exchange rate gives us the best short-term out-of-sample forecasting power. Third, the combination of the term spread, exchange rate, and the growth rate of real GDP provides convincing recession prediction in longer horizons.

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1. Some literature refers to the difference in interest rates on long-term and short-term marketable bonds as “yield of slope curve” while other studies use “term spread” to represent this value. In my study, I use these two definitions interchangeably.

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# 1. Introduction

Economists have been taking great efforts to search for the ideal macroeconomic indicators that could summarize and predict the behavior of business cycles. Such work usually requires sophisticated mathematical techniques dealing with a large set of time-series data. Moreover, the prediction of business cycle fluctuations is extremely difficult since movements in macroeconomic conditions are never directly observable. However, successfully forecasting macroeconomic behaviors, on one hand, gives policy makers a chance to adjust monetary and fiscal policy, either to bring the economy back on track during recessions or to stabilize the economic growth during expansions. On the other hand, accurately predicting future economic movements also gives private investors and individual consumers the opportunity to adjust their investment and consumption decisions and minimize unnecessary costs.

Two groups of approaches exist in terms of choosing forecast indicators. Some economists point out the over-fitting problem, which states that introducing extra or redundant macroeconomic variables will possibly distort the predicting power of certain single variables such as the commonly used “slope of the yield curve.” Estrella and Mishkin (1996) first test the forecasting power of the yield curve with various tests and confirm the substantial positive relationship between the inversion of the term spread and the US economy. Laurent (1998) further confirms this standpoint. Other studies published in late 1990s that use macroeconomic datasets from industrialized countries like US, Germany, and Canada re-emphasize the important relationship between the slope of yield curve and economic fluctuations from different

perspective.

Contrarily, some economists argue that instead of using individual indicators, certain combinations of financial and real market variables provide the most trustable properties in terms of forecasting recessions. For example, Stock and Watson (1989) introduce advanced time-series data techniques to investigate the predictive power of different combinations of macroeconomic variables. King, Levin, and Perli (2007) find that the corporate bond spread, together with the term spread, carry particular useful predictive power. Moreover, Haltmaier (2008) finds that international oil prices, as well as primary US stock price indices, improve business cycles forecasting performance besides the term spread.

The 2008 subprime crisis has brought back the public's attention on this issue of recession forecasting. Accurately predicting the turning points in business cycle has become an urgent task for economists. With adequate information, governments will be able to conduct the most efficient policies in order to avoid potential future losses. Moreover, the private sector and individual consumers also need updated information about future economic movements to adjust their investment and consumption behaviors to maximize profit and utility.

More comprehensive modeling tools have emerged based on the vector autoregression technique. Within these forecasting models, some leading indicators show robust predicting power. Wright (2006) finds that the addition of the federal funds rate improves the predictive performance of the term spread in the US economy based on the binary choice (probit) model. Katayama (2010) points out that the combination of the term spread, growth rate of S&P 500

index, and the growth rate of non-farm employment rate best fits the NBER recession dates. Other relevant contributions to this topic of recession forecasting include Nyberg (2010) and Fossati (2013), among others.

This paper evaluates the forecasting power of various macroeconomic variables based on the Qual VAR model, developed by Dueker (2005), in application to the Canadian economy. In particular, I focus on the forecasting performance of the term spread between short-term and long-term Canadian marketable bonds and the noon-spotted US-Canada exchange rate. I provide additional experiments that combine different financial and real activity macroeconomic variables with the above two leading indicators, to check if any combination of indicators can improve the predictive power of the slope of the yield curve.

I offer a different perspective in this paper on recession forecasting through applying the augmented probit Vector Autoregressive model to the Canadian dataset with most updated information on macroeconomic variables. Given the current behavior of the leading indicators, I argue that the results presented in this study are more precise than the estimation of recession probability based on simple probit model and early datasets, with particular contributions to the Canadian economy. Also, I separate in-sample fitting and out-of-sample predicting results in order to distinguish which indicators fit the recent economic performance better and to evaluate forecasting power in different horizons.

Specifically, I present summary data on the quarterly behavior of six major Canadian recessions after 1959. Most importantly, I introduce the dynamic latent variable, which is a

binary dependent variable consistent with the Statistics Canada declared recession periods, as one of the key independent variable in the Qual VAR model. Six leading indicators and different amalgamation of these variables are treated in numerical level forms as well as growth rate forms to conduct the in-sample fitting analysis. For out-of-sample forecasting analysis, the sample set is constrained to the end of 2007 in order to investigate the forecasting power of different indicators during the subprime crisis.

The rest of the paper is organized as follows. Section 2 summarizes the critical findings on the topic of recession probability predictions from previous studies. Section 3 discusses the dataset and defines the forecasting techniques that I employ in this study. Section 4 compares the in-sample predicting power of various macroeconomics indicators and their combinations. Section 5 discusses out-of-sample forecasts of recession probabilities. Section 6 concludes.

## **2. Literature Review**

There is a classic joke about economists when it comes to predicting the probability of recessions in modern history: “The greatest economists have successfully predicted five of the last three recessions.” The complicated nature of business cycle modeling has caused insurmountable difficulties in modern macroeconomics. During the last few decades, researchers have kept on searching for the most accurate and reliable economic models to reflect the truth about future economic behaviors. Most recession forecasting models use mathematical techniques originated from the vector autoregression method. However, a number of recent

studies combine traditional probit models and vector autoregression models to develop more comprehensive dynamic probit VAR approaches.

In this section, I introduce several important questions based on notable findings by other researchers. The main focus is to examine recent studies about recessionary modeling by outstanding researchers to get an overview of the achievements and remaining challenges in this field of study.

## **2.1 Findings and Challenges in Recession Forecasting**

The 2008 US subprime mortgage crisis, which triggered the financial market crisis and led to the largest recession, has added urgency to the drive to improve the understanding of the possibilities of business cycle prediction. Therefore, people have started questioning if it is possible to prevent the occurrence of such devastating events either in the sense of securing jobs or maintaining strong purchasing power in the goods market.

A series of paper—Stock and Watson (1989b), and Friedman and Kuttner (1992)—show that, for the past four decades or so, the leading indicators in the financial market, namely the interest rates; the difference between long term and short term return on government issued bonds; and the the stock market index, all bear a systematic relation to subsequent changes of business cycle activities in the US. In particular, Friedman and Kuttner (1993) take one more step to test the positive relationship between the paper-bill spread and real economic activity in the US in early 1990s. The authors pay particular attention to the predictive power of the

paper-bill spread variation over time. They find a consistent statistically significant relationship between movements of the paper-bill spread and subsequent fluctuations in real output, even in the presence of other commonly used financial variables that previous researchers have often advanced as potential business-cycle indicators.

Estrella and Mishkin (1998) further developed these ideas by testing the performance of various financial indicators as potential indicators of US recessions. Since the prices of financial market instruments are usually heavily associated with public's expectations of long-term economic events, it is plausible to come up with the rational to model the significance of various financial indicators in predicting the probability of recession in the near future that one based on historical dataset. The findings were breathtaking. The authors concluded that the term spread and stock price indice individually served as the most useful simple financial indicators, conditional on a proper determined forecasting horizon. Also, they found the over-fitting problem in macroeconomic predictions. The predictive power of a particular macroeconomic model could be easily undermined by the addition of seemingly related variables. Filardo (1999) argues that a recession prediction model, which includes some variables that in truth have no predictive content for recessions, does not possess stable forecasting power.

Similarly, Cozier and Tkacz (1994) emphasize the strong relationship between the slope of the term structure and future changes in real GDP in Canada. The authors perform comparative analyses between the term structure and other leading financial indicators. Later, Atta-Mensah and Tkacz (1998) follow Estrella and Mishkin's (1998) ideas and use the probit model to test the

power of different financial variable to forecast Canadian recessions. Both studies find that the term spread between the Canadian long-term (10 years) bonds and the 90-day commercial paper rate is the best indicator among various financial variables in terms of predicting future economic movements in Canada.

Dueker (2005) proposes a new Qual Vector Autoregressive model. He incorporates information of both continuous and discrete variables in the vector autoregression. Dueker applies his model to US data and provides more comprehensive dynamic forecasts of the probability of a business recession based on National Bureau of Economic Research's (NBER) announced recession periods from the late 1950s. This paper contained not only leading financial indicators in the financial market but also several fundamental macroeconomic variables, including the quarterly growth rate of chain-weighted real GDP and quarterly inflation rate in the adjusted Consumer Price Index (CPI). Most importantly, unlike traditional approaches in recession modeling, Dueker includes a binary indicator for each recession as a dynamic component in the Qual VAR model. The overall results were satisfactory. Dueker appears to successfully solve the long time problematic assumption in traditional VAR models that treated qualitative variables as exogenous regressors. Moreover, the predictive power of the new set of various macroeconomic indicators was strong enough, compared to previous studies.

Several recent studies have applied the recession predicting models to countries other than the US. A study by Boysen-Hogrefe (2012) used the methodology presented in Estrella and Mishkin (1998) to demonstrate the possibility of predicting recession periods in the Euro area,

but using the real M1 money supply as a financial indicator. The author argued that the recent rising trend in real M1 in European economies might be strongly related to fluctuations in the financial market over the sample. He also argued that the structural instability in demand for real M1 in the Euro area increased the overall predictive power of this macro variable. The results, however, were not very convincing. Both the in-sample fitting and out-of-sample prediction lacked considerable accuracy. Yet, this study re-emphasized the difficulties in precisely modeling business cycle fluctuations using few but well chosen macroeconomic variables.

With respect to the Canadian economy, Kiani and Kastens (2006) employed artificial neural networks to forecast recessions based on Canadian data. By applying the neural network models, the out-of-sample forecast showed that most of the indicator variables such as the indicator variables term spread between 10-year and 3-year bonds, the monetary base, industrial production growth, and the combined indicator variable were successful in terms of predicting Canadian recessions for two to ten quarters in the future. As for the accuracy measurement that is associated with the model, Kiani and Kastens's results successfully predicted recessions in the following ten periods of time in the future.

Since I will present analyses of out-of-sample forecasting performance of the leading macroeconomic indicators with respect to the 2008 Great Recession in a later section, it is important to demonstrate some related studies that pay particular attention to the last two recession periods in developed countries.

Fornari and Lemke (2010) apply dynamic ProbVAR model to trace the recession profile of

the US 2001 and 2008 recession. They find that, compared to a simple probit model, the dynamic ProbVAR model not only captures the beginning of each recent recession, but also accurately signals the timings when the economy recovers from economic downturns in longer horizons. Nyberg (2010) successfully gives accurate out-of-sample forecasts to the US and Germany for the recession period that began in 2001, as well as the Great Recession during 2008. The author finds that, in addition to domestic term spread, stock market returns and foreign term spreads also exhibit some predictive power.

However, Fossati (2013) finds that financial indicators exhibit a large deterioration in fit after 2005 for the US economy. Also, they argue that macro factors, other than financial variables, provide the best and most robust forecasting performance for the Great Recession in the US at either shorter or longer horizons.

