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FORECASTING MONTHLY GDP FOR CANADA

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ABSTRACT/RÉSUMÉ

Forecasting monthly GDP for Canada

The objective of this paper is to develop a short-term indicator-based model to predict quarterly GDP in Canada by efficiently exploiting all available monthly information. To this aim, monthly forecasting equations are estimated using the GDP series published every month by Statistics Canada as well as other monthly indicators. The procedures are automated and the model can be run whenever major monthly data are released, allowing the appropriate choice of the model according to the information set available. The most important gain from this procedure is for the current-quarter forecast when one or two months of GDP data are available, with all monthly models estimated in the paper outperforming a standard quarterly autoregressive model in terms of size of errors. The use of indicators also appears to improve forecasting performance, especially when an average of indicator-based models is used. Real-time forecasting performance of the average model appear to be good, with an apparent stability of the estimates from one update to the next, despite the extensive use of monthly data. The latter result should nonetheless be interpreted with caution and will need to be re-assessed when more data become available.

JEL classification: C52, C53, E37
Keywords: Canada, indicators models, monthly GDP, short-term forecasts, real-time estimations

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Prévoir le GDP mensuel au Canada

L'objective de cet article est de développer un modèle d'indicateurs conjoncturels pour prédire le PIB trimestriel au Canada en utilisant de manière efficace toute l'information mensuelle disponible. À cette fin, des équations mensuelles de prévisions de court terme sont estimées en utilisant la série de PIB publiée chaque mois par Statistique Canada et d'autres indicateurs conjoncturels. Les procédures ont été automatisées et le modèle peut être mis à jour chaque fois qu'une donnée importante est publiée, la spécification du modèle variant ainsi en fonctions de l'ensemble des données disponibles. Le gain le plus important de la procédure développée est obtenue pour les prévisions du trimestre courant quand un ou deux mois de données du PIB mensuel sont disponibles. Dans ce cas, tous les modèles mensuels estimés dans cet article ont des erreurs de prévisions inférieures à celle d'un modèle trimestriel autorégressif standard. L'utilisation d'indicateurs conjoncturels améliore les performances en termes de prévisions, en particulier lorsqu'une moyenne de tous les modèles d'indicateurs conjoncturels est utilisée. Les prévisions réalisées en temps réel en faisant la moyenne des différents modèles d'indicateurs conjoncturels se sont avérées de qualité satisfaisante, avec une stabilité apparente des estimations successives, malgré l'utilisation extensive de données mensuelles. Ces résultats doivent toutefois être interprétés avec prudence et devront être vérifiés quand plus de données seront disponibles.

Classification JEL : C52, C53, E37
Mots clés : Canada, modèles d'indicateurs conjoncturels, GDP mensuel, prévisions de court terme, estimations en temps réel

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Forecasting monthly GDP for Canada

By
Annabelle Mourougane[1]

Introduction and main results

In recent years, indicator-based models have been developed by international organisations, national administrations and private forecasters and are now important short-term forecasting tools. In particular, they have been successfully used for the six largest OECD economies in the Economic Outlook projections (Sédillot and Pain, 2005). These models exploit information that is available before the release of the official national accounts data, including 'soft' indicators, such as business surveys, financial and "hard" indicators, such as industrial production or employment. They usually rely on quarterly forecasting equations, supplemented by monthly satellite bridge models which estimate missing monthly indicators. Such an approach has recently been applied to Canada (Zheng and Rossiter, 2006). Another promising alternative is to estimate quarterly models conditional on the monthly information currently available (*e.g*. Dubois and Michaux, 2006).

The objective of this paper is to construct a short-term indicator-based model to predict quarterly GDP in Canada by efficiently exploiting all available monthly information. To this aim, monthly forecasting equations are estimated using the GDP series published every month by Statistics Canada.[2] The wide use of monthly series could imply a less than satisfactory predictive performance, especially for 4 or 5 months ahead (Parigi, 2004), and it will be important to test whether such a monthly model performs better than quarterly models. One obvious advantage of forecasting directly GDP on a monthly basis is that it spares the use of satellite bridge equations. These models are often difficult to estimate because of the high volatility of the indicators they rely on and as a result, add further (and sometimes significant) forecasting errors to the final quarterly GDP forecasts.

Moreover the model developed in this paper is quite practical. The procedures to select the data and compute an aggregate monthly GDP forecast and its resulting quarterly average are automated. Thus, the model can be run whenever major monthly data are released, allowing the appropriate choice of the model according to the information set available.

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1. The author is Economist at the OECD Economics Department. The author is indebted to Peter Jarrett, Nigel Pain, Deborah Roseveare and Frank Sédillot for many helpful discussions, as well as to Benoît Bellone and Frédéric Demers for their comments. Special thanks go to Mee-Lan Frank for excellent technical assistance.

