Bank of Canada Banque du Canada

Working Paper 2001-18 / Document de travail 2001-18

Evaluating Factor Models: An Application to Forecasting Inflation in Canada

by

Marc-André Gosselin and Greg Tkacz

ISSN 1192-5434

Printed in Canada on recycled paper

Bank of Canada Working Paper 2001-18

November 2001

Evaluating Factor Models: An Application to Forecasting Inflation in Canada

by

Marc-André Gosselin[1] and Greg Tkacz[2]

[1]International Department
[2]Monetary and Financial Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
mgosselin@bank-banque-canada.ca
gtkacz@bank-banque-canada.ca

Contents

Acknowledgements

Thanks to Robert Lafrance, David Longworth, John Murray, Graydon Paulin, James Powell, Larry Schembri, Jack Selody, Pierre St-Amant, and to seminar participants at the Bank of Canada, Canadian Economics Association (Montreal), and Western Economic Association International (San Francisco) for several valuable comments and suggestions.

Abstract

This paper evaluates the forecasting performance of factor models for Canadian inflation. This type of model was introduced and examined by Stock and Watson (1999a), who have shown that it is quite promising for forecasting U.S. inflation. Using a dimension-reduction method similar to traditional principal-components analysis, we extract a small number of factors from a sample consisting of both Canadian and U.S. data and construct four different factor models. Using parametric and non-parametric tests, we compare the forecasting performance of the factor models to various benchmark forecasting models. We conclude that factor models are as good as more elaborate models in forecasting Canadian inflation. Moreover, we find evidence that a model estimated using only U.S. data is helpful in predicting changes in the Canadian inflation rate.

JEL classification: C32, E37
Bank classification: Inflation and prices; Econometric and statistical methods

Résumé

Les auteurs évaluent la capacité des modèles factoriels de prévoir l'inflation au Canada. Ce type de modèle a été proposé et étudié par Stock et Watson (1999a), qui ont obtenu des résultats très prometteurs en ce qui concerne la prévision de l'inflation aux États-Unis. Au moyen d'une méthode de réduction de la dimension de l'espace des caractéristiques qui s'apparente à une analyse classique des composantes principales, les auteurs extraient un petit nombre de facteurs à partir d'un ensemble de données canadiennes et américaines et élaborent quatre modèles factoriels différents. Ils comparent le pouvoir de prévision de leurs modèles factoriels à divers modèles de prévision en usage, en se servant pour cela de tests paramétriques et non paramétriques. Les auteurs concluent que les modèles factoriels parviennent aussi bien que des modèles plus sophistiqués à prévoir l'inflation au Canada. Ils constatent également qu'un modèle estimé uniquement au moyen de données américaines aide à prévoir l'évolution du taux d'inflation canadien.

Classification JEL : C32, E37
Classification de la Banque : Inflation et prix; Méthodes économétriques et statistiques

1. Introduction

The aggregate price level is affected by the saving, spending, and investment decisions of millions of individual households, firms, and levels of government, both domestic and foreign. As a result, its determinants are certainly numerous and can include such variables as the growth of monetary aggregates, exchange rates, capacity utilization, and interest rates, to name but a few. To be successful, any forecasting model of the rate of change of prices should incorporate as many of these determinants as possible.

Economists use the economic theory behind traditional inflation-forecasting models to guide their choice of explanatory variables for models such as the Phillips-curve type (e.g., Fillion and Léonard 1997) or the money-based vector-error-correction type (e.g., Engert and Hendry 1998). However, given the relatively small samples of macroeconomic data used, economists must necessarily make strong assumptions to limit the number of explanatory variables, since degrees of freedom are quickly lost with the addition of each variable.

An alternative to the theory-driven forecasting model is the data-driven model, where no limit on the number of explanatory variables is imposed. In essence, every conceivable variable can be used as long as its time span is sufficiently long, so that a small number of factors that most explain the data set can be extracted. This is similar to principal-components analysis, where key forecasting information is extracted from data sets for which the number of data series can exceed the number of observations. Such models can offer better forecast performance, although this occurs at the expense of being unable to give precise economic meaning to the underlying factors, which can only be identified in an approximate manner to economic fundamentals. Bernanke and Boivin (2000) argue that factor models have the advantage of offering a framework for analyzing data that is clearly specified and statistically rigorous, but that remains agnostic about the structure of the economy.

This approach was first used by Stock and Watson (1999a, b). By performing a simulated forecasting exercise with 215 monthly indicators, the authors find that, among others, factor models outperform various benchmark models such as a Phillips-curve model and a vector autoregression (VAR) based on output, prices, and interest rates. Following these authors, the Federal Reserve Bank of Chicago (2000) used factor analysis to construct the Chicago Fed National Activity Index (CFNAI), a monthly index of economic activity in the United States. The CFNAI is a common factor extracted from 85 monthly indicators of economic activity. Fisher (2000) found that this indicator led inflation relatively well over the last 40 years. For Canada, however, Brisson, Campbell, and Galbraith (2001) find that factor models cannot outperform the published GDP forecasts of the OECD, raising the possibility that the OECD information set may contain data that are not publicly available.

The purpose of this paper is to examine the performance of factor models at forecasting core Canadian inflation four quarters in advance. Recognizing that Canada is a small open economy that is affected by events outside its borders, we extract factors from three different samples that include (i) only domestic variables, (ii) domestic and U.S. variables, and (iii) only U.S. variables. Our results indicate that factor models are at least as good at forecasting inflation as the alternative models, and that substantial information for Canadian inflation is contained within U.S. data. In section 2 we briefly describe the benchmark and factor forecasting models, and in section 3 we describe the data set. An out-of-sample forecasting exercise is performed in section 4, and section 5 offers some conclusions.

2. Models

Our objective is to forecast the year-over-year growth rate of the core inflation rate, defined as the consumer price index (p_t), excluding food, energy, and the effect of changes in indirect taxes. For our purposes, the inflation rate (π_t) is computed as

$$\pi_t = \log\left(\frac{p_t}{p_{t-4}}\right) \times 100 . \tag{1}$$

In our out-of-sample forecasting exercise, we use quarterly data from 1969Q1 to 1989Q1 to estimate the parameters of each model, which are then used to produce a forecast of inflation for 1990Q1. The sample is then extended to 1989Q2, the models are re-estimated, and we produce a forecast for 1990Q2. This procedure is repeated until we have a forecast for 2000Q1. Our forecasting sample of 1989 to 2000 is chosen for several reasons. First, it allows for a sufficiently large sample to initialize the parameters in the forecasting sample. Second, it incorporates a potential regime change with the large drop in inflation that occurred in 1991. Finally, the forecasting sample also encompasses the entire period through which the Bank has adhered to a policy aimed at keeping inflation within a specified band, which is currently 1 to 3 per cent.

2.1 Benchmarks

Any serious forecasting model should at least outperform naive time-series benchmarks. For this purpose we consider two naive benchmarks, namely a random-walk model and an AR(4) model. These are respectively specified as

$$\pi_t = \pi_{t-4} + \varepsilon_t \tag{2}$$

and

$$\pi_t = \alpha_0 + \alpha_1 \pi_{t-4} + \varepsilon_t, \tag{3}$$

where α_0 and α_1 are parameters to be estimated, and ε_t is an identically, independently distributed (i.i.d.) error term. For the random-walk model (2), the inflation forecast at t+4 is simply the inflation rate that was observed at time t. The AR model (3) is more general, as the slope and intercept are not constrained to equal 1 and 0, respectively.

In addition to the naive benchmarks, we consider the performance of the vector-error-correction model (VECM) of Engert and Hendry (1998). This model is constructed around an equilibrium relationship among money, output, prices, and interest rates, and includes, among others, dummy variables to account for changes in policy regimes and potential structural breaks caused by financial innovations in the 1980s and 1990s. It is specified as

$$\Delta V_t = \Gamma(L)\Delta V_t + DZ_t + \phi\theta'[V_{t-1}] + \varepsilon_t,$$

where V_t is a vector containing the endogenous variables (money, output, prices, and interest rates), Z_t is a vector of stationary exogenous variables, and ε_t is an error term. $\Gamma(L)$ contains the parameters of a lag process of V_t and the matrix D consists of the parameters on the exogenous variables. ϕ measures the short-run adjustment of the endogenous variables toward their long-run equilibrium and θ' is the matrix of parameters on the long-run cointegrating relationships within the model. We do not compare our results to a Phillips-curve type model, since Engert and Hendry (1998) showed that the VECM was superior in terms of forecasting performance throughout the 1990s.

2.2 Factor models

Factor analysis can be used to combine the information content of several different variables into one (or few) representative factors. For example, if growth rates of money and credit are two potentially useful explanatory variables for the rate of inflation, then we could combine the useful information content of money and credit into a single explanatory variable (factor) through the use of a regression line that represents the “best” summary of the linear relationship between money and credit. Generalizing this procedure to hundreds of potential explanatory variables, we can extract a handful of representative factors, similar to weighted linear combinations of all the variables.

To perform factor analysis, a number of issues need to be addressed; namely, the time series to use, the optimal number of factors to extract, and the economic interpretations of the selected factors. The advantage of factor analysis is the use of information from a much wider data set than that of standard regression models, and potentially more accurate forecasts.

We denote the number of variables in the sample as N, and we let T represent the sample size. All variables are of similar frequency (quarterly) and available over a similar time period, so T observations are available for each variable. Unlike traditional regression models, the number of explanatory variables in the model is not constrained by the sample size, so N may exceed T. Thus, X_{it} for $i = 1, ..., N$ and $t = 1, ..., T$ represents the observed value of explanatory variable i at time t. In our sample we have between $N = 110$ and $N = 444$ variables, depending on the constraints we impose on the data, and $T = 124$ observations.

To construct a forecasting model, we must first extract a pre-specified number of factors from the available N variables. Let q denote the maximum number of lags and $\bar{r}$ represent the pre-specified number of factors to extract from the data. In our work we set $\bar{r}$ to 10, since the marginal information content of every additional factor is relatively small. In other words, we find that 10 factors capture most of the common variance of the entire data set.

We express the explanatory variables as a function of the unknown factors as

$$X_{it} = \lambda_i(L)F_t + e_{it}, \tag{4}$$

where $F_t = (f_t, ..., f_{t-q})$ is a $r \times 1$ vector, $r = (q+1)\bar{r}$, and $\lambda_i(L)$ is a lag polynomial.[1] The factor f_t and disturbance e_{it} are assumed to be mean-zero stochastic processes. The explanatory variable X_{it} is expressed as a deviation from the mean.