## **2.2 The Contribution of This Study to Previous Literature**

Although recently, there has emerged a large amount of literature that studies recession forecasting using different models based on the vector autoregressive method, the majority of the works still focus on the US economy and countries in the Euro zone. Less attention has been paid to the smaller economies like Canada. Several contributions of this study to the previous literature include: 1) I focus on the Canadian economy using the recent updated macroeconomic dataset. I examine which of the main leading indicator(s) can fit in-sample business cycle fluctuations and which indicator(s) can provide the strongest forecasting power out-of-sample. 2)

Instead of using the traditional probit model, I apply a more comprehensive Qual VAR model, which could arguably improve the overall performance of indicators in terms of forecasting power. 3) I pay particular attention to the predictive performance of the yield curve and noon-spotted exchange rate between US and Canada. This approach gives me an opportunity to compare the results with early findings by Clinton (1995) and Hu (1993) to examine whether these two favorite leading indicators are still the most reliable predictors and offer the most timely readings on the most recent subprime crisis.

### **3. Data and Methodology**

#### **3.1 Database**

The analysis in this paper focuses on several Canadian leading macroeconomic indicators from the January 1959 till December 2012. The sample dataset includes all six major recessions in Canadian history from the early 1960s to the most recent Great Recession. All the variables can be found using the CANSIM database provided by Statistics Canada. This database provides easy access to almost all the latest and daily updated statistics available in Canada. Moreover, CANSIM also provides a fast and simple platform to isolate and manipulate useful macroeconomic variables from a lot of statistics.

## 3.2 Variables

Various works have been done on predicting recession probability using the growth rate of different macroeconomics indicators. One possible explanation is that it is preferable in economic modeling to use growth rates instead of levels to analyze variables that are not similar in size. However, except for the term spread, there are few studies that examine the predictive power of other leading macroeconomic variables in level form. There is a debate in the recent literature about which kind of data transformation should be applied in recession forecasting. In the VAR content, some studies show that level forms or log-level forms are preferable (see Pirschel and Wolters (2014) and Estrella (2005) for an example). In this study, I want to examine which data transformation technique performs better under the Qual VAR regime.

In order to highlight my approach, I take two different aspects in my empirical models. First, I include six macroeconomic leading Canadian economy indicators in level form as the independent variables for the time series regression analysis. The six individual level variables are the Consumer Price Index (CPI), the natural logarithm of the chain-weighted real GDP, the natural logarithm of the Toronto Stock Exchange Closed Index, Canadian-US noon spotted exchange rate, the Bank Rate and the Term Spread between 10-year and 3-month Government of Canada Marketable Bonds. Since the Canadian economy is heavily influenced by the US economy, I also include the US term spread in later studies at the end of each sub-sections of the in-sample discussion in order to provide comparative analysis. The log transformation method is

applied to monetary amounts. Taking the natural logarithm can help restore the symmetric property and significance of these variables in empirical modeling. Second, I replace all the level variables by their corresponding growth rates, namely: the inflation rate (the growth rate of Consumer Price Index), the growth rate of the Toronto Stock Exchange (TSX) Closed Index, the growth rate of Canadian-US noon spotted exchange rate, the growth rate of Bank of Canada announced Bank Rate and the difference between the growth rate of 10-year and 3-month Government of Canada Marketable Bonds and again, the commonly used growth rate of real GDP. Since my study requires data from early 1960s, and only the information of Government of Canada long-term marketable bonds are available for access, so I use Government of Canada long-term bonds instead of the Baa bond yields to measure the term spread. Table 1 provides precise information about the definitions and labels for each of the variables that I use in later discussions.

The six independent macroeconomic variables, regardless of the choice of level forms or growth rates, can be categorized into two subgroups: Financial market indicators include the Bank rate, the Canadian-US noon spotted exchange rate, the term spread and the TSX closed index; while macroeconomic variables include real GDP and CPI. Financial market indicators are commonly accepted as trustable signals in recession forecast for developed countries including Canada. Among various leading financial indicators, the term spread and the US-Canada exchange rate are commonly considered the most important. For example, Estrella

and Mishkin (1998) first propose that the slope of the yield curve, which measures the term spread between 10-year and 3-month Treasury bill, and the stock prices play an important role in the macroeconomic predictions. In 2013, Statistics Canada reports that exports account for over 30 percent of Canadian GDP and the US is Canada's primary trading partner. Thus, it is reasonable to argue that the fluctuations of the Canadian-US exchange rate provide us with another potential useful indicator. However, recent studies reveal that recession prediction models using only financial indicators exhibit a considerable deterioration in fit after 2005 in countries such as the US (see Fossati (2012) and Annaert (2001)). Since there is a noticeable reorganization in financial markets as well as in the structure of the Canadian economy over the last two decades, I think it is important to not only test the predictive power of financial indicators, but also include macroeconomic variables such as real GDP and the CPI. In my empirical analyses in the later section, I discuss whether including additional real market activity variables will improve the forecasting power of financial market indicators.

### **3.3 Definition of Recession Turning Points**

Intuitively, Canada represents a small open economy with strong economic vitality. Modeling and predicting Canadian recession periods pose additional challenges to researchers, in terms of choosing among the most accurate financial indicators. Unlike the US economy, which has a central research bureau NBER to determine the recession dates officially, there is no

commonly accepted knowledge about business cycle facts in Canada. Thus, I have to be more carefully when dealing with defining recession periods in the Canadian economy.

As we discussed above, good understanding of business cycle facts is crucial to decision-making in fiscal and monetary policies. It is important to determine the exact dates for the beginning and the end of a recession. In my study, the recession periods will serve as a dependent binary variable under the dynamic Qual VAR method. Unlike the US, the Canadian economy does not have an authorized research bureau like NBER to officially date the recession periods. Therefore, it is a technical challenge for me to determine the exact peaks and troughs in Canadian economic downturns. Hamilton (2011) reviews a number of alternative approaches to date business cycle turning points. He argues that a good approach should keep the model as simple and robust as possible, and at the same time, make full use of the available information. Moreover, a simple model based on real GDP alone has a good out-of-sample track record, but with potential space to improve. I directly rely on the method outlined in C.D. HOWE's Commentary No.366 by economist Philip Cross and Philippe Bergeven in 2012. The authors employ three dimensions to identify recession period in Canada since 1926: duration, amplitude and scope. Typically, a quarterly decline in aggregate economic activity is a necessary minimum for a recession.

Whatever is provoking the slowdown in economic activity does not lead to at least one quarter of outright decline, it apparently has not produced the sequence of cutbacks cascading from one sector to another that is one of the keys to studying business cycles (C.D.

HOWE Commentary No.366, Page 4).

In terms of amplitude, a 0.1 percent decrease in overall economic activities is not a very strong evidence to support the beginning of a recession period. If a quarterly drop in the Canadian economy is of a low amplitude, only the economic slowdown that is being accompanied by continuous weakness in economic performance can be validated as the adequate situation of such recession.

I use a quarterly Canadian dataset from the first quarter in 1959 till the last quarter in 2012. There are six recession periods in total. Another crucial adjustment that I make is to define the starting point of each recession to the next closest quarter. For example, a recession that starts from July is characterized as starting in the third quarter of the same year while any recession that starts from November in a given year is characterized as starting in the first quarter of the next year. I take one more step to analyze the magnitude of each economic downturn in terms of the total decline in real GDP from the beginning to the end of each recession. Table 2a summarizes the dating of each of the six recession periods that I include in my study based on the method from C.D.Howe's Commentary. I pay careful attention to the dating of the 2008 Great Recession in Canada since the exact timing of the Great Recession is crucial in my out-of-sample forecasting analysis. I argue that the beginning time of the Great Recession in Canada should be the last quarter of 2008. Starting from October 2008, there was a sharp decline in the Canadian real GDP, which accompanied measurable deteriorations in the labour market. And I argue that the end point of the Great Recession should be the second quarter of 2009.

Since then, the Canadian economy experienced positive growth for over three quarters. So in my study, I consider that the 2008 Great Recession lasts for three quarters from 2008: Q4 till 2009: Q2.

### **3.4 Model Specification**

This study focuses on the forecasting power of various leading indicators to predict the probability of a recession in Canada. Modeling time-series macroeconomic datasets has been a long time challenge for economists. After the pioneering contribution by Sims (1980), vector autoregressive (VAR) models have become the primary tool used to analyze macroeconomic time-series databases. Numerous papers modify the standard linear VAR model and apply the concept to either cointegration continuous time-series analysis (see Johansen (1988)) or non-linear time series (see Bevilacqua et al., (2001) for example).

I use discrete choice models instead of continuous models. One common approach consists of simple probit/logit models (see Fossati (2013)). The simple probit model allows the analyst to evaluate the forecasting performance of any combination of candidate leading indicators. However, one disadvantage of the probit model is that the probit model is restricted to predicting recessions at a given forecast horizon. So any recessions that exhibit unusual lead times may increase the estimated probability that results from the probit model approach and distort the reliability of the forecasting results. Also, the probit model faces the problem of overfitting, adding variables that have no predictive content for recessions will influence the overall results.

Recent studies show that using different functional forms consist of dynamic frameworks outperforms the simple probit models in forecasting power based on the experiments in different countries (see Katayama (2010)).

I apply Deuker's (2005) "mixed" Qual-VAR method. One improvement that Dueker contributes to recession forecasting modeling is that the Qual VAR method includes a latent binary variable underlying the recession periods in Canada as a dependent variable, along with other macroeconomic indicators as independent variables. From this approach, the Qual VAR framework introduces methods for producing dynamic forecasts of a qualitative variable within the VAR model. However, I cannot ignore the fact that Qual VAR model may still suffer from the potential overfitting problem. Thus, one should be careful in choosing the appropriate forecasting indicators.

The essential idea of the Qual VAR model is the application of the Kalman Smoother, which allows econometricians to estimate the recession periods using all available macroeconomic data. It first transforms a continuous latent variable,  $y_t^*$  to the binary dependent variable  $y_t$  such that:

$$y_t = \begin{cases} 1, & \text{if } y_t^* > 0 \\ 0, & \text{if } y_t^* \leq 0 \end{cases} \quad (1)$$

The basic dynamic probit model developed by Eichengreen et al. (1985) can be characterized as

$$y_t^* = \rho y_{t-1}^* + X_{t-1} \beta + \varepsilon_t, \quad (2)$$

where  $y_t^*$  follows a VAR( $\rho$ ) process, and  $X_{t-1}$  is the set of explanatory variables for different macroeconomic indicators. The fact that  $y_t^*$  follows a vector autoregressive process makes this dynamic probit model suitable as a candidate in the VAR system. Dueker (2005) presents that the VAR model with  $k$  variables and  $p$  lags as:

$$\phi(L)Y_t = \mu + \varepsilon_t \quad (3)$$

where

$$Y_t = \begin{pmatrix} X_t \\ y_t^* \end{pmatrix} \quad (4)$$

consists of the same set of explanatory indicators, as well as the continuous latent variable  $y_t^*$  at time  $t$ ;  $\phi(L)$  is a set of  $k \times k$  matrices, from  $L = 0, \dots, p$ , with the identity matrix at  $L = 0$ ;  $\mu$  the intercept vector and  $\varepsilon_t$  the error vector at time  $t$  that is normally distributed with zero mean. Dueker applies the Markov chain Monte Carlo (MCMC) estimation method to estimate the joint distribution  $\Lambda = (\Sigma, \Phi, y^*)$ .  $\Sigma$  represents the covariance matrix of the error vector  $\Sigma$ ;  $\Phi$  represents the VAR regression coefficient; and  $y^*$  represents the latent variable.

The essential idea behind MCMC estimation is that after a large number of iterations, “the draws from the respective conditional distributions jointly represent a draw from the joint posterior distribution, which cannot be evaluated directly” (Dueker (2002), page 4).