2. Canada and Finland are the only OECD countries which officially publish a monthly GDP. Estimates are also produced for the United Kingdom and the euro area, but not on a regular basis or by the Statistical office (Mitchell *et al*., 2005; Astolfi *et al*., 2000).

The main findings from the empirical tests undertaken are as follows:

- It was found preferable to forecast business and non-business GDP separately, as they are affected by very different factors. For business GDP, variables that appear to bring useful information are: the US and domestic confidence indicators as well as new orders for the soft indicators. Amongst the hard indicators, employment, retail sales, the lagged value of industrial production, the production of motor vehicles and the terms of trade each appear to play a significant role.

- The specification of the most suitable model for any given information set varies with the forecast horizon. For the current-quarter forecast, all monthly models appear to outperform a standard quarterly autoregressive model in terms of size of errors when one or two months of GDP data are available for the quarter being forecast. By contrast, in the absence of monthly information on GDP for the current quarter, no significant difference between quarterly and monthly models could be found.

- For a one-quarter ahead projection, the gain in using monthly models is much smaller in terms of forecast errors, but monthly models continue to do a better job in terms of directional accuracy.

- The use of indicators appears to improve forecasting performance, especially when an average of indicator-based models is used. Overall, differences between the monthly indicator-based models examined in this paper are most of the time not statistically significant, even though the average of the indicator-based models appears to perform slightly better.

The model has been used during the last two Economic Outlooks (EO78 and EO79). Its track record appears to be good, and forecasting errors were relatively low compared to the other G7 countries. One attractive feature of the model is its apparent stability from one update to the next, despite the extensive use of monthly data. This suggests that is it is possible to get a relatively accurate forecast for the current and even possibly the next quarter as soon as the current quarter is completed i.e. two months before the first release of quarterly national accounts. Real-time estimations using several vintages of data indicate that less than half of the total errors stem from data revisions. Given the small number of observations, the latter results should nonetheless be interpreted with caution.

The dataset

The variable of interest is the monthly GDP by industry (see Box 1). Business and non-business components are forecast separately, as they are likely to be affected by different indicators.[3] An aggregate GDP measure is computed once each component has been forecast using a Fisher chain formula to be consistent with the output- and expenditure-based GDP published by Statistics Canada.[4] Although the coverage of the monthly GDP indicator was extended to 216 industries in 1997, the analysis makes use of the data since 1980.[5] Indeed, there does not appear a major break in the GDP series and extending the sample allows to have a sufficient number of observations to perform estimation and out-of-sample tests. Robustness checks indicate that starting the analysis in 1997 would slightly deteriorate the precision of the models.

3. Non-chained data are used for estimation and forecasting.

4. Chain Fisher formulae were adopted in May 2001 for Quarterly Income and Expenditure Accounts and in September 2002 for the monthly GDP by industry.

5. The period spanning 1981 to 1996 is covered at a more summary level of aggregation, totalling 129 industries.

Box 1. **GDP by industry, an output-based approach to measuring GDP**

Statistics Canada produces monthly estimates of GDP that are fully integrated with the rest of the National Accounts. The monthly estimates of GDP are obtained from the production approach for distinct NAICS industries. They are estimated at constant basic prices of 1997 and are published both raw and seasonally adjusted at annual rates. Monthly estimates are consistent with the annual Input-Output estimates and adjusted to the quarterly estimates of GDP from the income and expenditure account after all the major inconsistencies between the two are resolved.

GDP by industry is released on a monthly basis approximately 60 days after the end of the reference period. The release dates are announced in advance for each year.

GDP by industry requires a very wide range of input data, which are primarily derived from surveys of Canadian businesses. More precisely, the monthly estimates are based on various indicators that fall into five broad groups: physical quantities of gross output; gross output indicators at current prices (deflated); gross output indicators at constant prices; employment indicators; and other indicators. The fundamental hypothesis underlying the use of these indicators is that the ratio of the indicator to value added is relatively constant in the short-term, whether the indicator is gross output or a measure of employment.

Given that GDP by industry is a timely indicator of economic growth, the input data going into monthly calculations of GDP are often preliminary and are subject to revision. In addition, the monthly data sources are incomplete in the sense that they do not provide all the necessary information on outputs and intermediate inputs for calculating value added.

When estimates of GDP by industry are prepared for a current month, several preceding months are revised. The revisions extend back to January of the year, during which the most recent annual revision was made. The two main reasons for the regular monthly revisions are data updates due to more complete response to surveys and revisions to seasonal factors. The revisions are generally random and decrease over time. The largest revision usually occurs with the month of December because with the closing of the calendar year revisions to both the source data and the seasonal factors tend to be more significant than in other months. Each year, when the annual input-output-based estimates are released, the monthly GDP series are normally revised for several years.

Source: Statistics Canada (2002a and 2002b).