The factor F_t is estimated by the method of principal components. This involves minimizing the sum of squared residuals of (4), which can be expressed as a non-linear objective function

$$V(F, \Lambda) = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T}(X_{it} - \lambda'_i F_t)^2}{NT} \quad . \tag{5}$$

1. λ_i(L) is the i-th line of the factor loading matrix Λ. Stock and Watson (1999a) show that the factors are consistently estimated by principal components even in the presence of time-varying parameters.

After concentrating out F, minimizing (5) is equivalent to maximizing $tr[\Lambda'(X'X)\Lambda]$, subject to $\frac{(\Lambda'\Lambda)}{N} = I_r$, where $\Lambda = (\lambda_0, ..., \lambda_q)$ and each λ is of dimension $N \times 1$ (see Stock and Watson 1999a). The principal-components estimator of F is thus

$$\hat{F} = (X\hat{\Lambda})/N \cdot \tag{6}$$

$\hat{\Lambda}$ is obtained by setting it equal to $N^{1/2}$ times the eigenvectors of the N x N matrix $X'X$ corresponding to its r largest eigenvalues. When N exceeds T, it can be computationally convenient to estimate $\hat{F}$ directly. By concentrating out Λ instead of F in (5), Stock and Watson (1999a) show that direct estimation is possible by setting $\hat{F}$ equal to $T^{1/2}$ times the eigenvectors of the T x T matrix XX' corresponding to its r largest eigenvalues. We chose this approach, since it involved dealing with significantly smaller matrices.

Having estimated the factors, the next step in the exercise is to construct a forecasting model for inflation. The forecasting model is expressed as

$$\pi_{t+k} = \alpha\pi_t + \beta(L)\hat{F}_t + \varepsilon_{t+k}, \tag{7}$$

where π_t is the inflation rate expressed in (1), k is the forecast horizon (which is set to 4 in our work), β(L) is a lag polynomial, and ε_t is an i.i.d. process.

To perform the forecasting exercise, we need to choose the factors that enter the forecasting model (7), in addition to the optimal lag structure. Both the factors and lags are chosen by minimizing the Schwarz criterion (SC), since Ng and Perron (1995) noted that the SC is usually preferable to other competing information criteria. We begin by searching for the combination of estimated factors that minimize the SC of a linear regression. Once the factors are selected, we then search for the optimal lag structure that minimizes the same criterion. The model selected therefore minimizes the SC, but does not necessarily yield the minimal forecasted root-mean-squared error (RMSE).

3. Data and Estimation

We use quarterly data from 1969Q1 to 2000Q1. The sample size was chosen to strike a sensible balance between the number of variables that can be included in the study and the need to obtain sufficiently long periods of time for the estimation and forecasting samples. We use the period 1969 to 1989 to obtain initial estimates of the parameters of all the forecasting models, and 1990 to 2000 to conduct our forecasting exercise. We employ 334 Canadian and 110 U.S. macroeconomic and financial variables in this study, which are listed in the Data Appendix. Since we require stationary data, non-stationary variables are transformed by first-differencing, where necessary. All series are standardized to have a sample mean of zero and unit sample variance.

In this paper we consider four different factor models. Recognizing that Canada is a small open economy, inflation in Canada is likely influenced by events outside its borders, namely by the actions of its largest trading partner, the United States.[2] Thus, we estimate models with and without U.S. data. More specifically:

- Model 1 uses all 334 Canadian variables. In Model 1, we extract $\bar{r} = 10$ factors.[3]
- Model 2 uses the same 334 variables but groups them according to their economic sectors, and we extract only $\bar{r} = 1$ factor from each sector.[4] Since Model 2 is a restricted version of Model 1, we expect its forecasting performance to be inferior to that of Model 1. This grouping involves ad hoc sample stratification, but it aids in the identification of the underlying economic factors that characterize the Canadian economy.
- In Model 3 we estimate 10 underlying factors from the 110 U.S. variables.
- In Model 4 we pool together the Canadian and U.S. data, from which 10 factors are extracted. The factors extracted from this sample explain the common variance of both U.S. and Canadian data, so identification of the factors is very difficult. On the other hand, by using the widest data set with the fewest restrictions, this last model should have the best forecast performance, assuming that there is relevant information content in both the U.S. and Canadian data.

Table 1 presents the full-sample parameter estimates for the four factor models. The SC yields a small three-factor model in each case. Model 1 regresses inflation on AR terms, factor 1, factor 3, and factor 8.[5] We find that the first factor in Model 1 carries the heaviest weight, with the three factors being plotted in Figure 1. Although we make no attempt to provide an exact structural interpretation of the factors, they could be regressed on the Model 2 factors to determine which sector of the economy each is most highly correlated with.

---

2. Exports total more than 45 per cent of Canadian GDP, with 80 per cent of these exports going to the United States and 70 per cent of Canadian imports originating from the United States.
3. The total number of factors actually extracted is imposed by the number of observations available. Since our conditioning data set covers the period 1969–2000, XX' is 124x124. This yields 124 eigenvectors, each of length 124. For the purpose of our analysis, we choose to keep only 10 of these factors (the ones corresponding to the 10 largest eigenvalues).
4. We define eleven economic sectors: production, housing, employment, prices, capacity utilization, government, retail trade, interest rates, money and credit, international trade, and stock prices.
5. As measured by the trace-R^2, we find that the three selected factors of Model 1 account for a full 26 per cent of the variance in the whole economy of 334 variables. The marginal contribution of each additional factor (i.e., the size of its corresponding eigenvalue) declines rapidly.

The specification of Model 2 enables us to identify three structural variables: factors 4 (prices), 5 (capacity utilization rate), and 9 (money and credit); see Figure 2. The price factor is the one with the heaviest weight in this model and the sign on its parameter is negative. A possible explanation is that this factor captures cyclical effects in price movements. Upon examination of Figure 2, we find that factor 4 resembles the negative of inflation.

Model 3 has the lowest in-sample fit, as denoted by the marginally lower $\overline{R}^2$. This suggests that U.S. variables have less explanatory power for Canadian inflation than Canadian variables do. Factors selected for Models 3 and 4 are depicted in Figures 3 and 4, respectively. Over some periods, factor 1 of Model 3 resembles the CFNAI (see Federal Reserve Bank of Chicago 2000).

4. Forecasts

We begin this section by summarizing the forecast performance of each model using standard summary statistics, such as the RMSE, mean absolute deviation (MAD), and confusion rate (CR), which indicates a forecast's directional accuracy. Bounded by 0 and 1, a value of 0 for the CR would indicate that every change in the direction of the inflation rate has been captured, while a value of 1 would indicate that every change has been incorrectly predicted. Tests comparing the statistical significance in forecast errors across models are performed in section 4.2.

4.1 Summary statistics

Table 2 presents the performance of the four factor models along with the three benchmarks. Our forecasting sample period extends from 1990Q1 to 2000Q1, thereby encompassing the large drop in inflation that occurred in the early 1990s following the decline in real economic activity. Throughout the rest of the decade, inflation remained low and stable, anchored by the Bank's 1 to 3 per cent target band. Based on the summary diagnostics, we find that the factor models perform better than some of the alternatives. The root-mean-squared inflation-forecast errors of the factor models are between 0.71 and 0.78, whereas the RMSEs are 0.74, 0.83, and 1.16 per cent per quarter from the VECM, random-walk, and AR models, respectively. Given that inflation has remained low and stable for most of these periods, the no-change forecasts produced by the random-walk model provide a strong benchmark with which to compare the performance of the factor models.

Apart from the large drop in inflation occurring in 1991, movements in inflation have been relatively mild, as shown in Figure 5, which depicts the forecasts from factor models 1 and 3, and the VECM. Nevertheless, all three of these models correctly forecasted the large drop in inflation.

Although all models have roughly similar average forecast errors, it is apparent that the forecast errors of the VECM are more serially correlated than those of the factor models, indicating that the VECM is more prone to making consistently positive or negative forecast errors.[6] Moreover, we note that only forecast errors in Models 1, 3, and 4 are normally distributed (according to the Bowman-Shenton test, with a 95 per cent confidence level), which indicates that those models are more suitable for constructing confidence bands around the inflation forecasts than the alternatives. The large error of Model 1 occurring around 1995 (Figure 5) is likely imputable to factor 1. This factor has shown a temporary but important increase over this period. A structural economic interpretation, which is beyond the scope of this paper, would have to be provided to explain the reasons for the movements in this factor.

With regard to the mild oscillations that have occurred since 1991, it is striking that Model 3, which uses only U.S. data, correctly predicts 75 per cent of all directional changes of Canadian inflation (having a CR of only 0.25). Canadian data appear to lead to less-accurate predictions of directional changes. The worse-performing models are the naive time-series benchmarks. With the exception of the VECM,[7] the benchmarks perform worse than factor models, only correctly predicting about 30 per cent of such directional changes (having a CR of 0.7). This indicates that the estimated factors contain useful information regarding the movements in inflation.

It is surprising that Canadian inflation forecasts are at least as good through the use of only 110 U.S. variables (Model 3) compared with 334 for Canada (Model 1). In general, a subset of the 334 Canadian variables should yield less-accurate forecasts, since less information is considered, but here a smaller set of U.S. variables can produce forecasts of similar quality. This indicates that careful selection of the relevant series can improve forecasts. Moreover, Model 3 is less subject to the Lucas critique than the other models, since it uses U.S. variables to explain Canadian price growth. Such a relationship is also less subject to instability as a result of a change in expectations, since it involves variables that are not affected by Canadian policies. As an experiment, we tested the robustness of our Model 3 results by reproducing the forecasting exercise for U.S. inflation. We found that U.S. inflation was better forecasted using U.S. data than Canadian data. Furthermore, our best model for forecasting U.S. inflation, in terms of lowest RMSE, was the one that included

6. This can also be seen from the Ljung-Box Q-stat, which is higher in the case of the VECM.
7. In this rolling forecast exercise, dummy variables modelling structural breaks were not excluded from the VECM, even though they were not known in advance. This significantly improved the model's forecasting performance. Nonetheless, it is clear that such a practice is not representative of a typical real-time forecasting exercise (since dummy variables cannot be identified ex ante).

both U.S. and Canadian data.[8] The inclusion of Canadian data therefore helps to span the global set of determining factors. Overall, these results are in line with our intuition.

4.2 Forecast-encompassing tests

As in Tkacz (2001), we perform three different forecast-encompassing tests, to determine whether the differences in forecast performance are statistically significant. We consider three different tests, since the underlying assumptions of each test may not hold in every case.