I apply the same ordering of draws as Dueker in the dataset, which is  $\Phi \rightarrow \Sigma \rightarrow y^*$ . In the first iteration, starting values for the latent variable are randomly generated. Then, depending on the values of the latent variable  $y^*$ , the distributions of the VAR coefficients  $\Phi$  have the simple ordinary least squares distribution while the covariance matrix  $\Sigma$  have the inverted Wishart distribution. Thus, each of the three variables has a unique distribution conditioned on the other two endogenous variables plus the macroeconomic variables matrix  $X_t$ . The conditional distributions can be summarized as follows (see Dueker (2005)), while the superscripts identify the iteration sequence:

1) VAR coefficients ~ normal distribution

$$f\left(\Phi^{(i+1)} \mid \left\{y_t^{*(i)}\right\}_{t=1,\dots,T}, \{X_t\}_{t=1,\dots,T}, \Sigma^{(i)}\right);$$

2) Covariance matrix ~ inverted Wishart

$$f\left(\Sigma^{(i+1)} \mid \left\{y_t^{*(i)}\right\}_{t=1,\dots,T}, \{X_t\}_{t=1,\dots,T}, \Phi^{(i+1)}\right);$$

3) Latent variable ~ truncated normal

$$f\left(y_t^{*(i+1)} \mid \Phi^{(i+1)}, \{y_j^{*(i+1)}\}_{j < t}, \{y_k^{*(i)}\}_{k > t}, \{X_t\}_{t=1,\dots,T}, \Sigma^{(i+1)}\right).$$

It is commonly accepted to use three quarters to five quarters as the lag periods in macroeconomic forecasting models. I follow this argument and include three quarters lags in the Qual VAR model. Numerically, it is impossible to compute  $y_t^{*(i+1)}$  for the first and last three

periods. I apply M-P algorithm to solve this problem. Detailed description of the numerical method can be found in Dueker (2002).

I use the latest version of the Regression Analysis of Time Series (RATS) program developed by Estima to conduct my analysis. I use the growth rate of real GDP in Canada to approximate the Canadian business cycle fluctuations and the economic movements during each recession and expansion periods. Although real GDP is subject to frequent revision, it is still the most popular indicator of the business cycle in Canada. I study each of the six recession periods in Canada from 1959 till 2012 in the previous section. I impose several evaluation criteria that determine how successful a particular forecasting model is. First, I argue that an adequate forecasting model should signal the beginning and the exact length of each recession periods. Second, a successful leading indicator should accurately reflect the relative magnitude and severity of each recession. In other words, a good forecasting indicator should closely match the movements of the growth rate of real GDP during each recession. For example, if any combination of forecasting indicators describes a relative steep economic downturn during the early 1960s recession compared to the recent 2008 Great Recession, then this forecasting model fails to meet this criterion. Third, I argue that if any indicator(s) fulfill the above two criteria, a preferable forecasting indicator(s) should also roughly follow the increase in real GDP during every expansionary period. I propose this criterion because the best forecasting indicator should closely reflect business cycle movements during the current recession period and the following

expansionary period, so that such forecasting indicator can smoothly predict the economic fluctuations during the next recession period.

#### **4. In-sample results**

I use average quarterly data from the first quarter in 1959 till the last quarter in 2012 to fit the Canadian business cycle fluctuations based on the Qual VAR model. I will base my in-sample analysis on the sample to the end of the fourth quarter in 2012 to avoid using inaccurate time-series dataset since the level of chain-weighted real GDP in late 2013 is still subject to revision and not officially determined. Also, it is commonly accepted that the Canadian economy has fully recovered from the 2008 subprime recession since 2012.

I divide this section into two sub-sections: the predictive performance of all six macro variables in level form and the predictive performance of all six macro variables in growth rate form. Each model includes different combination of leading indicators listed in Table 3, as well as the recession indicator. Within each sub-section, I am particularly interested in the relative performance of the exchange rate and the yield curve in terms of the in-sample forecasting power, with or without the addition of other macro indicators. Thus, I construct seven alternative predictive models in each group. Model L1 uses only the level of the term spread in as the independent variable while model L2 uses only the level of exchange rate as the independent variable. Model L3 includes the term spread, bank rate, and the natural logarithm of the Toronto

Stock Exchange closed index. Model L4 replaces the term spread in model 3 with the exchange rate. Model L5 adds the two real activity macro variables level of real GDP and level of CPI to model 1. Similarly, model L6 replaces the term spread in model 5 with exchange rate. Model L7 includes all the six macroeconomic variables mentioned in this study in level form to provide a comparative analysis later between level form variables and growth rate form variables. Model L8 uses only the level of US term spread as the dependent variable. Similarly, Models G1 and G2 include only the growth rate of the term spread and the exchange rate. Models G3 and G4 add growth rate of the bank rate and the TSX Index to model G1 and G2. Models G5 and G6 replace financial variables with the growth rate of GDP and CPI in model G3 and G4. Model G7 includes all the six indicators in growth rate form. Model G8 uses only the yield curve of the US term spread as the indicator.

#### **4.1 Level Form Indicators**

Figure 1 illustrates the in-sample prediction results using the term spread and the exchange rate as the unique macroeconomic indicator that is included in the Qual VAR model in addition to the binary recession indicator. The horizontal axis indicates each quarter included in the study. Vertical axis characterizes the relative movements of the indicators in different forecasting models. The solid line measures the posterior mean of the latent business cycle index,  $y^*$ , which corresponds to the average estimate of the latent recession variable. Shaded areas represent recession periods when the latent variable  $y^*$  is negative.

I combine the growth rate of real GDP with every forecasting model to determine whether any particular model exhibits good forecasting property based on the criteria I imposed in the previous section. From the figures, I can see that both of the models show some forecasting power. However, there are a few issues that need to be carefully addressed. First, both models show an economic downturn around the second-half year of 1970, which is not officially documented as a recession period. A re-examination of the dataset reveals a 0.6 percent decline in real GDP in the first quarter of 1971. Also, the relatively high level of the long-term bond returns signals the presence of some recessionary forces. However, the overall stability of both US-Canada exchange rate and the term-spread index do suggest that this particular period in late 1970 till early 1971 should be characterized as an economic slowdown rather than a recession. This argument is supported by the findings by C.D.Howe's Commentary taking into consideration of the performance of the unemployment rate during this period. Moreover, the forecasting pattern of the Canadian term spread and the US term spread are very similar in nature (see Figure L8), which emphasize the important relationship between the US and Canadian economy. I will focus my study based on the Canadian term spread in later discussions.

Second, Table 3 shows that the early 1980s recession contributes as one of the most severe economic downturn in the Canadian history with a 4.9% total decline in real GDP. The eight quarters 1990 recession lasts longest in the Canadian history. The decline in real GDP even reaches -1.5% in a single period in the first quarter in 1991. Compared to these two recessions, the 2008 subprime crisis recession could be considered rather mild, with only a 3.3% decrease in

real GDP. And the other three recessions through the early 1960s to 1980s can be considered weak. A precise indicator should accurately reflect the relative severity of each recession. I find that the term spread accurately reflects the relative severity and decline in real GDP during the recent three recessions while the model based on the exchange rate alone does not perform well. Model L2 indicates severe recessions in the early 1960s and in 2008 compared to the other recession periods, which is not supported by my arguments above.

In terms of predicting the length and the beginning of each recession, both models closely follow the movements of real GDP at the start of each economic downturn and represent exactly the same shading areas. One notable result of the term spread prediction is that although the term spread successfully reflects the trend of the movements in the business cycle, it somehow overestimates the magnitude of most recession periods except for the 2008 subprime crisis. One possible explanation could be that financial markets are usually more volatile than goods markets. Consequently, the movement in the term spread is considerably more volatile than the movement in real GDP. However, the increase in the flexibility and number of various derivatives in the financial market make financial indicators more sensitive to economic shocks and better reflect business cycle fluctuations recently.

Figure 2 presents the results when I include two extra financial market indicators to each previous model, BR and LNTSX. The overall spectral shape of these two results becomes more alike in pattern compared to Model L1 and L2 in Figure 1. The exchange rate, together with the Bank rate and TSX index, improves the forecasting power of exchange rate by itself in the sense

that it better predicts a harsh economic downturn in early 1980s. However, this model still lacks reliability since it fails to indicate the long and severe recession from 1990 to 1992. Thus, I conclude that the addition of the Bank rate and the TSX index improve the predicting power of exchange rate but do not necessarily make it an adequate candidate for the reliable predictor of Canadian economic fluctuations.

Regarding the performance of the term spread, the addition of the Bank rate and the TSX index smooth the economic vibration during almost every expansion periods since 1960s. For example, empirically there was a mild recovery of a roughly 2.3% increase in real GDP in year 1993 after the oil price shock that triggered a six-quarter economic downturn from 1991 to 1992 that corresponds to a 3.4% total decline in real GDP. Model L3 follows the real GDP movement during this particular expansionary period more closely. Contrarily, Model L1 predicts an upsurge in real GDP around 1996, which is not supported by empirical data. However, the addition of the Bank rate and the TSX index also distort the forecasting power of the term spread to some extent. Model L3 indicates that the most severe Canadian recession happened during the early 1980s, which is inconsistent with model L1. Consequently, I argue that the predicted pattern of the term spread with regards to the recessionary behavior is satisfactory without the introduction of additional financial indicators. The addition of the Bank rate and the TSX index to the term spread does help correct the predicting bias with respect to the pace at the beginning of each recovery period after a recession.

Figure 3 illustrates the results when I replace the additional Bank rate and TSX index with

the growth rate of real GDP and CPI. Both models exhibit an increasing amplitude of volatility compared to the previous model L3 and L4 with only financial variables, especially for years before the 1980s recessions. However, model L5 indicates roughly similar levels of economic downturns in the three recent recessions, while model L6 predicts the 2008 recession as the most severe recession in Canadian history. Both models contradict empirical evidence. I argue that a smoother and stable pattern better fits the business cycle facts in Canada during expansionary periods. Thus, introducing real activity variables seems to distort the forecasting power of both the term spread and the exchange rate.

In summary, the term spread variables alone presents an acceptable level of forecasting power since they both provide substantial signals for the beginning and ending of each economic downturns. The term spread outperforms the exchange rate as a single forecast indicator in the sense that it more accurately captures the relative decline in real GDP in each recession. Intuitively, this is not surprising since the term spread captures not only short-term economic fluctuations but also people's expectation about long-term economic performance. The addition of the bank rate and the TSX index decreases the volatility of the term spread but also reduces the forecasting power of this single indicator. Real activity variables such as GDP and CPI make poor in-sample fittings compared to financial indicators.

## **4.2 Growth Rate Form Indicators**

I use the growth rate of the term spread only as the first model G1 in this sub-section. Figure

4 illustrates the result that is broadly unsatisfactory. This model predicts roughly the same level of economic downturns during three recent recessions, as well as the early 1960s recession. Compared to model G1, the predicting model G2 that only includes the percentage change in exchange rate performs even worse. The percentage change in the exchange rate does not accurately capture the economic downturns in early 1980s. Also, it falsely predicts a huge decline in real GDP during the 2008 recession and rapid surge in recovery of the Canadian economy after each of the three main recessions after 1980.

Following the same logic, I include two additional financial market indicators: the percentage change in the Bank rate and the percentage change in the TSX closed index to the previous models and the results can be found in Figure 5. The addition of financial market indicators seemingly alters the weak forecasting power of the percentage change of the term spread. On the other hand, the addition of financial variables somehow remedies the forecast performance of the growth rate of exchange rate. However, it still cannot explain the depicted rapid and deep drop in the real GDP in 2008 compared to other recession periods. Next, instead of adding financial market indicators to the percentage change in bond spread and exchange rate, I add two real activity variables: the growth rate of real GDP and CPI. The predictive power of the group of variables that consists of the growth rate of the term spread, GDP and CPI is decidedly weak. Fluctuations in the exchange rate serve as a better indicator when coupling with real activity variables, but still should be considered unacceptable (see Figure 6).

In summary, the overall predictive power weakens when I use growth rates of variables in

comparison of the level form. Estrella (2006) argues that since the recession periods are often characterized as a “decline” in real GDP, it may suggest that it is preferable to use the growth rate, rather than the level form, to assess the state of the economy. However, for variables that already contain useful information in the level form, such as the term spread, using the level form instead of the growth rate form may be a better choice. My in-sample discussions confirms this proposal. The growth rate of the term spread alone exacerbates the magnitude of the economic downturns in Canada during the subprime crisis. The introduction of the growth rate of either financial variables or real activity variables further distorts the predictive result. The growth rate of the exchange rate alone also serves as a poor forecast indicator. The addition of the growth rate of GDP and CPI helps improve the predictive power to some extent, but still does not reflect the business cycle fluctuations in Canada precisely.

### **4.3 Level variables VS Growth rate variables**

I conclude my discussion about the in-sample predicting results with a comparative analysis between the overall performance of level variables and growth rate variables (see Model L7 and G7 in Figure 7). In general, the level variables outperform growth rate variables in terms of accuracy in recession signaling and accuracy in fitting the magnitude of the decline in economic activities. Pairwise comparisons confirm my argument. For example, the exchange rate alone does not accurately measure the severity of each recession but at least reconstructs the mild recovery at the beginning of recent expansionary periods. However, the growth rate of the

exchange rate as the sole pointer fails in both criteria. Similar arguments can apply to other models.

#### **4.4 Brief summary**

I provide a brief summary of the main findings in this section:

- (1) Generally speaking, the six leading indicators in the level form fit the in-sample Canadian recessions better than they do in the growth rate form.
- (2) Among the level form indicators, the term spread by itself provides the best forecasting power for Canadian economy. Although there is no universal agreed-upon theory as to why a relationship between the term spread and GDP fluctuations should exist, many studies attribute the forecasting power of the term spread to monetary policies to stabilize GDP fluctuations. For example, monetary policy tightening during expansionary periods causes both long-term and short-term interest rates to rise. But short-term interest rate are likely rises more than long-term rate. Thus, yield curve usually becomes flatter during expansionary periods. Including additional financial market indicators may remedy the goodness of fit of the term spread. However, adding real activity variables biases the predictive power and causes over-fitting problems.
- (3) Consistent with the findings by Hu (1993), for the US economy, the yield curve, together with some major leading financial indicators, represents the most reliable in-sample forecasting indicator. The fluctuations in the term spread between long-term and short-term

marketable bonds accurately reflect the timing and magnitude of each recession in the post-war Canadian history.

## **5 Out-of-sample Results**

In-sample prediction results may seemingly help us eliminate potential “bad” indicators in forecasting recession probabilities. However, Hansen (2008) has shown that a good in-sample forecasting indicator does not necessarily become an adequate candidate for out-of sample forecasting. In other words, macroeconomic indicators that have good in-sample predictive power do not necessarily possess the same level of significance in predicting out-of-sample business cycle fluctuations. In this section, I first focus on the out-of-sample forecasting power of different combinations of macroeconomic variables in the short term (three quarters ahead) as well as in the long term (twelve quarters ahead), including those that have shown poor in-sample prediction properties. I then compare the forecasted recession probabilities with the officially announced business cycle facts by Statistics Canada during the subprime crisis. Table 2b in Appendix 2 illustrates the Statistics Canada announced recession periods from the last quarter in 2008 until the first quarter in 2011 and the associated real chain-weighted GDP changes. The recession dating provided by Statistics Canada is consistent with the recession dating provided by C.D.Howe’s discussions, but with the detailed business cycle fluctuations information around the 2008 subprime crisis. I pay attention to the dating of the 2008 Great Recession in Canada since the exact timing of the Great Recession is crucial for my out-of-sample forecasting analysis.

I argue that the beginning time of the Great Recession in Canada should be the last quarter in 2008. Starting from October 2008, there was a sharp decline in Canadian real GDP, which was accompanied by measurable deteriorations in the labour market. And I argue that the end point of the Great Recession should be the second quarter of 2009. Since then, the Canadian economy retrieves a positive growth for over three quarters. So in my study, I claim that the 2008 Great Recession lasts for three quarters from the last quarter in 2008 till the second quarter in 2009.

I use the quarterly data from 1959: Q1 to 2008: Q1 to construct different models for the out-of-sample forecasting analysis. The end-of-sample forecast of recession probabilities for three quarters (short term) and twelve quarters (long term) ahead under each particular model will be examined respectively. I apply the estimated recession probabilities based on the Qual VAR model to check how well the particular variables signal recession periods during the Great Recession. Applying this criterion gives me a more reliable and straightforward numerical results compared to the in-sample forecasting. This procedure mimics what a Qual VAR model would have predicted with the information available up to 2008: Q1.

I repeat a basic framework addressing how Qual VAR model predicts recession probabilities here. A detailed discussion can be found from Dueker (2002). Dynamic Qual VAR forecasts of recessions are based on the simulations of the vector autoregressive system  $K$  quarters from the forecast date. So the forecasted recession probability is the proportion of draws that has a negative value in the  $(t+K)$  period in the future.

$$\Pr(\mathbf{y}_{t+K} = \mathbf{0} | I_t) = \frac{1}{2000} \sum_{i=1}^{2000} J(\dot{\mathbf{y}}_{t+K}^{*(i)} < \mathbf{0}),$$

where  $J$  is the binary function that takes value of 1 when the simulated latent variable  $\dot{\mathbf{y}}_{t+K}^{*(i)}$  is negative and 0 when the simulated latent variable is positive; 2000 is the number of iterations that I will include in the models, and  $\Pr(\mathbf{y}_{t+K} = \mathbf{0} | I_t)$  is the predicted recession probabilities  $K$  periods ahead of the data, where  $K$  takes value of 3 and 12. All the estimated recession probabilities are reported in Table 4 to 7.

### **5.1 Three Quarters Ahead (Short Run) Forecasted Recession Probabilities Based on Six Individual Indicators Through 2008:Q1**

I first provide three quarters ahead prediction of the recession probabilities based on the level form of each of the four individual macroeconomic indicators, as well as the growth rate of real GDP and CPI. Many studies recognized the relatively “stable” performance of the Canadian economy compared to US economy during the subprime crisis, possibly due to Canada’s healthier fiscal and monetary policies and more centralized banking system. However, a recent study by Carfagnini (2012) suggests that the total economic activity decline in terms of real GDP in Canada was only slightly smaller than the size of the total real GDP decline in US. The Bank of Canada reports that after the data revision, the total decline in real GDP in the Canadian economy is 3.3% during the recent subprime recession, which is only 0.1% less than the total drop in real GDP in US. Again, unlike the US, where foreclosure statistics are updated routinely, Canada lacks comprehensive research facilities to track and monitor business cycle movements

during a recession. Thus, the detailed macroeconomic data in Canada are sometimes hard to obtain during periods of recessions. Despite the similarities in economic structures between these two economies, recessions in Canada do possess different business cycle facts in terms of timing and magnitude. This argument motivates the study of the out-of-sample forecasting power of various macroeconomic indicators specifically for the Canadian economy. Moreover, since the Great Recession started in the fourth quarter of 2008 till the second quarter of 2009 in Canada, an exceptional short-term forecasting indicator should accurately signal the start of such recession.

Table 4 presents the predicted three quarters recession probability by six individual indicators based on the Qual VAR model with 2000 iterations. I use the growth rate of real GDP and the growth rate of CPI to better capture the movements in these two real activity market variables. The numerical values in each column are the corresponding predicted relative probability of recession in a given period. Again, I argue that an adequate short-term forecasting indicator should explicitly signal the start of a recession. In other words, the successful short-term forecasting indicators should demonstrate a considerable increase in the predicted recession probability in 2008:Q3 and 2008:Q4 compared to the second quarter of 2008.

Among financial market indicators, the short-term predictive ability of the Bank rate and the TSX closed index are weak and negligible. None of these variables alone precisely signal the Canadian economic turning point in the fourth quarter of 2008. Inevitably, compared to in-sample results, the out-of-sample forecasting power of the term spread and the exchange rate

show some deterioration in forecasting accuracy, but the predicted recession probabilities based on these two indicators are still better in forecasting power than the estimations based on other indicators. Noticeably, the term spread predicts a substantial probability of a recession during 2008: Q2 and 2008: Q3 rather than 2008: Q4. The exchange rate improves the result by indicating a convincing level of recession during the third quarter and last quarter of 2008. One possible explanation related to this inaccurate forecasted timing might be the close link between the US and the Canadian economies. The subprime mortgage crisis started in US at the end of 2007. The credit market shocks in the US economy likely influence the investment behavior of Canadian agents. Thus, the leading indicators in Canada's financial market like the term spread, the Bank rate and the TSX index rapidly adjusted to the financial crisis in the US, which predicted an early recession probability in the Canadian economy compared to the actual dataset. Similarly, the exchange rate closely reflects the financial market deterioration in the US and, as a result, the short-term forecasting power specifically targeting the Canadian economy is satisfactory, but somehow lacks absolute accuracy. However, compared to the bank rate, the TSX index and the inflation rate, the exchange rate still represents a relatively strong signal of upcoming recessions despite the inaccuracy in terms of timing. On the other hand, the inflation rate provides poor and weak information in predicting the start of the subprime crisis in Canada. The growth rate of real GDP successfully signals the beginning of the recession but lacks significance.

I further eliminate the Bank rate; the TSX closed index, and the inflation rate from the three

quarters ahead out-of-sample forecasting pools because these three indicators provide both weak and inadequate information about the timing of the subprime crisis in Canada. Since the term spread and the exchange rate show some good predicting properties, and the growth rate of real GDP can provide information of the timing of the recession, I put the term spread, the exchange rate, and the growth rate of real GDP together to see if I can get better out-of-sample forecasting results. The outcome is solid. The estimates with/without the growth rate of real GDP is given in Table 5. Birchenhall et al. (1999) investigated methods to translate forecasted recession probabilities to yes/no recession signals. They suggested that any predicted probability greater than 50% is a strong signal for upcoming recessions and any predicted probability greater than 16% is noticeable a warning for possible economic downturns. Based on this criterion, both estimates I presented predict a convincing short period recession probability around the third and fourth quarter of 2008. During the second quarter of 2008, the Canadian economy likely exhibits signs of fluctuation. It is also noteworthy that without the growth rate of real GDP, the exchange rate and the term spread provide an even stronger prediction of the upcoming recession. Moreover, the introduction of the term spread improves the short-term out-of-sample predicting power of exchange rate.