If forecast errors are defined from two competing models—base case (B) and alternative (A)—as $e_{A,t}$ and $e_{B,t}$, their sums and differences can then be defined, respectively, as $s_t = e_{A,t} + e_{B,t}$ and $d_t = e_{A,t} - e_{B,t}$. Ashley, Granger, and Schmalensee (1980), henceforth AGS, show that the equality of the mean-squared errors against the alternative (that the Model B errors are lower) can be determined by jointly testing the significance of the parameters β_1 and β_2 in the regression

$$d_t = \beta_1 + \beta_2(s_t - \bar{s}) + u_t, \tag{8}$$

where $\bar{s}$ is the mean of s_t and u_t is an i.i.d. normally distributed error.

The second test that we consider is the Morgan-Granger-Newbold (MGN) test of Diebold and Mariano (1995). Unlike the AGS test, the MGN test does not require the absence of contemporaneous correlation between forecasts. The statistic is constructed as

$$MGN = \frac{\hat{\rho}_{sd}}{\sqrt{\dfrac{1-\hat{\rho}_{sd}}{T-1}}}, \tag{9}$$

where $\hat{\rho}_{sd}$ is the contemporaneous correlation between s and d. If the forecasts are equally accurate, then the correlation between s and d will be zero.

Finally, we consider the non-parametric sign test as a method of evaluating the forecasts, as it does not rely on the assumption of normality of forecast errors. If T forecasts are produced, and if Model A forecast errors are greater than those of Model B in exactly $T/2$ periods, then both forecasts would be considered to be equally accurate. Model A would be considered to be worse if its forecast errors were higher than Model B's in more than $T/2$ periods. If $E(S_T)$ denotes the

8. This is consistent with Kuszczak and Murray (1987), who show that at least 20 to 30 per cent of the forecast variance of U.S. prices can be attributed to innovations in foreign variables.

expected number of periods in which Model A's errors exceed Model B's, then a test of H_0: $E(S_T) = T/2$ against H_1: $E(S_T) > T/2$ is given by

$$Sign = \frac{E(S_T) - T/2}{\frac{1}{2}\sqrt{T}} . \qquad (10)$$

The results of the various tests, presented in Table 3, are performed with Model 3 as the base-case (B) model. Of the benchmarks, we find that the AR and VECM models are statistically inferior to Model 3 at the 95 per cent level for the AGS test. The other tests, which have more power than the AGS test when the underlying assumptions do not hold, lead us to conclude that forecast errors of all the other models are not statistically different from those of Model 3. This implies that the models generate forecasts that are not statistically different. More work on the optimal lag structure of the factor models and on optimal functional forms, however, might improve the forecast performance of the factor models. Still, even if the RMSE is not significantly lowered, the factors nevertheless provide information useful in at least predicting changes in the direction of inflation (as shown by the CR, especially for Model 3). This is an important feature for monetary policy decisions.

5. Conclusion

This paper has evaluated a new type of inflation-forecasting model that exploits the relevant underlying factors extracted from a set of hundreds of macroeconomic and financial variables. Inflation is the product of the activities in hundreds of different markets; thus, the wider the information set at our disposal, the more likely we are to uncover the fundamental determinants of inflation.

Focusing on the year-over-year growth rate of core CPI, we constructed four different factor models. This practice was followed in an attempt to (i) take advantage of leading information from the estimated factors (Model 1), (ii) relate the underlying factors to fundamental macroeconomic variables (Model 2), and (iii) recognize the fact that the Canadian economy is an open economy that is affected by events outside its borders (Models 3 and 4). Comparing the forecast errors of the factor models and the benchmarks, we conclude that each model produces, statistically, equally accurate forecasts. The positive forecasting performance of the factor models occurs, however, at the expense of being unable to give exact economic meaning to the processes generating inflation.

We also conclude that there is some evidence that U.S. data may be helpful in predicting changes in the direction of Canadian inflation. This suggests that the U.S. is a data-rich environment that contains useful and substantial information for the modelling of other economies.

Several topics can be pursued in future research. For example, the construction of non-linear factor models, such that the underlying factors are linked to inflation within a non-linear framework, could potentially improve the inflation-forecast performance. Moshiri and Cameron (2000) find some evidence of non-linearities in the Canadian inflation process and note that neural network models perform as well as, or better than, traditional time-series models. Another potential research topic involves the estimation of forward-looking policy-reaction functions, which take as inputs factor-model forecasts of target variables.

References

Ashley, R., C.W.J. Granger, and R. Schmalensee. 1980. “Advertising and Aggregate Consumption: An Analysis of Causality.” *Econometrica* 48: 1149–68.

Bernanke, B.S. and J. Boivin. 2000. “Monetary Policy in a Data-Rich Environment.” Princeton University. Unpublished manuscript.

Brisson, M., B. Campbell, and J.W. Galbraith. 2001. “Forecasting Some Low-Predictability Time Series Using Diffusion Indices.” CIRANO Working Paper No. 2001s-46.

Diebold, F.X. and R.S. Mariano. 1995. “Comparing Predictive Accuracy.” *Journal of Business and Economic Statistics* 13: 253–63.

Engert, W. and S. Hendry. 1998. “Forecasting Inflation with the M1-VECM: Part Two.” Bank of Canada Working Paper No. 98–6.

Federal Reserve Bank of Chicago. 2000. *CFNAI Background Release*.

Fillion, J.-F. and A. Léonard. 1997. La courbe de Phillips au Canada: Un examen de quelques hypothèses.” Bank of Canada Working Paper No. 97–3.

Fisher, J.D.M. 2000. “Forecasting Inflation with a Lot of Data.” *Chicago Fed Letter* (March).

Kuszczak, J. and J.D. Murray. 1987. *A VAR Analysis of Economic Interdependence: Canada, The United States, and the Rest of the World*. Technical Report No. 47. Ottawa: Bank of Canada.

Moshiri, S. and N. Cameron. 2000. “Neural Network Versus Econometric Models in Forecasting Inflation.” *Journal of Forecasting* 19: 201–17.

Ng, S. and P. Perron. 1995. “Unit Root Tests in ARMA Models with Data Dependent Methods for the Truncation Lag.” *Journal of the American Statistical Association* 429: 268–81.

Stock, J.H. and M.W. Watson. 1999a. “Diffusion Indexes.” Princeton University. Unpublished manuscript.

———. 1999b. “Forecasting Inflation.” *Journal of Monetary Economics* 44: 293–335.

Tkacz, G. 2001. “Neural Network Forecasting of Canadian GDP Growth.” *International Journal of Forecasting* 17(1): 57–69.

Table 1: Estimated Parameters, Factor Models (1969Q1–2000Q1)

Variable	Estimate	*t*-stat	$\overline{R}^2$	S.E.E.
Model 1 (Canada)				
Constant	2.461	12.50	0.913	0.861
π_{t-4}	0.462	12.26		
$f_{1,t-4}$	19.020	16.18		
$f_{3,t-4\ to\ t-5}$	-3.936	-3.72		
$f_{8,t-4}$	-3.436	-3.89		
Model 2 (Canada by sector)				
Constant	2.788	9.08	0.920	0.823
$\pi_{t-4\ to\ t-5}$	0.391	6.15		
$f_{4,t-4}$	-14.661	-7.79		
$f_{5,t-4}$	4.466	3.35		
$f_{9,t-4}$	7.574	6.00		
Model 3 (United States)				
Constant	2.165	9.35	0.902	0.927
π_{t-4}	0.539	12.12		
$f_{1,t-4\ to\ t-8}$	14.904	8.75		
$f_{2,t-4}$	10.127	5.65		
$f_{7,t-4\ to\ t-5}$	3.481	2.37		
Model 4 (Canada and United States)				
Constant	1.975	10.69	0.908	0.883
π_{t-4}	0.564	16.24		
$f_{1,t-4}$	16.664	15.41		
$f_{3,t-4}$	2.894	3.24		
$f_{9,t-4}$	-2.246	-2.43		

Note: If there is more than one lag, we present the summary of the linear combination of the coefficients.

Table 2: Out-of-Sample Four-Quarter Inflation-Forecast Performance

1990Q1 to 2000Q1 (41 obs.)

Model	RMSE	MAD	Confusion rate	Normality $\chi^2(2)$	Q(1) $\chi^2(1)$	Q(4) $\chi^2(4)$
Model 1 (334 Can.)	0.752	0.589	0.575	2.228 (0.329)	12.65 (0.000)	19.32 (0.000)
Model 2 (334 Can., by sector)	0.782	0.578	0.475	7.573 (0.023)	11.19 (0.001)	16.89 (0.002)
Model 3 (110 U.S.)	0.717	0.563	0.250	0.484 (0.785)	7.63 (0.006)	11.71 (0.020)
Model 4 (444 Can. and U.S.)	0.714	0.579	0.450	2.054 (0.358)	15.86 (0.000)	24.54 (0.000)
AR(4)	1.164	0.583	0.700	8.624 (0.013)	26.63 (0.000)	37.77 (0.000)
Random walk	0.829	0.927	0.675	11.44 (0.003)	24.79 (0.000)	34.18 (0.000)
VECM	0.738	0.610	0.400	7.362 (0.025)	28.62 (0.000)	60.45 (0.000)

Notes: RMSE = root-mean-squared error; MAD = mean absolute deviation; Confusion rate = ratio of incorrect forecast directions; Normality = Bowman-Shenton non-normality test; Q(1) and Q(4) = Ljung-Box Q-test for serial correlation in the forecast errors of orders 1 and 4, respectively. VECM has 40 obs. from 1990Q1 to 1999Q4.

Table 3: Tests of Forecast-Error Equality

Base-case model (B): Model 3

Alternative model (A)	AGS $F(2,39)$	MGN $t(40)$	Sign $N(0,1)$	$\# e_A > e_B$ $\# e_B > e_A$
Model 1	1.517	1.166	-0.156	20
	(0.232)	(0.125)	(0.562)	21
Model 2	1.248	1.322	0.156	21
	(0.298)	(0.097)	(0.438)	20
Model 4	3.032	1.027	0.781	23
	(0.060)	(0.155)	(0.218)	18
AR(4)	9.982	1.379	2.343	28
	(0.000)	(0.088)	(0.010)	13
Random walk	1.528	1.661	-0.781	18
	(0.230)	(0.052)	(0.783)	23
VECM	8.320	1.204	-0.632	18
	(0.001)	(0.118)	(0.736)	22

Notes: $\# e_A > e_B$ is the number of periods in which the forecast error of Model A is greater than the forecast error of Model B. p-values are in parentheses (values less than 0.05 indicate that Model B is superior to Model A with at least 95 per cent confidence).