## **5.2 Twelve Quarters Ahead (Long Run) Forecasted Recession Probabilities Based on Six Individual Indicators Through 2008:Q1**

I further examine the long run forecasting properties of each of the six leading indicators. In

addition to the requirement that a “successful” macroeconomic variable in terms of predicting power should carefully remark the start of a recession, I argue that a satisfactory long run forecasting indicator should also accurately predict the length of the recession with minor adjustment. In other words, such indicator should characterize the beginning of the recession as well as roughly the ending of such a recession in a longer horizon.

Forecasted recession probabilities of six single indicators based on the Qual VAR method is summarized in Table 7. Similar results follow as in the short term recession forecasting. The Bank rate, the TSX closed index and the inflation rate still provide poor and weak information on recession probabilities even in the longer horizons. The exchange rate again strongly signals the beginning of the recession in Canada but inadequately suggests that the recession would highly likely not persist to 2009. Contrarily, the term spread lacks significance in recession forecasting but indicates a sizable drop in recession probability after the second quarter in 2009 which is officially supported by empirical data.

Following this argument, I again eliminate the weak indicators: the Bank rate, the TSX index, and the inflation rate from my future study. I provide twelve quarters recession forecasting probabilities based on noon-spotted US-Canada exchange rate, with the term spread and the growth rate of real GDP as potential remedial variables. Table 8 summarizes the details. Both estimates give us good forecasting results regarding the beginning of the subprime crisis. Without including the growth rate of real GDP, the exchange rate and the term spread signal more convincing clues about the upcoming recession. However, this set of indicators fails to

distinguish the ending point of the recession around the second or third quarters of 2009. Adding the growth rate of real GDP somewhat remedies this problem, but at the same time, also suggests some misleading information when the economy slowly turns back to expansion during the third quarter of 2009 till the second quarter of 2010.

### **5.3 Brief Summary**

I may draw some conclusions based on these out-of-sample experiments. First, for the short term (three quarters ahead) recession forecasting, none of the leading indicators I included in this study present satisfactory results in terms of accurately signaling the timing and severity of the 2008 recession ahead of time. However, combining the exchange rate with the term spread gives me a very reliable signal. Second, the long term (twelve quarters ahead) recession forecasting properties of each of these single leading indicators are still unacceptable. Combining the exchange rate and the term spread predicts a strong recession possibility around the third quarter and fourth quarter of 2008, which is supported by real macroeconomic data. Yet it fails to identify the length of such recession and the timing when the Canadian economy gets out of the recessionary trap. Introducing the growth rate of real GDP, together with the exchange rate and the term spread, remedies this problem to some extent and provides a more trustable forecasting power in longer horizons.

## 6. Conclusion

This study examines the performance of several leading indicators in predicting future Canadian recessions using the sample from 1959: Q1 to 2012: Q4. Moreover, this paper focuses specifically on the forecasting power of the term spread between the 10-year and 3-month Canadian marketable bonds and the noon-spotted US-Canada exchange rate. I study both the in-sample fitting properties, as well as the out-of-sample predicting ability of these variables.

Several encouraging principles emerged from my study:

First, consistent with the findings from Estrella and Mishkin (1998), I find that the slope of the yield curve provides the most reliable in-sample fitness of economic turning points in recent Canadian history. Besides, the US-Canada noon-spotted exchange rate also presents some in-sample forecasting power.

Second, the over-fitting problem (see Filardo (1999) for details) is not very severe in terms of in-sample fitting. Although the addition of leading financial indicators like the Bank rate and the TSX index distort the in-sample forecasting behavior of the term spread to some extent, it also helps correct the bias of the forecasting model based on the term spread by itself. In general, financial market indicators are more reliable than real market variables in terms of predicting power.

Third, compared to variables in growth rate forms, the level form indicators mimic the trend of in-sample recession periods much better.

Fourth, I find that the exchange rate outperforms the term spread in out-of-sample prediction.

However, none of the single variables included in this study provides significant out-of-sample forecasting power. Combining the exchange rate and the term spread gives the most accurate short-term signal of upcoming recessions in Canada. The addition of the growth rate of real chain-weighted GDP to the exchange rate and the term spread produces the most trustable forecasting model in the long run.

However, despite the positive results about the desired forecasting ability of particular macroeconomic indicator, we should not be overly optimistic about our ability to predict the evolution of GDP or forecast recessions in general. One of the major problems of accurate recession forecasting is that the available data is always lagged and limited in its use and, therefore, forecasts of recessionary behavior always cannot be precise. Moreover, more and more risks are accumulating in recent global economic markets and there are just too many potential triggers that could initiate a recession that is not well predictable. Thus, we should not simply rely on numerical models, sometimes qualitative information may give a much better signal of what is forthcoming in the near future.

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# Appendix 1: Figures

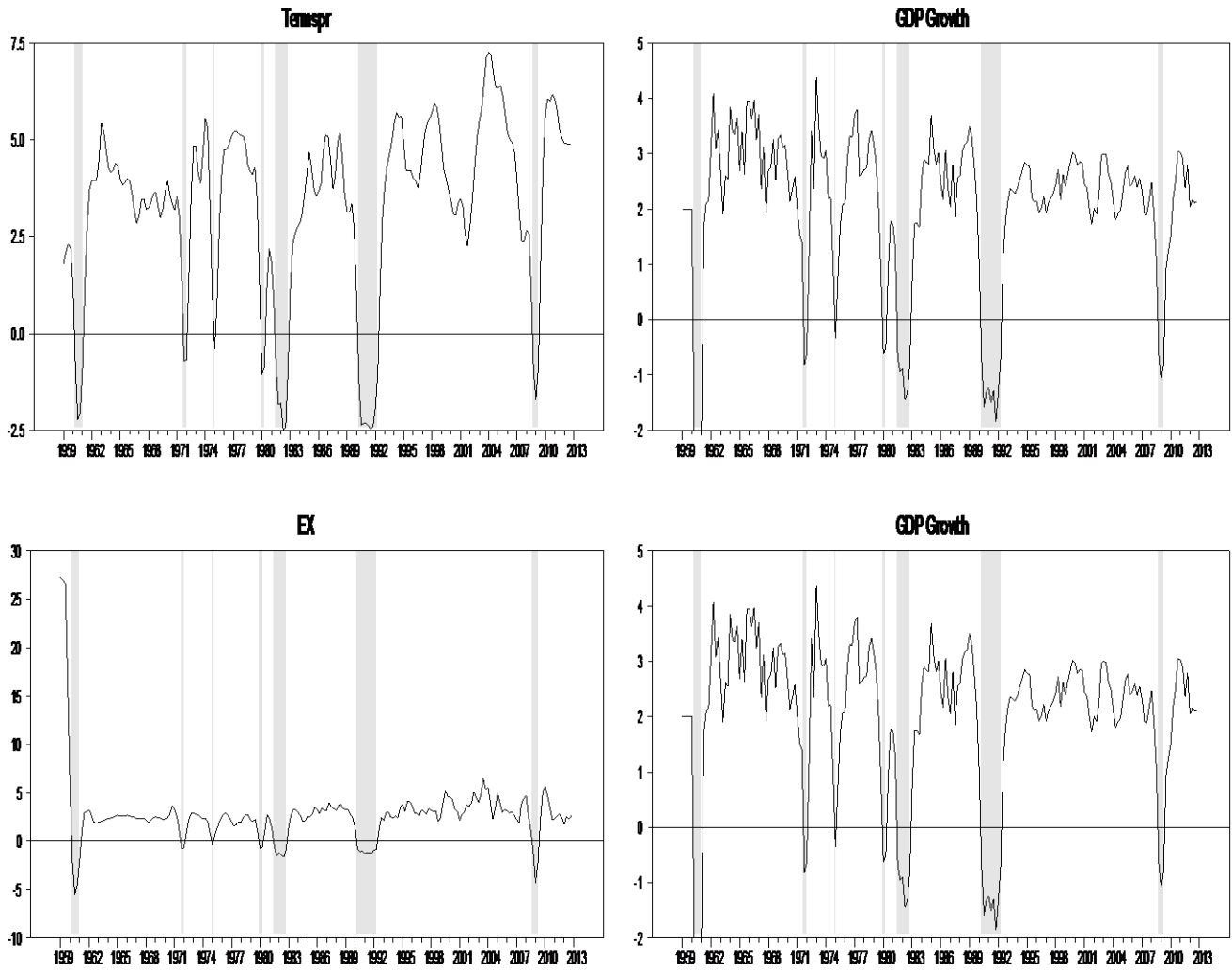
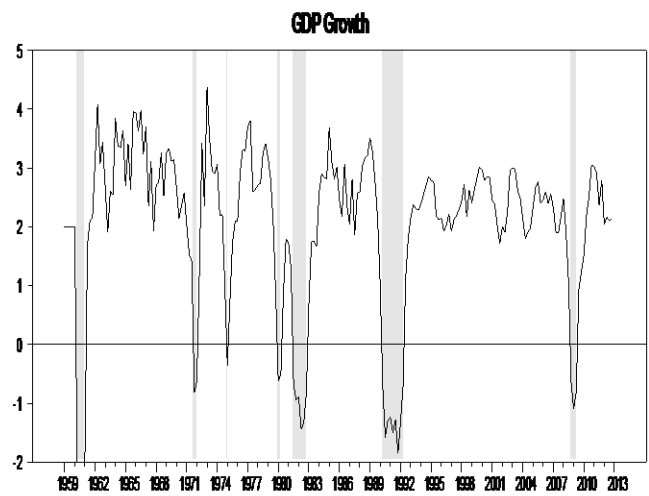
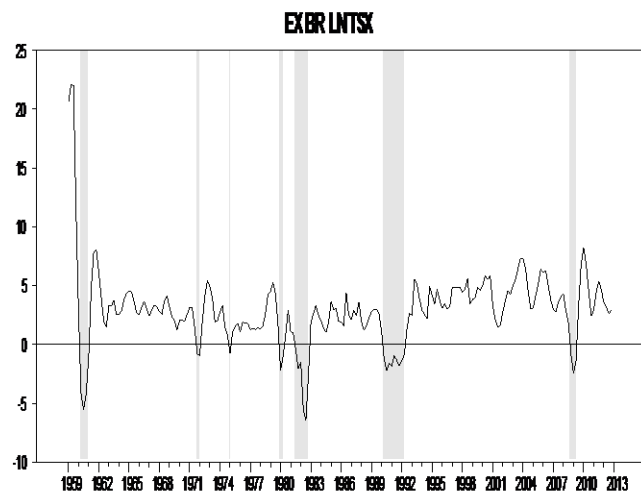
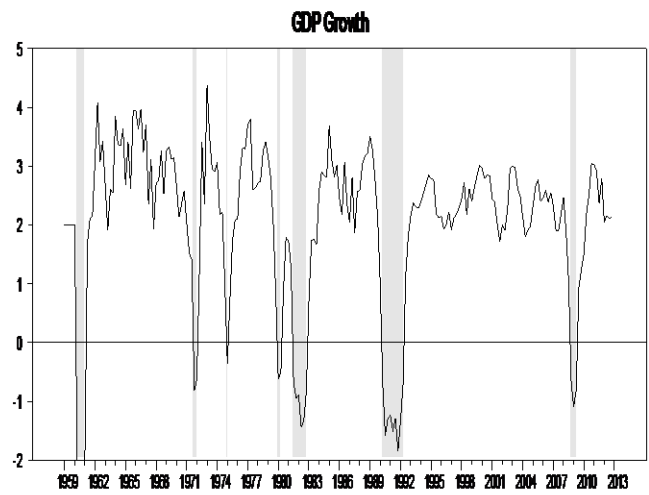
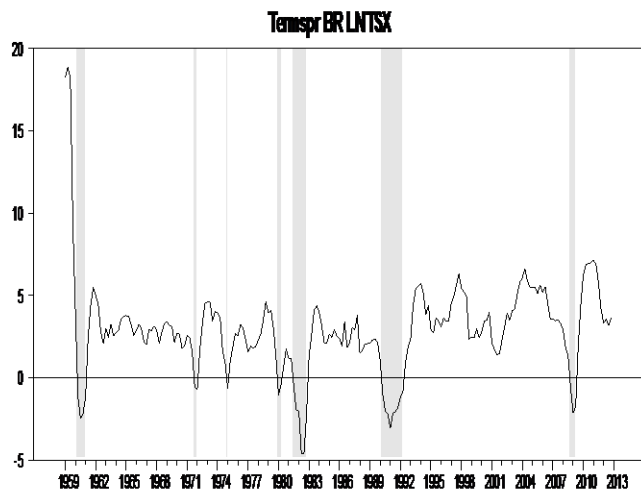
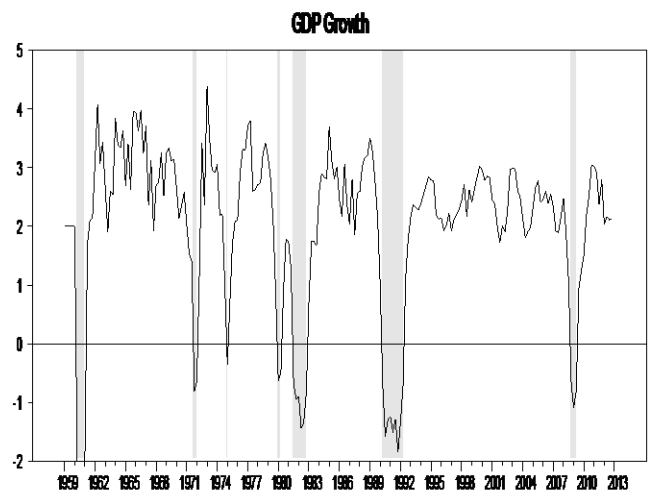
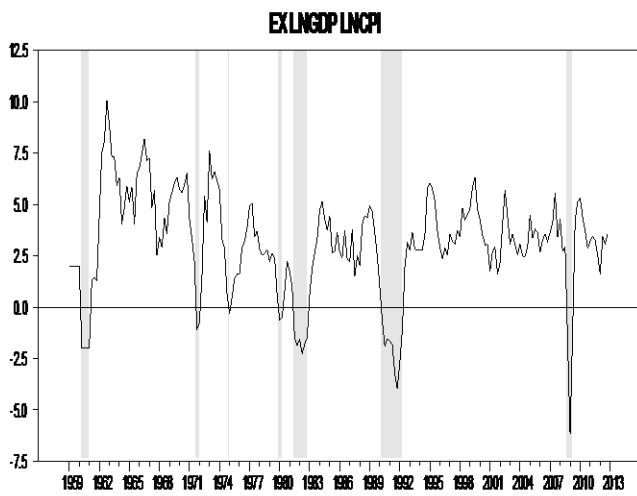
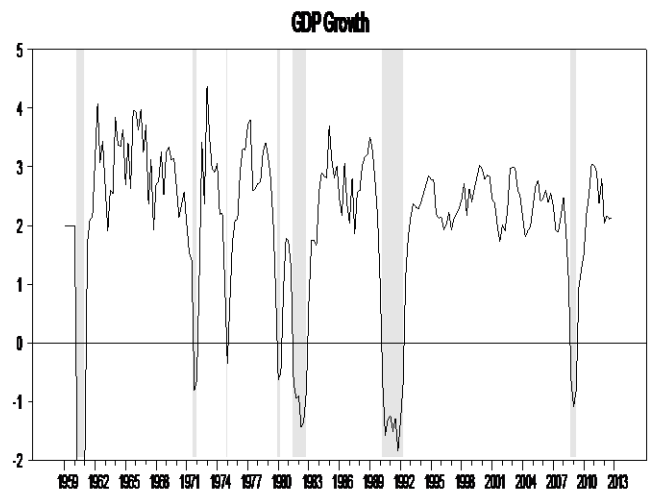
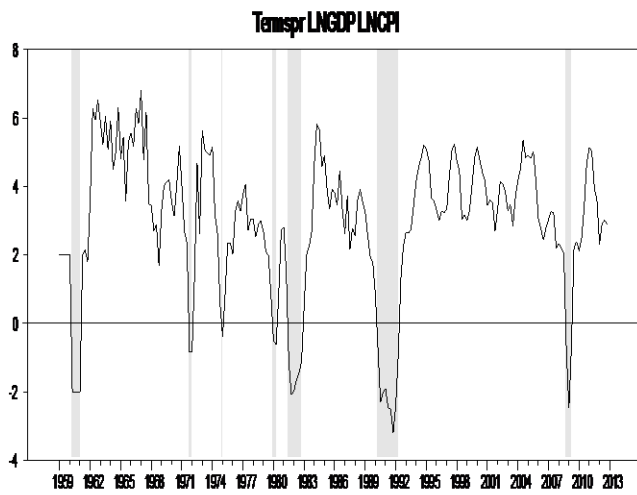