Figure 1: Selected Model 1 Factors

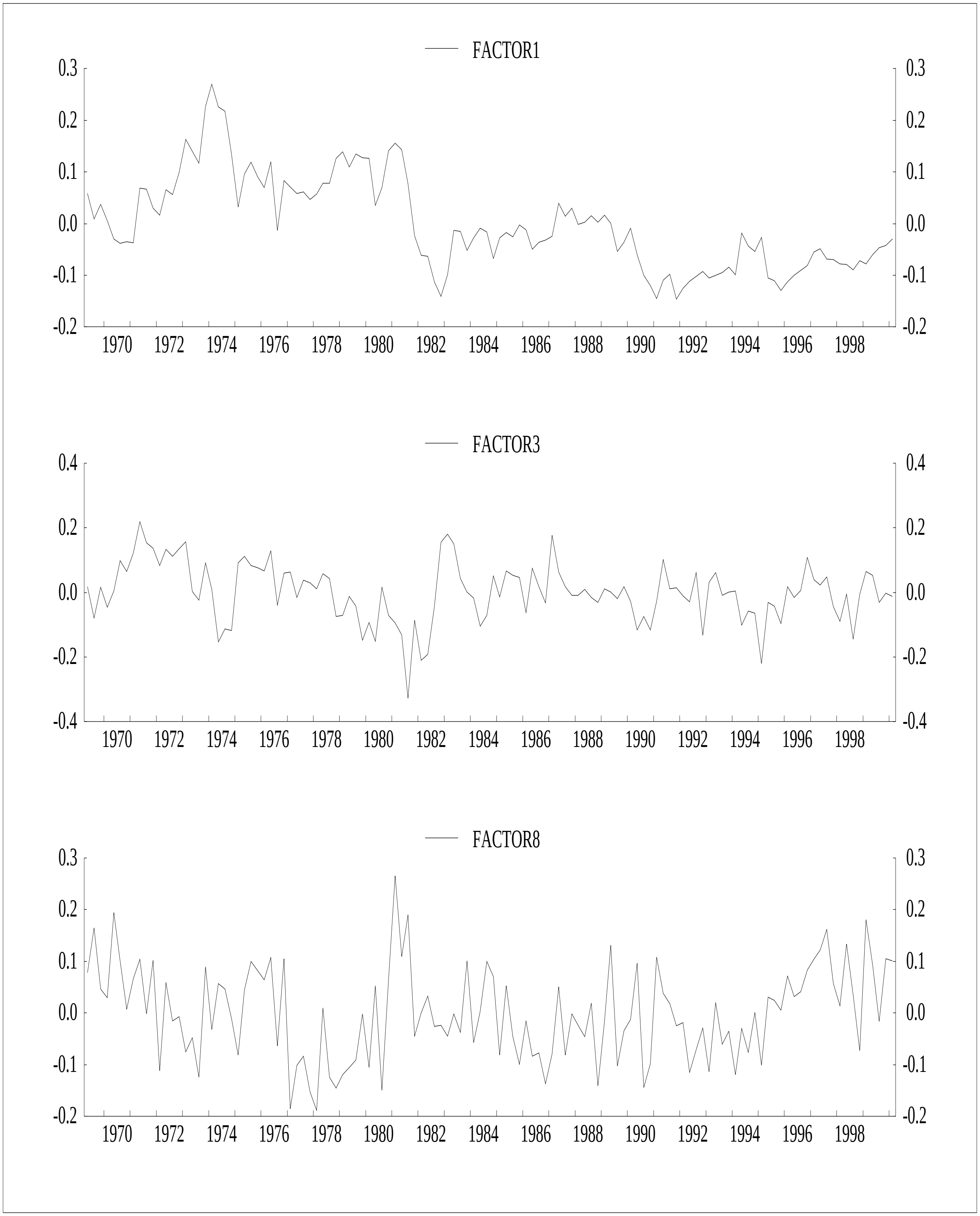
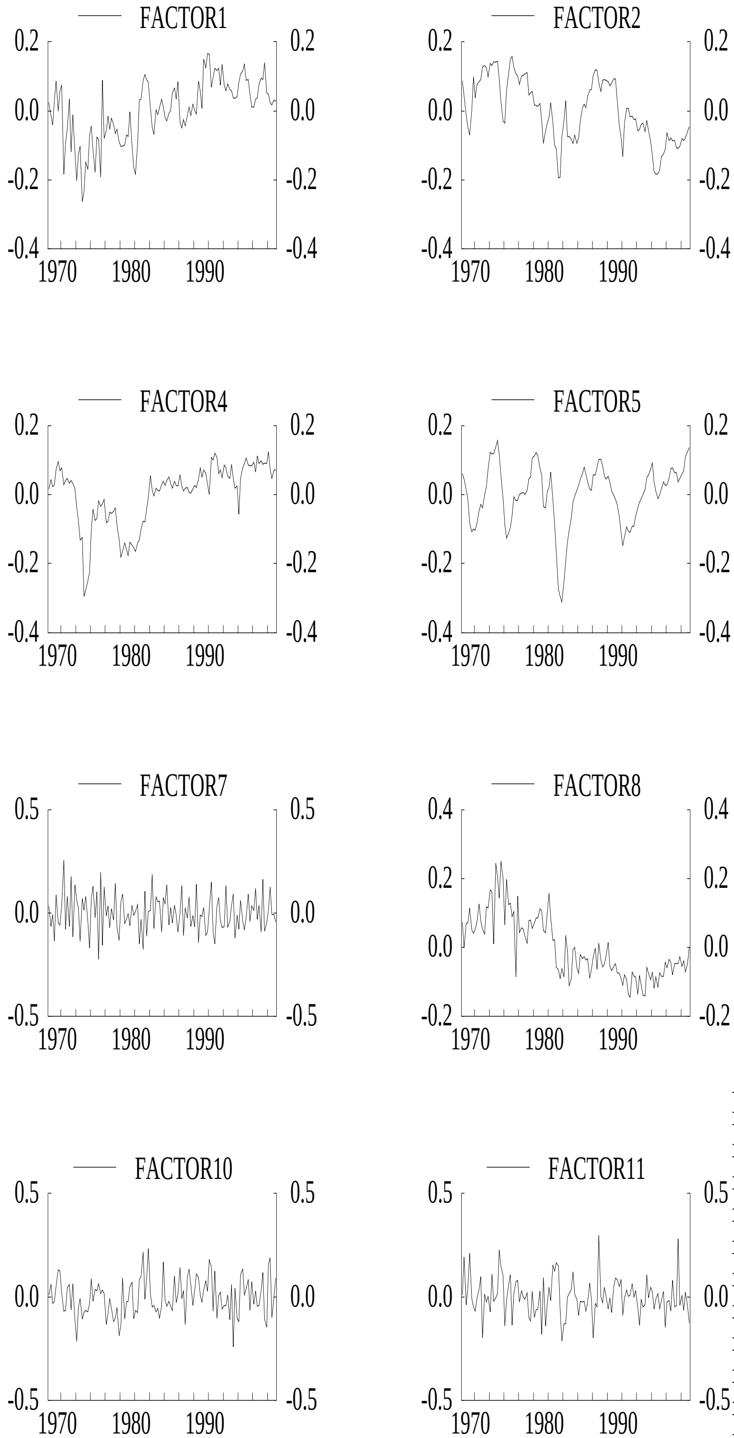


Figure 2: Model 2 Factors



Factor 1: Production
Factor 2: Housing
Factor 3: Employment
Factor 4*: Prices
Factor 5*: Capacity utilization
Factor 6: Government
Factor 7: Retail trade
Factor 8: Interest rates
Factor 9*: Money and credit
Factor 10: International trade
Factor 11: Stock prices
*:Factors selected in Model 2