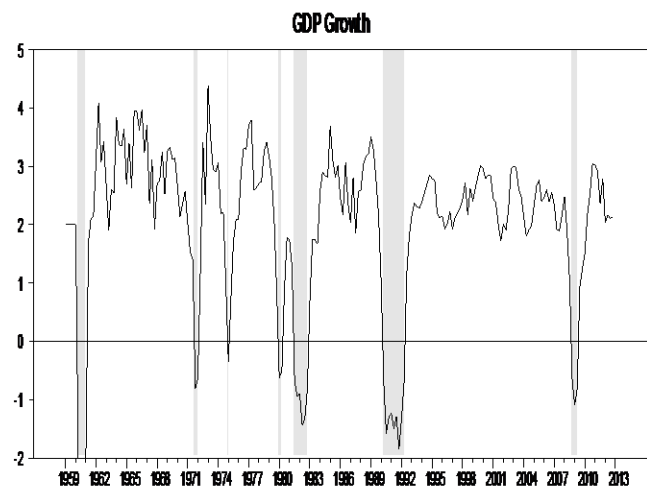
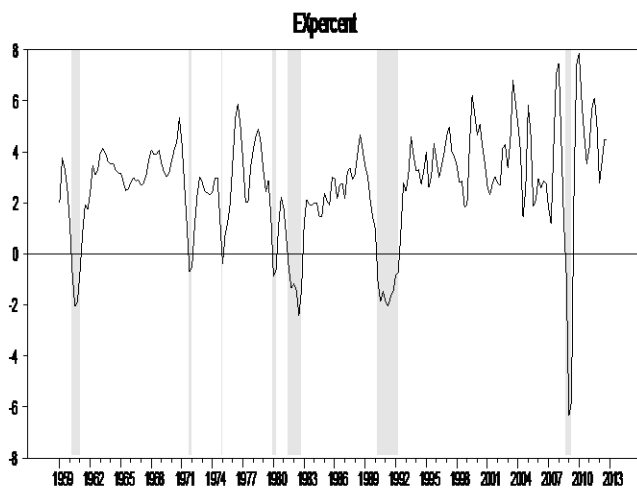
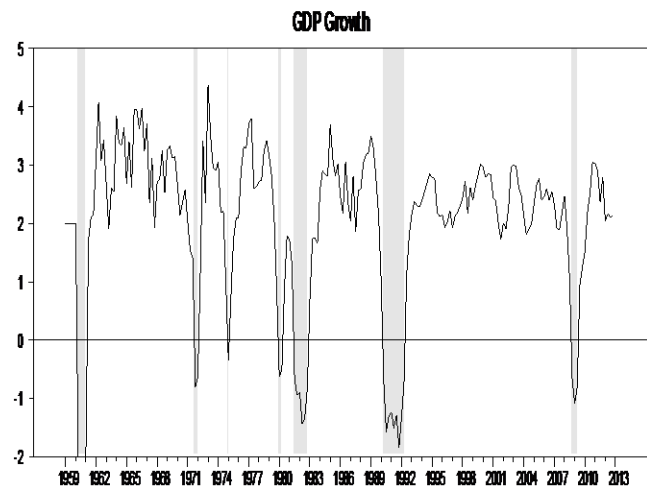
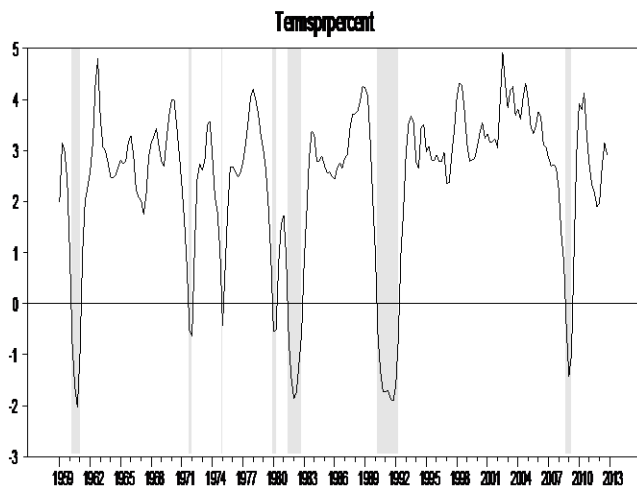
Figure 1. Models L1 and L2 with growth rate of real GDP



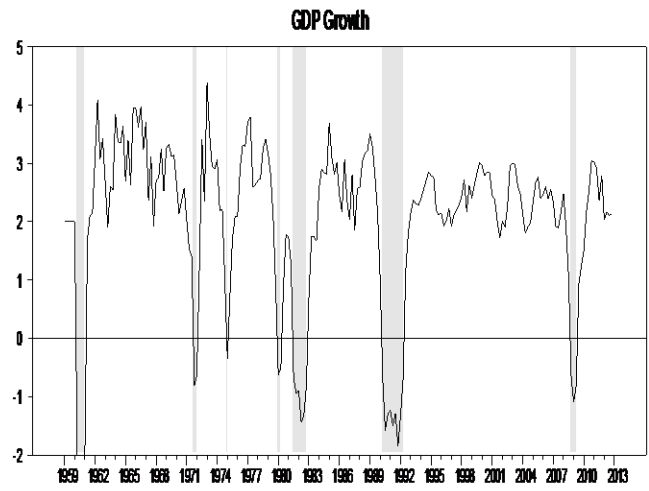
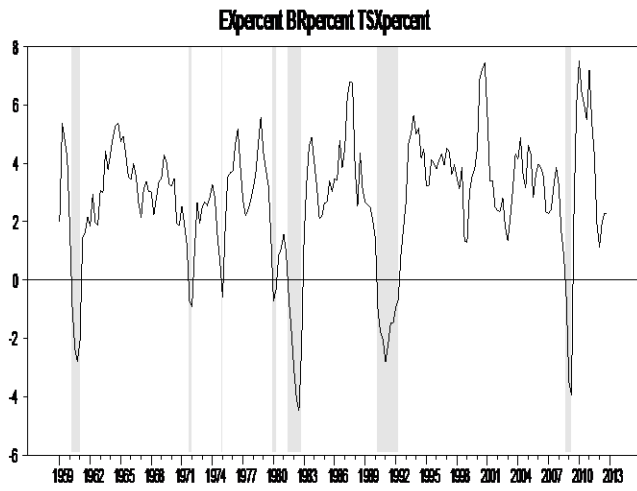
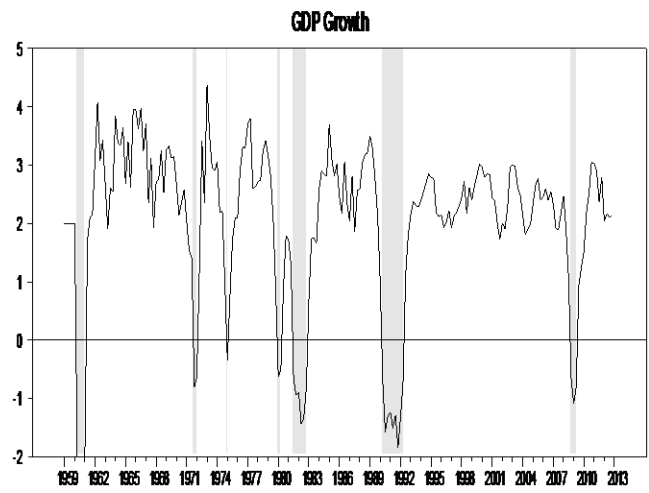
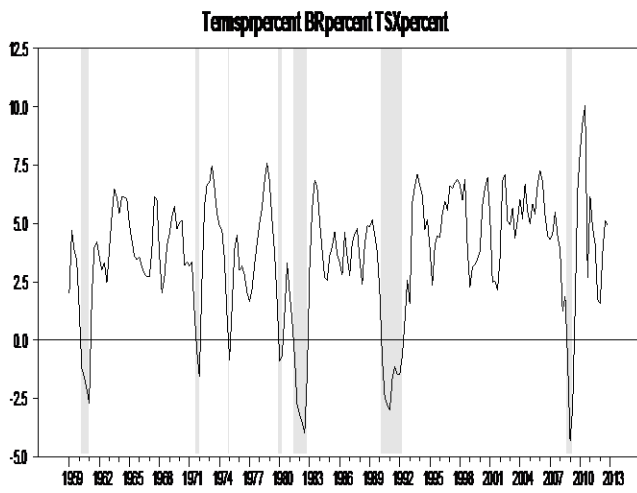
**Figure 2. Models L3 and L4 with growth rate of real GDP**



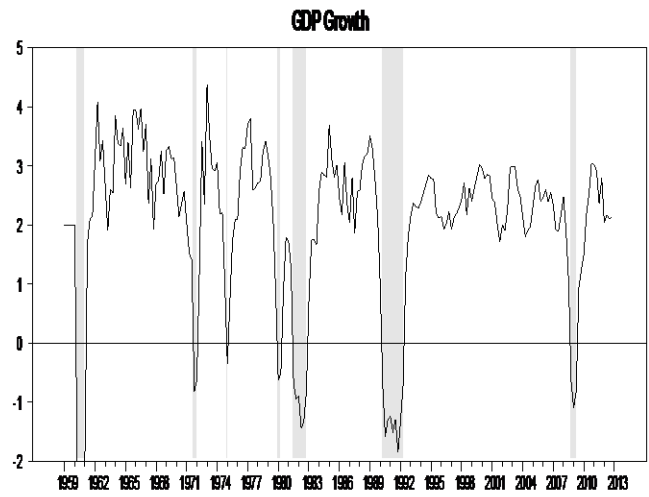
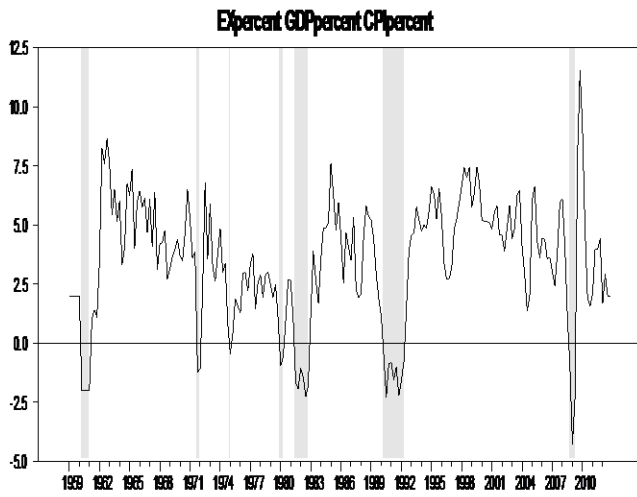
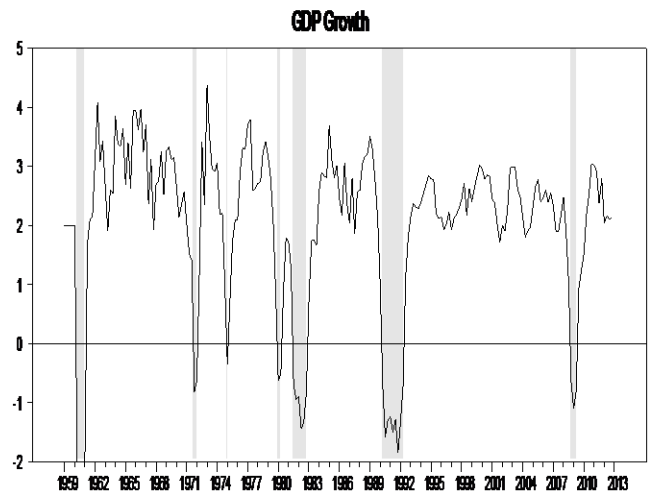
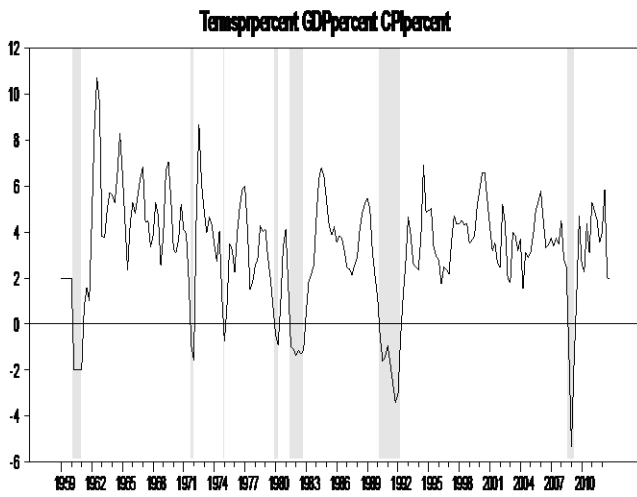
**Figure 3 Models L5 and L6 with growth rate of real GDP**



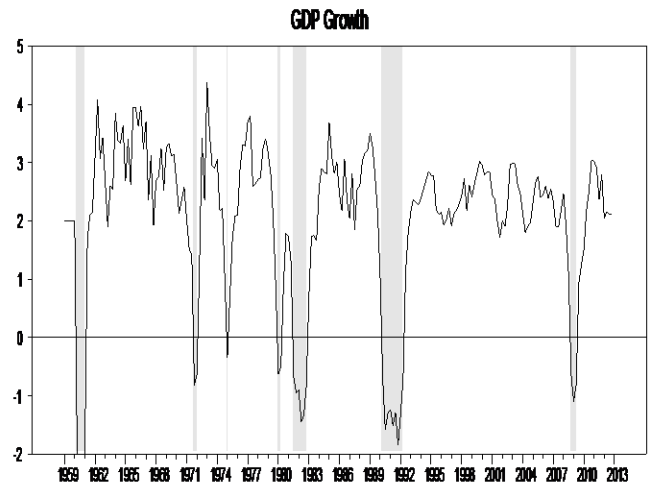
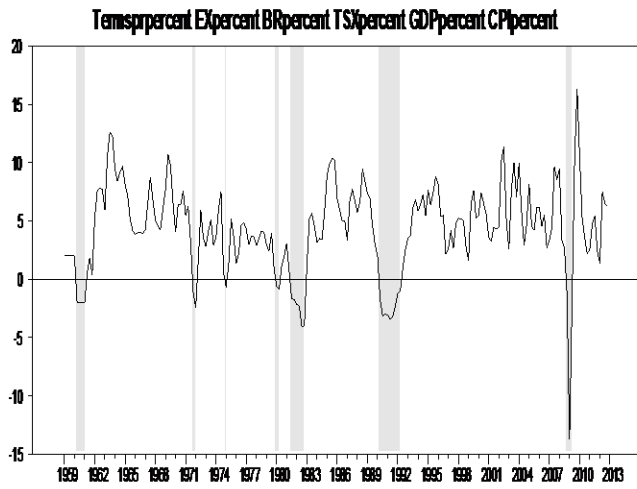
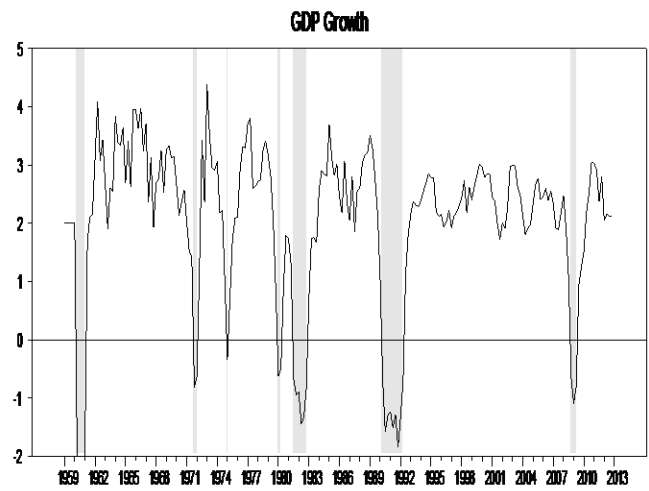
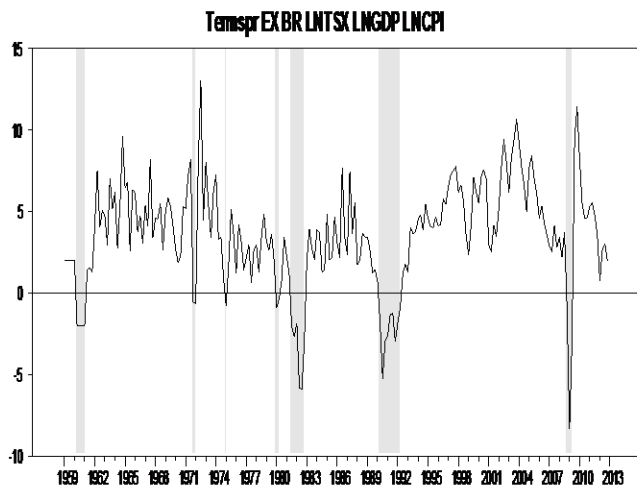
**Figure 4. Models G1 and G2 with growth rate of real GDP**