Figure 3: Selected Model 3 Factors

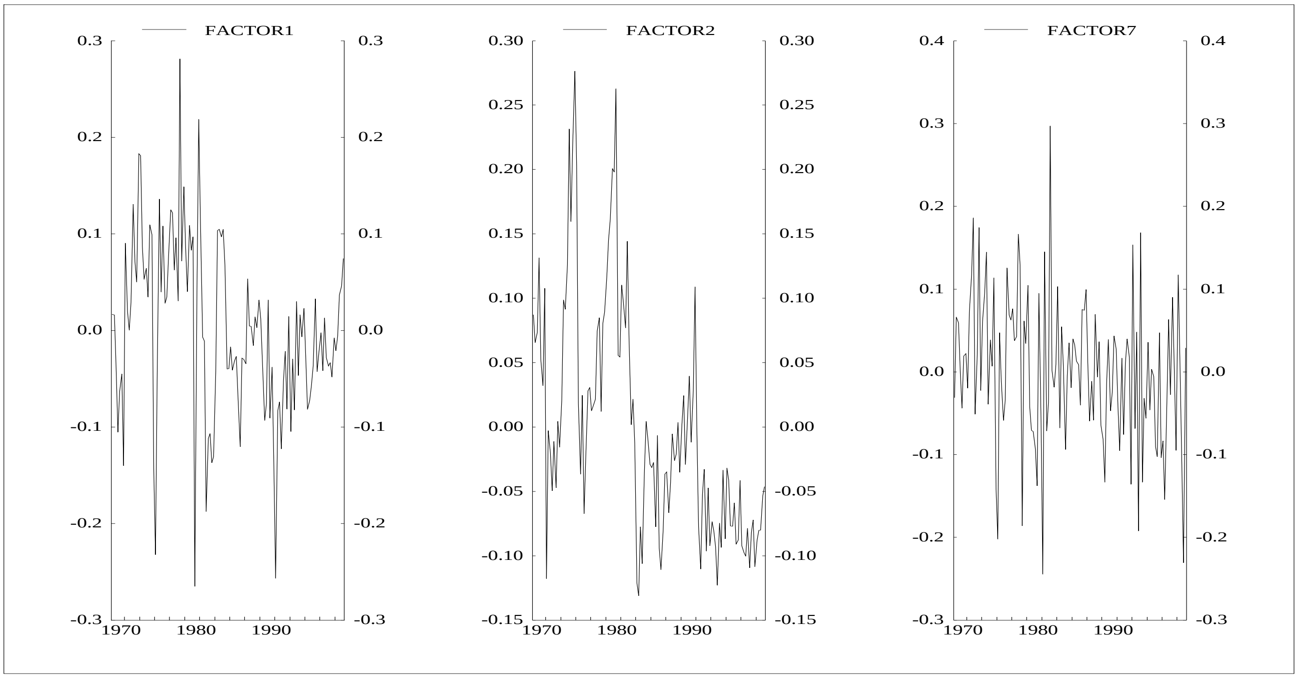


Figure 4: Selected Model 4 Factors

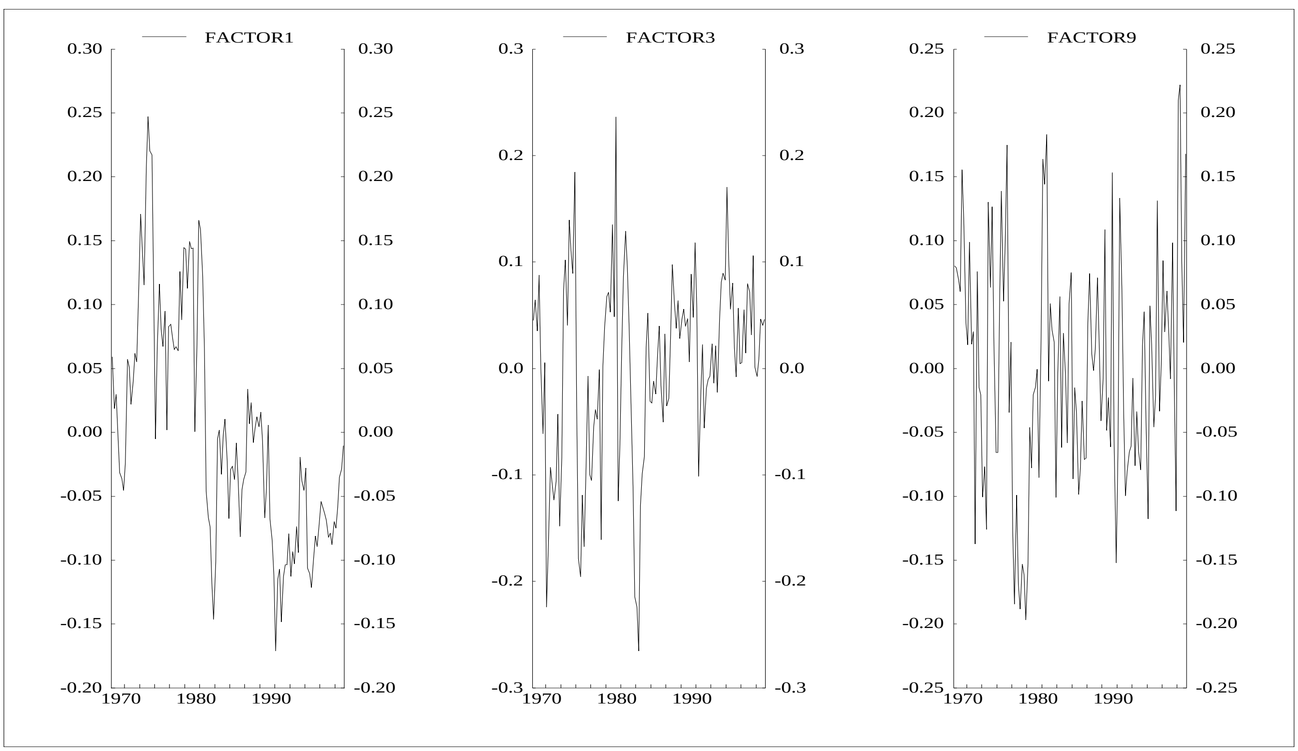
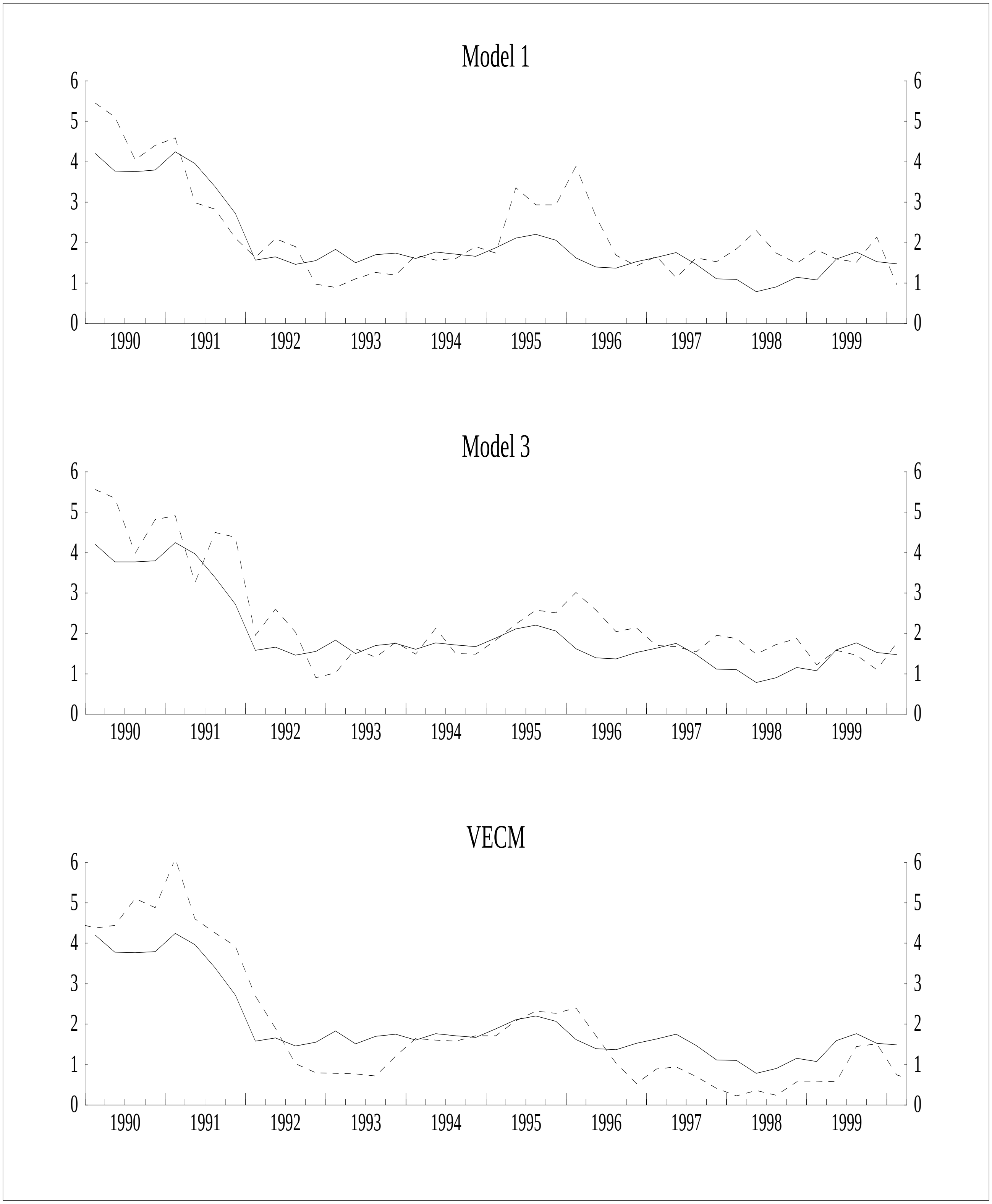


Figure 5: Forecasts



______ : Actual _ __ __ _ : Forecast

Data Appendix

NATIONAL ACCOUNTS

1. GROSS DOMESTIC PRODUCT AT MARKET PRICES - VALUE
2. GROSS DOMESTIC PRODUCT AT MARKET PRICES - VOLUME
3. GROSS DOMESTIC PRODUCT AT MARKET PRICES - PRICE (86=100)
4. GROSS NATIONAL PRODUCT AT MARKET PRICES - VALUE
5. GROSS NATIONAL PRODUCT AT MARKET PRICES - VOLUME
6. PERSONAL EXPENDITURE ON GOODS AND SERVICES
    7. DURABLE GOODS
    8. SEMI-DURABLE GOODS
    9. NON-DURABLE GOODS
    10. SERVICES
11. GOVERNMENT EXPENDITURE
12. RESIDENTIAL STRUCTURES
13. BUSINESS FIXED INVESTMENT
    14. NON-RESIDENTIAL STRUCTURES
    15. MACHINERY & EQUIPMENT
16. FINAL DOMESTIC DEMAND
    17. NET EXPORTS
    18. FINAL SALES
19. BUSINESS INVESTMENT IN INVENTORIES: NON-FARM
20. BUSINESS INVESTMENT IN INVENTORIES: FARM
21. DOMESTIC DEMAND
    22. EXPORTS OF GOODS & SERVICES
23. TOTAL DEMAND
    24. DEDUCT: IMPORTS OF GOODS & SERVICES
25. LABOUR INCOME
26. CORPORATION PROFITS BEFORE TAXES
27. INVENTORY VALUATION ADJUSTMENT
28. NET INC OF NON-FARM UNINC BUSINESS, INCLUDING RENT
29. ACCRUED NET INC OF FARM OPERATORS FROM PRODUCTION
30. OTHER NET INCOME
31. INDIRECT TAXES LESS SUBSIDIES
32. CAPITAL CONSUMPTION ALLOWANCES
33. NET LENDING (GOVERNMENT BALANCE)
    34. FEDERAL
    35. PROV. & MUNICIPALITIES
    36. C.P.P. & Q.P.P.
37. INCOME (PERSONAL)
38. CURRENT TRANSFERS TO GOVERNMENT
39. DISPOSABLE INCOME

RETAIL & WHOLESALE INDICATORS

1. DEPARTMENT STORE SALES - TOTAL S.A.
    2. INVENTORIES
    3. STOCK-TO-SALES RATIO

BUSINESS INVESTMENT

1. BUILDING PERMITS (INDUSTRIAL & COMMERCIAL)
2. COMMERCIAL VEHICLE SALES

HOUSING MARKET

1. DWELLING STARTS - ALL AREAS - TOTAL S.A.A.R. UNITS
2. DWELLING STARTS - URBAN AREAS - TOTAL S.A.A.R. UNITS
3. DWELLING STARTS - URBAN AREAS - SINGLES S.A.A.R. UNITS
4. DWELLING STARTS - URBAN AREAS - MULTIPLES S.A.A.R. UNITS
5. DWELLING STARTS - URBAN AREAS - ATLANTIC PROVINCES S.A.A.R. UNITS
6. DWELLING STARTS - URBAN AREAS - QUEBEC S.A.A.R. UNITS
7. DWELLING STARTS - URBAN AREAS - ONTARIO S.A.A.R. UNITS
8. DWELLING STARTS - URBAN AREAS - PRAIRIE PROVINCES S.A.A.R. UNIT
9. DWELLINGS STARTS - URBAN AREAS - BRITISH COLUMBIA S.A.A.R. UNITS

BUILDING PERMITS AND NEWLY COMPLETED BUT UNOCCUPIED DWELLINGS

1. BUILDING PERMITS TOTAL UNITS ALL AREAS (SAAR)
2. BUILDING PERMITS SINGLE UNITS ALL AREAS (SAAR)
3. BUILDING PERMITS MULTIPLE UNITS ALL AREAS (SAAR)
4. HOUSES AND DUPLEXES - DWELLINGS COMP. BUT UNOC UNITS - S.A.
5. ROW AND APARTMENTS - UNOC. DWELLINGS - TOTAL METROPOLITAN AREAS UNITS - S.A.
6. ROW AND APARTMENTS - UNOC. DWELLINGS - MONTREAL DWELLING UNITS - S.A.
7. ROW AND APARTMENTS - UNOC. DWELLINGS - TORONTO DWELLING UNITS - S.A.
8. ROW AND APARTMENTS - UNOC. DWELLINGS - VANCOUVER DWELLING UNITS - S.A.

BALANCE OF PAYMENTS

1. TOTAL CURRENT ACCOUNT BALANCE
2. TOTAL CURRENT ACCOUNT BALANCE (AS % OF GDP)
3. GOODS AND SERVICES BALANCE
    4. GOODS BALANCE
    5. SERVICES BALANCE

6. INVESTMENT INCOME BALANCE
    7. DIRECT INVESTMENT INCOME BALANCE
    8. PORTFOLIO INVESTMENT INCOME BALANCE
    9. OTHER INVESTMENT INCOME BALANCE
10. TRANSFERS BALANCE
11. TOTAL CURRENT ACCOUNT RECEIPTS
    12. GOODS AND SERVICES RECEIPTS
    13. GOODS RECEIPTS
    14. SERVICES RECEIPTS
15. INVESTMENT INCOME RECEIPTS
    16. DIRECT INVESTMENT INCOME RECEIPTS
    17. PORTFOLIO INVESTMENT INCOME RECEIPTS
    18. OTHER INVESTMENT INCOME RECEIPTS
19. TRANSFERS RECEIPTS
20. TOTAL CURRENT ACCOUNT PAYMENTS
21. GOODS AND SERVICES PAYMENTS
    22. GOODS PAYMENTS
    23. SERVICES PAYMENTS
24. INVESTMENT INCOME PAYMENTS
    25. DIRECT INVESTMENT INCOME PAYMENTS
    26. PORTFOLIO INVESTMENT INCOME PAYMENTS
    27. OTHER INVESTMENT INCOME PAYMENTS
28. TRANSFERS PAYMENTS
29. CAPITAL ACCOUNT, NET FLOW
30. FINANCIAL ACCOUNT, NET FLOW
31. CANADIAN ASSETS, NET FLOW
32. CANADIAN DIRECT INVESTMENT ABROAD
33. CANADIAN PORTFOLIO INVESTMENT
    34. FOREIGN PORTFOLIO BONDS
    35. FOREIGN PORTFOLIO STOCKS
36. OTHER CANADIAN INVESTMENT
    37. LOANS
    38. DEPOSITS
    39. OFFICIAL INTERNATIONAL RESERVES
40. CANADIAN LIABILITIES, NET FLOW
41. FOREIGN DIRECT INVESTMENT IN CANADA
42. FOREIGN PORTFOLIO INVESTMENT
    43. CANADIAN PORTFOLIO BONDS
    44. CANADIAN PORTFOLIO STOCKS
    45. CANADIAN MONEY MARKET
46. OTHER FOREIGN INVESTMENT
    47. DEPOSITS
    48. OTHER LIABILITIES
49. TOTAL CAPITAL AND FINANCIAL ACCOUNTS, NET FLOW

LABOUR FORCE SURVEY

1. POPULATION AGE 15+ UNADJ CDA
2. POPULATION AGE 15-24 UNADJ CDA
3. POPULATION AGE 25+ UNADJ CDA
4. POPULATION WOMEN AGE 15+ UNADJ CDA
5. POPULATION WOMEN AGE 15-24 UNADJ CDA
6. POPULATION WOMEN AGE 15-19 UNADJ CDA
7. POPULATION WOMEN AGE 20-24 UNADJ CDA
8. POPULATION WOMEN AGE 25+ UNADJ CDA
9. LABOUR FORCE AGE 15+ SA CDA
10. LABOUR FORCE AGE 15-24 SA CDA
11. LABOUR FORCE AGE 15-19 SA CDA
12. LABOUR FORCE AGE 20-24 SA CDA
13. LABOUR FORCE AGE 25+ SA CDA
14. LABOUR FORCE MEN AGE 15+ SA CDA
15. LABOUR FORCE MEN AGE 15-24 SA CDA
16. LABOUR FORCE MEN AGE 15-19 SA CDA
17. LABOUR FORCE MEN AGE 20-24 SA CDA
18. LABOUR FORCE MEN AGE 25+ SA CDA
19. LABOUR FORCE MEN AGE 25-54 SA CDA
20. LABOUR FORCE WOMEN AGE 15+ SA CDA
21. LABOUR FORCE WOMEN AGE 15-24 SA CDA
22. LABOUR FORCE WOMEN AGE 15-19 SA CDA
23. LABOUR FORCE WOMEN AGE 20-24 SA CDA
24. LABOUR FORCE WOMEN AGE 25+ SA CDA
25. EMPLOYMENT AGE 15+ SA CDA
26. UNEMPLOYMENT AGE 15+ SA CDA

SURVEY OF EMP., PAYROLLS & HOURS

1. EMPLOYMENT - COMMERCIAL INDUSTRIES S.A.
2. EMPLOYMENT - SERVICE PRODUCING (INCL. UTILITIES) - COMMERCIAL S.A.
3. EMPLOYMENT - NON-COMMERCIAL INDUSTRIES S.A.
4. AVERAGE WEEKLY EARNINGS - COMMERCIAL INDUSTRIES S.A.
5. AVGE WKLY EARNINGS - SERVICE PRODUCING (INCL. UTILITIES) - COMMERCIAL S.A.

LABOUR INCOME

1. WAGES AND SALARIES
    2. COMMERCIAL
    3. MANUFACTURING
    4. NON-COMMERCIAL
    5. AGRICULTURE, FISHING AND TRAPPING
6. SUPPLEMENTARY LABOUR INCOME
7. LABOUR INCOME

UNIT LABOUR COSTS

1. LABOUR INCOME PER UNIT OF REAL OUTPUT - TOTAL ECONOMY
2. WAGES & SALARIES PER UNIT OF OUTPUT - NON-FARM SECTOR
3. WAGES & SALARIES PER UNIT OF OUTPUT - NON-FARM COMMERCIAL INDUSTRIES
4. WAGES & SALARIES PER UNIT OF OUTPUT - MANUFACTURING
5. WAGES & SALARIES PER UNIT OF OUTPUT - NON-COMMERCIAL INDUSTRIES

CONSUMER PRICE INDEX

1. C.P.I. - TOTAL
2. C.P.I. - FOOD
    3. C.P.I. CEREAL & BAKERY PRODUCTS
    4. C.P.I. DAIRY PRODUCTS INCL. BUTTER
5. C.P.I. FUEL OIL AND OTHER LIQUID FUEL
6. C.P.I. PIPED GAS
7. C.P.I. ELECTRICITY
8. C.P.I. - GASOLINE AND OTHER FUELS
9. C.P.I. EXCL. FOOD AND ENERGY
10. C.P.I. GOODS EXCL. FOOD AND ENERGY
11. C.P.I. GOODS EXCL. MOTOR VEHICLES
12. C.P.I. NON-DURABLES EXCL. FOOD AND ENERGY
13. C.P.I. SEMI-DURABLE GOODS
14. C.P.I. DURABLE GOODS
    15. C.P.I. AUTO AND TRUCK PURCHASE
    16. C.P.I. DURABLES EXCL. MOTOR VEHICLES
17. C.P.I. TOTAL SERVICES
    18. C.P.I. SHELTER SERVICES
    19. C.P.I. RENTALS

INDUSTRIAL PRODUCT PRICE INDEX

1. I.P.P.I. - ALL MANUFACTURING INDUSTRIES S.A.
2. I.P.P.I. - FOOD AND BEVERAGE INDUSTRIES S.A.
    3. I.P.P.I. - MEAT AND MEAT PRODUCTS (EX POULTRY) S.A.
    4. I.P.P.I. - BEEF (FRESH OR FROZEN) EXCL. GROUND S.A.
    5. I.P.P.I. - PORK (FRESH OR FROZEN) S.A.
6. I.P.P.I. - TOTAL EXCL. FOOD & BEVERAGES S.A.
    7. I.P.P.I. - TOBACCO PRODUCTS INDUSTRIES S.A.
    8. I.P.P.I. - RUBBER PRODUCTS INDUSTRIES S.A.
    9. I.P.P.I. - PLASTIC PRODUCTS INDUSTRIES S.A.
    10. I.P.P.I. - LEATHER AND ALLIED PRODUCTS INDUSTRIES S.A.
    11. I.P.P.I. - PRIMARY TEXTILES INDUSTRIES S.A.
    12. I.P.P.I. - TEXTILE PRODUCTS INDUSTRIES S.A.
    13. I.P.P.I. - CLOTHING INDUSTRIES S.A.
    14. I.P.P.I. - WOOD INDUSTRIES S.A.
    15. I.P.P.I. - FURNITURE AND FIXTURE INDUSTRIES S.A.
    16. I.P.P.I. - PAPER & ALLIED PRODUCTS INDUSTRIES S.A.
    17. I.P.P.I. - PRIMARY METALS INDUSTRIES S.A.
    18. I.P.P.I. - FABRICATED METAL PRODUCTS (EX. MACH.) INDUSTRIES S.A.
    19. I.P.P.I. - MACHINERY INDUSTRIES (EXCL. ELECTRICAL) S.A.
    20. I.P.P.I. - TRANSPORTATION EQUIPMENT S.A.
    21. I.P.P.I. - MOTOR VEHICLE INDUSTRY S.A.
    22. I.P.P.I. - ELECTRICAL & ELECTRONIC PRODUCT INDUSTRIES S.A.
    23. I.P.P.I. - NON-METALLIC MINERAL PRODUCTS INDUSTRIES S.A.
    24. I.P.P.I. - REFINED PETROLEUM & COAL PRODUCTS INDUSTRIES S.A.
    25. I.P.P.I. - CHEMICAL AND CHEMICAL PRODUCTS INDUSTRIES S.A.
26. I.P.P.I. - TOTAL EXCL. FOOD, BEVERAGES, PETROLEUM & COAL - S.A.