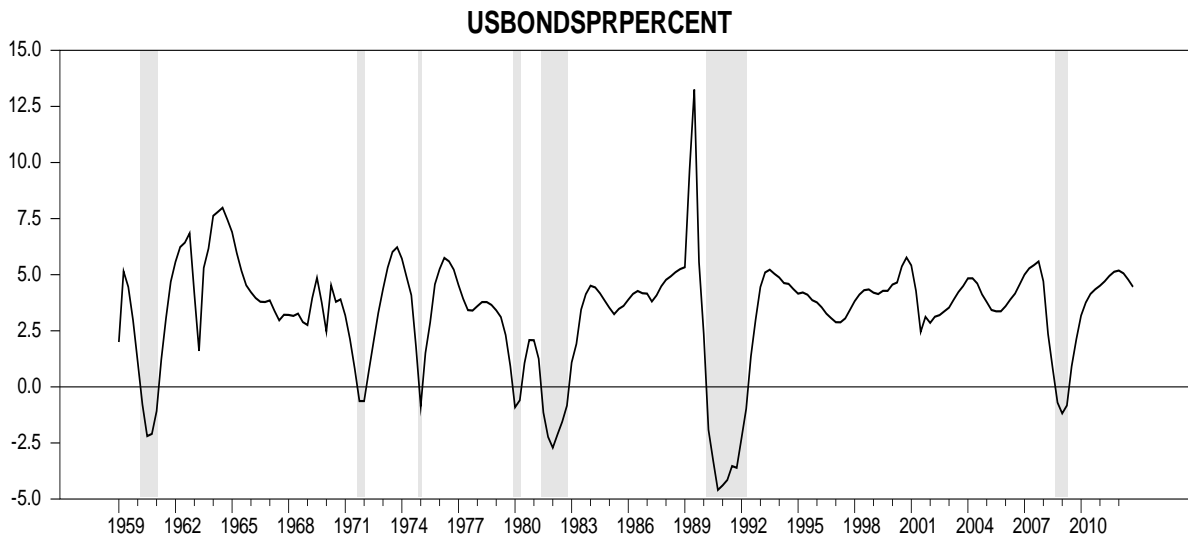
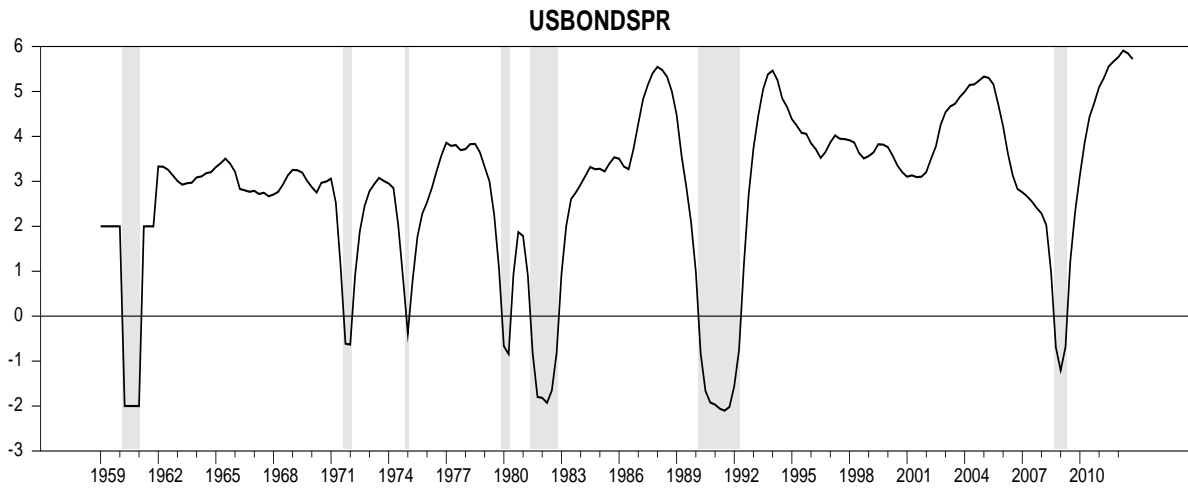
**Figure 5. Models G3 and G4 with growth rate of real GDP**



**Figure 6. Models G5 and G6 with growth rate of real GDP**



**Figure 7. Models L7 and G7 with growth rate of real GDP**



**Figure 8. Model L8 and G8 include the US term spread**

## Appendix 2: Tables

<b>Variables</b>	<b>Definitions</b>	<b>CANSIM Table Reference</b>	<b>Level Form Label</b>	<b>Log-Transformation or Not</b>	<b>Growth Rate Form Label</b>
<b>Term Spread</b>	Difference between 10-year and 3-month Canadian Marketable bonds/US treasury bills yield	Table 176-0043	Termspr	No	Termsprpercent
<b>US Term Spread</b>		Table 176-0044	USTermspr		USTermsprpercent
<b>Exchange Rate</b>	Average noon spot exchange rate between US and Canada	Table 176-0064	Ex	No	Expercent
<b>Bank Rate</b>	Bank of Canada announced Bank Rate on every Wednesday	Table 176-0043	BR	No	BRpercent
<b>TSX Index</b>	Standard and Poor's TSX closed Index	Table 176-0047	LNTSX	Yes	TSXpercent
<b>Real GDP</b>	Expenditure-based chain-weighted real GDP	Table 380-0002	LNGDP	Yes	GDPpercent
<b>CPI</b>	Consumer Price Index based on 2011 Canadian consumer's representative consumption basket	Table 326-0020	LNCPI	Yes	CPIpercent

**Table 1. Precise information, data sources, and labels for six indicators used in this study**

<b>Recession Starting Point</b>	<b>Recession End Point</b>	<b>Length (Quarters)</b>	<b>Total Decline in Real GDP from the Beginning to the End of the Recession</b>
1960: Q2	1961: Q1	4	-1.4%
1975: Q1	1975: Q1	1	-0.4%
1980: Q1	1980: Q2	2	-0.2%
1981: Q3	1982: Q4	6	-4.9%
1990: Q2	1992: Q2	8	-3.4%
2008:Q4	2009: Q2	3	-3.3%

**Table 2a. Definition of recession turning points and fluctuations in real GDP**

**Source: C.D.Howe's Commentary No. 366. Available at  
[http://www.cdhowe.org/pdf/Commentary\\_366.pdf](http://www.cdhowe.org/pdf/Commentary_366.pdf)**

<b>Periods</b>	<b>Statistics Canada Recession Indicator</b>	<b>Real GDP Fluctuations from Last Quarter</b>
2008:Q2	0	+0.1%
2008:Q3	0	+0.2%
2008:Q4	1	-0.9%
2009:Q1	1	-2.0%
2009:Q2	1	-0.9%
2009:Q3	0	+0.4%
2009:Q4	0	+1.2%
2010:Q1	0	+1.4%
2010:Q2	0	+0.6%
2010:Q3	0	+0.6%
2010:Q4	0	+0.8%
2011:Q1	0	+0.9%

**Table 2b. Statistics Canada announced recession periods and associated changes in GDP**

**Source: Statistics Canada. Available at <http://www.statcan.gc.ca/>**

<b>Level Group</b>	<b>Models</b>	<b>Figures</b>
<b>Model L1</b>	Term Spread and Recession Indicator	1
<b>Model L2</b>	Exchange Rate and Recession Indicator	1
<b>Model L3</b>	Term spread; Bank Rate; TSX Index and Recession Indicator	2
<b>Model L4</b>	Exchange Rate; Bank Rate; TSX Index and Recession Indicator	2
<b>Model L5</b>	Term Spread; Growth rate of GDP; CPI and Recession Indicator	3
<b>Model L6</b>	Exchange Rate; Growth rate of GDP; CPI and Recession Indicator	3
<b>Model L7</b>	Term Spread; Exchange Rate; Bank Rate; TSX Index; Growth rate of GDP; CPI and Recession Indicator	7
<b>Growth rate group</b>		
<b>Model G1</b>	Growth rate of Term Spread and Recession Indicator	4
<b>Model G2</b>	Growth rate of Exchange Rate and Recession Indicator	4
<b>Model G3</b>	Growth rate of Term Spread; Growth rate of Bank Rate; Growth rate of TSX Index and Recession Indicator	5
<b>Model G4</b>	Growth rate of Exchange Rate; Growth rate of Bank Rate; Growth rate of TSX Index and Recession Indicator	5
<b>Model G5</b>	Growth rate of Term Spread; Growth rate of GDP; Inflation Rate and Recession Indicator	6
<b>Model G6</b>	Growth rate of Exchange Rate; Growth rate of GDP; Inflation Rate and Recession Indicator	6
<b>Model G7</b>	Growth rate of Term Spread; Growth rate of Exchange Rate; Growth rate of Bank Rate; Growth rate of TSX Index; Growth rate of GDP; Inflation Rate and Recession Indicator	7

**Table 3. Grouping of models used for in-sample analysis. Each model include the recession indicator**

<b>Dates</b>	<b>Term spread</b>	<b>Exchange rate</b>	<b>Bank rate</b>	<b>TSX index</b>	<b>GDP growth</b>	<b>Inflation</b>	<b>Recession Indicator</b>
2008:Q2	.0425	.1230	.0035	.0180	.0095	.0025	0
2008:Q3	.0525	.3930	.0025	.0095	.0125	.0040	0
2008:Q4	.0255	.2405	.0010	.0035	.0075	.0050	1

**Table 4. Three quarters ahead forecasting probability based on six individual indicators**

<b>Dates</b>	<b>Term spread/Exchange rate forecast</b>	<b>Term spread/Exchange rate/GDP growth</b>
2008:Q2	.3935	.3075
2008:Q3	.7365	.5535
2008:Q4	.4925	.4100

**Table 5. Three quarters ahead forecasting probability based on combinations of variables**

<b>Date</b>	<b>Term Spread</b>	<b>Exchange rate</b>	<b>Bank rate</b>	<b>TSX index</b>	<b>GDP growth</b>	<b>Inflation</b>	<b>Indicator</b>
2008:Q2	.0715	.1190	.0040	.0160	.0070	.0210	0
2008:Q3	.1155	.3750	.0015	.0090	.0085	.0130	0
2008:Q4	.0695	.2295	.0005	.0045	.0070	.0005	1
2009:Q1	.0830	.0505	.0005	.0025	.0045	.0000	1
2009:Q2	.0320	.0365	.0010	.0015	.0010	.0000	1
2009:Q3	.0075	.0165	.0000	.0015	.0005	.0000	0
2009:Q4	.0040	.0055	.0005	.0015	.0010	.0000	0
2010:Q1	.0000	.0030	.0005	.0010	.0005	.0000	0
2010:Q2	.0000	.0025	.0005	.0010	.0000	.0000	0
2010:Q3	.0000	.0020	.0010	.0010	.0005	.0000	0
2010:Q4	.0000	.0015	.0010	.0010	.0000	.0000	0
2011:Q1	.0000	.0010	.0010	.0010	.0000	.0000	0

**Table 6. Twelve quarters ahead forecasted recession probability based on six indicators**

<b>Dates</b>	<b>Exchange rate/Term spread</b>	<b>Exchange rate/Term spread/GDP growth rate</b>
2008:Q2	.5040	.4325
2008:Q3	.8690	.7950
2008:Q4	.6755	.5850
2009:Q1	.0420	.4240
2009:Q2	.0015	.3190
2009:Q3	.0005	.3000
2009:Q4	.0010	.2525
2010:Q1	.0005	.2575
2010:Q2	.0010	.2065
2010:Q3	.0040	.1635
2010:Q4	.0070	.1300
2011:Q1	.0065	.1265

**Table 7. Twelve quarters ahead forecasted recession probability based on combination of indicators**