CAPACITY UTILIZATION RATE

1. TOTAL NON-FARM GOODS PRODUCING INDUSTRIES
2. LOGGING AND FORESTRY
3. MINING, QUARRYING AND OIL WELLS
4. MANUFACTURING INDUSTRIES
    5. NON-DURABLE GOODS MAMANUFACTURING
    6. FOOD INDUSTRIES
    7. BEVERAGE INDUSTRIES
    8. TOBACCO PRODUCTS INDUSTRIES
    9. RUBBER PRODUCTS INDUSTRIES
    10. PLASTIC PRODUCTS INDUSTRIES
    11. LEATHER AND ALLIED PRODUCTS INDUSTRIES
    12. PRIMARY TEXTILE INDUSTRIES
    13. TEXTILE PRODUCTS INDUSTRIES
    14. CLOTHING INDUSTRIES
    15. PAPER AND ALLIED PRODUCTS INDUSTRIES

16. PRINTING, PUBLISHING AND ALLIED INDUSTRIES
17. REFINED PETROLEUM AND COAL PRODUCTS INDUSTRIES
18. CHEMICAL AND CHEMICAL PRODUCTS

19. DURABLE GOODS MANUFACTURING
20. WOOD INDUSTRIES
21. FURNITURE AND FIXTURE INDUSTRIES
22. PRIMARY METAL INDUSTRIES
23. FABRICATED METAL PRODUCTS INDUSTRIES
24. MACHINERY INDUSTRIES
25. TRANSPORTATION EQUIPMENT INDUSTRIES
26. ELECTRICAL AND ELECTRONIC PRODUCTS INDUSTRIES
27. NON-METALLIC MINERAL PRODUCTS INDUSTRIES
28. OTHER MANUFACTURING INDUSTRIES

29. INTERMEDIATE GOODS MANUFACTURING
30. FINAL GOODS MANUFACTURING
31. ELECTRIC POWER AND GAS DISTRIBUTION SYSTEMS
32. CONSTRUCTION INDUSTRIES
33. ENERGY INDUSTRIES
34. TOTAL NON-FARM GOODS EXCLUDING ENERGY

GOVERNMENT REVENUE AND EXPENDITURE

1. DIRECT TAXES - PERSONS
2. FEDERAL
3. PROVINCIAL
4. C.P.P. & Q.P.P.

5. DIRECT TAXES - FROM CORPORATIONS & GOVT BUSINESS ENTERPRISES
6. FEDERAL
7. PROVINCIAL

8. INDIRECT TAXES
9. FEDERAL
10. PROVINCES & MUNICIPALITIES

11. OTHER REVENUES
12. OTHER REVENUES - FEDERAL
13. PROVINCES & MUNICIPALITIES
14. C.P.P. & Q.P.P.

15. CURRENT TRANSFERS FROM GOVERNMENT
16. FROM PROVINCIAL LEVEL
17. FED. TO PROV. & MUNIC.
18. PROV. TO MUNIC.

19. REVENUE BY LEVEL - FEDERAL
20. REVENUE BY LEVEL - PROVINCES & MUNICIPALITIES
21. REVENUE BY LEVEL - C.P.P. & Q.P.P.
22. GROSS CURRENT EXPENDITURE ON GOODS AND SERVICES
23. FEDERAL - DEFENCE
24. PROVINCES & MUNICIPALITIES
25. C.P.P. & Q.P.P.

26. INTEREST ON THE PUBLIC DEBT
27. INTEREST ON THE PUBLIC DEBT - FEDERAL
28. PROVINCES & MUNICIPALITIES

29. OTHER EXPENDITURES
30. OTHER EXPENDITURES - FEDERAL
31. C.P.P. & Q.P.P.
32. TOTAL
33. TRANSFERS TO OTHER LEVELS
34. TO GOVERNMENT
35. TO LOCAL LEVEL

36. EXPENDITURE BY LEVEL - FEDERAL
37. C.P.P. & Q.P.P.

38. SURPLUS OR DEFICIT (NET LENDING) - WITHOUT Q.P.P.
39. FEDERAL
40. PROVINCES & MUNICIPALITIES
41. C.P.P. & Q.P.P.

MOTOR VEHICLE SALES

1. PASSENGER CAR SALES--NORTH AMERICAN MANUFACTURED
2. PASSENGER CAR SALES--OVERSEAS MANUFACTURED
3. TOTAL PASSENGER CAR SALES
4. TOTAL - NEW COMMERCIAL VEHICLE SALES
5. PASS. CARS - NORTH AMERICAN MFRD. - UNITS, S.A.
6. PASSENGER OVERSEAS MANUFACTURED VEHICLE SALES, S.A.
7. TOTAL COMMERCIAL VEHICLE SALES, S.A.
8. TOTAL PASSENGER CAR SALES - UNITS, S.A.

INTEREST RATES

1. TREASURY BILL AUCTION - AVERAGE YIELDS: 3 MONTH
2. TREASURY BILL AUCTION - AVERAGE YIELDS: 6 MONTH
3. GOVERNMENT OF CANADA MARKETABLE BONDS, AVERAGE YIELD: 1-3 YEAR
4. GOVERNMENT OF CANADA MARKETABLE BONDS, AVERAGE YIELD: 3-5 YEAR
5. GOVERNMENT OF CANADA MARKETABLE BONDS, AVERAGE YIELD: 5-10 YEAR
6. GOVERNMENT OF CANADA MARKETABLE BONDS, AVERAGE YIELD: OVER 10 YEARS
7. PRIME CORPORATE PAPER RATE: 1 MONTH

8. PRIME CORPORATE PAPER RATE: 3 MONTH
9. BANKERS' ACCEPTANCES: 1 MONTH
10. CHARTERED BANK - 90 DAY DEPOSIT RECEIPTS (AVG. WK ENDING)
11. CHARTERED BANK (TYPICAL) - NON-CHEQUABLE SAVINGS DEPOSIT RATE
12. CHARTERED BANK ADMINISTERED INTEREST RATES: 5-YEAR PERSONAL FIXED TERM
13. CHARTERED BANK ADMINISTERED INTEREST RATES: PRIME BUSINESS
14. AVERAGE RESIDENTIAL MORTGAGE LENDING RATE - 5 YEAR
15. U.S. DOLLAR IN CANADA - 90 DAY DIFFERENTIAL

MONETARY AGGREGATES

1. CURR. OUTSIDE BKS., S.A.
2. GROSS M1 - CURRENCY & GROSS DEMAND DEPOSITS, AOW, SA
3. CDN. $ DEPS.NON-PERS. NOTICE, UNADJ.
4. CDN. $ DEPS.-PERS. NOTICE, UNADJ.
5. CDN. $ DEPS.-PERS. SAV.-FIXED TERM, UNADJ.
6. M2-CURR. & ALL CHEQ. NOT. & PERS. TERM DEPS., S.A.
7. GROSS M1,ALL NOTICE DEP. & CONTINUITY ADJUSTMENTS - M1++
7. M2+,CSB'S & NON MONEY MARKET MUTUAL FUNDS - M2++ - S.A.
9. TOTAL DEPOSITS AT TRUST AND MORTGAGE LOAN COMPANIES REPORTED BY CHARTERED BANKS
10. TOTAL DEPS. AT C.U. & C.P., S.A.

CREDIT AGGREGATES

1. HOUSEHOLD CREDIT (S.A.)
2. RESIDENTIAL MORTGAGE CREDIT (S.A.)
3. CONSUMER CREDIT (S.A.)
4. RES. MTG. CREDIT: O/S BAL. OF MAJOR PRIV. INSTIT. LENDERS, TOTAL, S.A.
5. TOTAL SHORT-TERM BUSINESS CREDIT (S.A.)
6. TOTAL BUSINESS CREDIT (S.A.)
7. TOTAL HOUSEHOLD & BUSINESS CREDIT (S.A.)

EXCHANGE RATES

1. U. S. DOLLAR (NOON)
2. NOON 90 DAYS FORWARD CAN/US EXCHANGE RATE
3. NOON CAN/FRANCE EXCHANGE RATE
4. NOON CAN/GERMANY EXCHANGE RATE
5. NOON CAN/ITALY EXCHANGE RATE
6. NOON CAN/JAPAN EXCHANGE RATE
7. NOON CAN/SWITZERLAND EXCHANGE RATE
8. NOON CAN/UK EXCHANGE RATE
9. CLOSING 90 DAYS FORWARD CAN/US EXCHANGE RATE

STOCK MARKET

1. TORONTO & MONTREAL STOCK EXCHANGES-VALUE OF SHARES TRADED
2. TORONTO & MONTREAL STOCK EXCHANGES-VOLUME OF SHARES TRADED
3. TORONTO STOCK EXCHANGE - COMPOSITE (300)-CLOSE
4. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - OIL AND GAS
5. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - METALS & MINERALS
6. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - UTILITIES
7. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - PAPER & FOREST PROD.
8. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - MERCHANDISING
9. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - FINANCIAL SERVICES
10. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - GOLD & SILVER
11. TORONTO STOCK EXCHANGE - CLOSING QUOTATIONS AT MONTH-END - STOCK DIVIDEND YIELD (COMPOSITE)

OTHER

1. CONSUMER ATTITUDES - FOR ALL RESPONDENTS - CANADA % S.A.

U.S. DATA

1. GROSS DOMESTIC PRODUCT
2. GROSS DOMESTIC PRODUCT (CHAINED)
3. CHAIN-TYPE PRICE INDEX - GDP
4. PERSONAL CONSUMPTION EXPENDITURES - TOTAL
5. PERSONAL CONSUMPTION EXPENDITURES - DURABLE GOODS
6. PERSONAL CONSUMPTION EXPENDITURES - NONDURABLE GOODS
7. PERSONAL CONSUMPTION EXPEND - SERVICES
8. GOVERNMENT CONSUMPTION EXPENDITURES & GROSS INVESTMENT
9. FEDERAL GOVT CONSUMPTION EXPENDITURES & GROSS INVESTMENT
10. STATE & LOCAL CONSUMPTION EXPENDITURES & GROSS INVESTMENT
11. PRIVATE FIXED INVESTMENT, NONRESIDENTIAL
12. PURCHASES OF NONRESIDENTIAL STRUCTURES - TOTAL
13. PURCHASES OF PRIVATE PDE, NONRESIDENTIAL - TOTAL
14. PRIVATE FIXED INVESTMENT, RESIDENTIAL
15. FINAL SALES TO DOMESTIC PURCHASERS
16. NET EXPORTS OF GOODS & SERVICES
17. EXPORTS OF GOODS & SERVICES
18. IMPORTS OF GOODS & SERVICES
19. FINAL SALES OF DOMESTIC PRODUCT
20. CHANGE IN BUSINESS INVENTORIES - TOTAL
21. CHANGE IN BUSINESS INVENTORIES - NONFARM
22. CHANGE IN BUSINESS INVENTORIES - FARM

23. PROPRIETORS' INCOME WITH IVA & CCADJ - FARM
24. COMPENSATION OF EMPLOYEES
25. CORPORATE PROFITS BEFORE TAX EXCLUDING IVA
26. DIVIDENDS
27. INVENTORY VALUATION ADJUSTMENT, CORPORATE
28. NET INTEREST
29. INDIRECT BUSINESS TAX & NONTAX LIABILITY
30. GOVERNMENT CURRENT SURPLUS OR DEFICIT, NIPA BASIS
31. FEDERAL GOVERNMENT CURRENT SURPLUS OR DEFICIT, NIPA BASIS
32. STATE AND LOCAL GOVERNMENT CURRENT SURPLUS OR DEFICIT, NIPA BASIS
33. PERSONAL INCOME
34. PERSONAL TAX & NONTAX PAYMENTS
35. DISPOSABLE PERSONAL INCOME
36. INDUSTRIAL PROD INDEX - PRODUCTS, TOTAL (G17)
37. INDUSTRIAL PROD INDEX - FINAL PRODUCTS TOTAL (G17)
38. INDUSTRIAL PROD INDEX - TOTAL EQUIPMENT (G17)
39. INDUSTRIAL PROD INDEX - INTERMEDIATE PRODUCTS (G17)
40. INDUSTRIAL PROD INDEX - MATERIALS (G17)
41. CAPACITY UTILIZATION - MANUFACTURING, MINING, & UTILITIES (G17)
42. CAPACITY UTILIZATION - MANUFACTURING (G17)
43. RETAIL UNIT SALES OF NEW PASSENGER CARS - TOTAL
44. RETAIL UNIT SALES OF NEW PASSENGER CARS - DOMESTIC
45. RETAIL UNIT SALES OF NEW PASSENGER CARS - IMPORTS
46. RETAIL DOMESTIC UNIT SALES OF TRUCKS & BUSES - 0 THRU 10,000 LBS
47. MOTOR VEHICLES ASSEMBLIES - TOTAL
48. AUTOMOBILE PRODUCTION/ASSEMBLIES (FED, SAAR) - DOMESTIC
49. MOTOR VEHICLES ASSEMBLIES, TRUCKS (G17)
50. SHIPMENTS - MANUFACTURING (M31)
51. SHIPMENTS - MANUFACTURING, DURABLE GOODS (M31)
52. SHIPMENTS - MANUFACTURING, NONDURABLE GOODS (M31)
53. SHIPMENTS - CAPITAL GOODS INDUSTRIES (M31)
54. NEW ORDERS - MANUFACTURING (M31)
55. NEW ORDERS - MANUFACTURING, DURABLE GOODS (M31)
56. NEW ORDERS - MANUFACTURING, NONDURABLE GOODS (M31)
57. NEW ORDERS - CAPITAL GOODS INDUSTRIES (M31)
58. UNFILLED ORDERS - MANUFACTURING (M31)
59. INVENTORIES - MANUFACTURING (M31)
60. RETAIL SALES -TOTAL
61. RETAIL SALES - DURABLES STORES
62. RETAIL SALES - NONDURABLES STORES
63. RETAIL SALES - TOTAL EXCLUDING AUTOMOTIVE GROUP
64. MONEY SUPPLY - CURRENCY, DEMAND DEPOSITS, OTHER CHECKABLE DEP.
65. MONEY SUPPLY - M2
66. MONEY SUPPLY - M3
67. HOUSING STARTS, PRIVATE INCLUDING FARM - TOTAL
68. HOUSING PERMITS, PRIVATE (C20)
69. NEW ONE-FAMILY HOMES SOLD
70. VACANCY RATE, RENTAL HOUSING UNITS
71. VACANCY RATE, HOMEOWNER HOUSING UNITS
72. CPI (ALL URBAN) - ALL ITEMS
73. CPIU - ENERGY
74. CPIU - SERVICES LESS ENERGY SERVICES
75. PRODUCER PRICE INDEX - FINISHED GOODS
76. PRODUCER PRICE INDEX - FINISHED CONSUMER GOODS
77. PRODUCER PRICE INDEX - CAPITAL EQUIPMENT
78. PRODUCER PRICE INDEX - INTERMEDIATE MATERIALS,SUPPLIES AND COMPONENTS
79. PRODUCER PRICE INDEX - CRUDE MATERIALS
80. CIVILIAN LABOR FORCE - TOTAL (ESIT)
81. EMPLOYED - CIVILIAN TOTAL (ESIT)
82. UNEMPLOYMENT RATE - CIVILIAN (ESIT)
83. PARTICIPATION RATE - CIVILIAN LABOR FORCE, TOTAL (ESIT)
84. HOURS, PRODUCTION WORKERS - PRIVATE NONAGRICULTURAL (ESIT)
85. OUTPUT PER WORKER
86. COMPENSATION PER HOUR INDEX - NONFARM BUSINESS SECTOR (PC)
87. UNIT LABOR COSTS INDEX - NONFARM BUSINESS SECTOR (PC)
88. RECEIPTS, FEDERAL GOVT - TOTAL
89. RECEIPTS, S&L GOVT - TOTAL
90. FEDERAL GOVERNMENT CURRENT EXPENDITURES
91. STATE & LOCAL GOVERNMENT CURRENT EXPENDITURES
92. U.S. BALANCE ON MERCHANDISE TRADE (BOP)
93. EXPORTS - MERCHANDISE, ADJUSTED, EXCLUDING MILITARY (BOP)
94. IMPORTS - MERCHANDISE, ADJUSTED, EXCLUDING MILITARY (BOP)
95. NON-MERCHANDISE TRADE BALANCE
96. U.S. BALANCE ON SERVICES (BOP)
97. U.S. BALANCE ON INVESTMENT INCOME
98. UNILATERAL TRANSFERS (EX MILITARY GRANTS), NET (BOP)
99. U.S. BALANCE ON CURRENT ACCOUNT (BOP)
100. U.S. BALANCE ON CURRENT ACCOUNT (BOP), % OF GDP
101. U.S. COMMON STOCKS-DOW-JONES INDUST. (30) - HIGH
102. U.S. COMMON STOCKS-DOW-JONES INDUST. (30) - LOW
103. U.S. COMMON STOCKS-DOW-JONES INDUST. (30) - CLOSE

104. N.Y. STOCK EXCHANGE-VALUE OF SHARES TRADED
105. N.Y. STOCK EXCHANGE-VOLUME OF SHARES TRADED
106. FEDERAL RESERVE BANK OF N.Y. DISCOUNT RATE
107. U.S. - FEDERAL FUNDS RATE
108. U.S. - GOVERNMENT 5 YEAR BOND YIELD (CONSTANT MATURITY)
109. U.S. - 90 DAY CERTIFICATES OF DEPOSIT (ADJUSTED)
110. U.S. - PRIME RATE CHARGED BY BANKS

Bank of Canada Working Papers
Documents de travail de la Banque du Canada

Working papers are generally published in the language of the author, with an abstract in both official languages. ***Les documents de travail sont publiés généralement dans la langue utilisée par les auteurs; ils sont cependant précédés d'un résumé bilingue*.**

2001

2001-17	Why Do Central Banks Smooth Interest Rates?	G. Srour
2001-16	Implications of Uncertainty about Long-Run Inflation and the Price Level	G. Stuber
2001-15	Affine Term-Structure Models: Theory and Implementation	D.J. Bolder
2001-14	L'effet de la richesse sur la consommation aux États-Unis	Y. Desnoyers
2001-13	Predetermined Prices and the Persistent Effects of Money on Output	M.B. Devereux and J. Yetman
2001-12	Evaluating Linear and Non-Linear Time-Varying Forecast-Combination Methods	F. Li and G. Tkacz
2001-11	Gaining Credibility for Inflation Targets	J. Yetman
2001-10	The Future Prospects for National Financial Markets and Trading Centres	C. Gaa, S. Lumpkin, R. Ogrodnik, and P. Thurlow
2001-9	Testing for a Structural Break in the Volatility of Real GDP Growth in Canada	A. Debs
2001-8	How Rigid Are Nominal-Wage Rates?	A. Crawford
2001-7	Downward Nominal-Wage Rigidity: Micro Evidence from Tobit Models	A. Crawford and G. Wright
2001-6	The Zero Bound on Nominal Interest Rates: How Important Is It?	D. Amirault and B. O'Reilly
2001-5	Reactions of Canadian Interest Rates to Macroeconomic Announcements: Implications for Monetary Policy Transparency	T. Gravelle and R. Moessner
2001-4	On the Nature and the Stability of the Canadian Phillips Curve	M. Kichian
2001-3	On Commodity-Sensitive Currencies and Inflation Targeting	K. Clinton
2001-2	Exact Non-Parametric Tests for a Random Walk with Unknown Drift under Conditional Heteroscedasticity	R. Luger
2001-1	The Elements of the Global Network for Large-Value Funds Transfers	J.F. Dingle

Copies and a complete list of working papers are available from:
Pour obtenir des exemplaires et une liste complète des documents de travail, prière de s'adresser à :

Publications Distribution, Bank of Canada
234 Wellington Street, Ottawa, Ontario K1A 0G9
E-mail: publications@bankofcanada.ca
Web site: http://www.bankofcanada.ca

Diffusion des publications, Banque du Canada
234, rue Wellington, Ottawa (Ontario) K1A 0G9
Adresse électronique : publications@banqueducanada.ca
Site Web : http://www.banqueducanada.ca