Both "soft" and "hard" indicators have been used to forecast GDP, but to facilitate frequent updates, the choice of the variables has been restricted to those readily available from Statistic Canada's Canadian Socio-Economic Information Management system (CANSIM).[6] The only exception is the ISM US indicator (the Institute of Supply Management index for the manufacturing sector). All the variables are seasonally adjusted and are fully described in Annex 1.

One variable, which could have been usefully used, is the diffusion index constructed by Statistics Canada. It measures the share of industries experiencing an increase in activity (measured by output, employment or other variables). But, while the diffusion index closely tracks the monthly change in GDP, it is not a reliable guide to what is about to occur in the economy (Statistics Canada, 2004). Other variables such as Business Conditions Index have been found to be well correlated with quarter-over-quarter real GDP growth (Rose, 2004), but the business conditions survey is available only on a quarterly basis.

In theory a number of monetary variables, such as interest rates or yield curves, are likely to play an important role in predicting real GDP growth. However given the long lags involved in monetary

6. See Sédillot and Pain (2005) for a discussion of the relative advantages of soft and hard indicators in forecasting GDP.

policy's transmission mechanisms, it is very unlikely that these variables have a significant impact over the horizon considered (typically no longer than 6 months).

Modelling approach

Model specification

The generic model used has the following form:

$$\Delta y_t^i = \sum_{j=1}^{k} \delta_{j,t}^i(L)\Delta x_{j,t}^i + \rho_t^i(L)\Delta y_t^i \quad [1]$$

with y_t^i the logarithm of real GDP in the business or non-business sector

$x_{j,t}^i$ the logarithm of the selected indicators

Δ denotes the first difference operator

$\delta_{j,t}^i(L) \quad and \quad \rho_t^i(L)$ are lag polynomials.

A similar specification was used in Sédillot and Pain (2005), but one major difference is that the Canadian model is selected and re-estimated at each period on monthly data.[7] Five variants of models [1] were estimated:

- A model using solely soft indicators (SOFT model)
- A model using only hard indicators (HARD model)
- A model using both soft and hard indicators (MIXED model)
- A conditional VAR model, using both soft and hard indicators (VAR)[8]
- A consensus estimate is also computed as the average of the indicators and VAR models (CONSENSUS)

Moreover, two benchmark models were also estimated:

- A quarterly autoregressive model (AUTOQ model)
- A monthly autoregressive model (AUTOM model)

Variable pre-selection

Given the multitude of monthly indicators in CANSIM and the number of possible combinations, it was necessary to make an *ad hoc* pre-selection of variables. A number of methods have been used in the

7. Another difference is that the level (rather than the growth rate) of soft indicators is sometimes used in their models.

8. Pure soft- or hard-based VARs were also estimated, but it was found that a VAR based on both types of indicators leads to better forecasting performance.

literature for that purpose, including regression or factor analysis. Given the specificity of the Canadian economy, a combination of methods was used.

First, a judgement-based choice was made to select variables that are considered important for a small open and resource-based economy such as Canada's. Typically variables such as the bilateral exchange rate *vis-à-vis* the United States or the terms of trade were tried in the analysis.

Second, a statistic criterion based on simple correlation was used to single out variables that are likely to bring useful information to forecast GDP.[9] As some variables can have an impact only after a certain period of time, coincident as well as lagged correlations (up to 2 lags) were considered. Correlations are reported in Table 1.

- When two variables are likely to convey similar information (for instance, the unemployment rate and employment), only one of the two was used, typically the one which has the highest correlation with GDP. In the case of trade variables, it was judged more relevant to test a combination of exports and imports variables (*e.g*. net trade or terms of trade) rather then imports and exports variables separately. Indeed, although both variables (in values) have a high correlation with business GDP, the net effect is economically the one that matters for explaining GDP growth. The terms of trade is also a much more relevant concept than separate trade prices as it summarises both the effect of the exchange rate and of commodity prices, both of them being of particular importance for the Canadian economy.

- Very few soft and financial indicators appear to bring useful information for the non-business monthly GDP. Only employment in the public sector has been pre-selected to forecast non-business GDP.

Similar to the approach adopted for the other G7 countries in Sédillot and Pain (2005), variables have been classified in two groups: soft and financial indicators on the one hand and hard indicators on the other hand. In each group a subset of five variables was selected with up to three lags considered (Table 2).

9. A somewhat different criterion was used by Sédillot and Pain (2005). The monthly GDP is regressed on a constant and the indicators (with lags up to 3). The number of lags is selected using a Schwarz criterion. Variables that lead to the higher adjusted R2 are then chosen. This procedure is found to select broadly the same variables as simple correlation analysis.

Table 1. **Correlations**

	Coincident		Lag 1		Lag 2	
	Business	Non-business	Business	Non-business	Business	Non-business
Soft indicators						
Confidence indicator	0.37	-0.08	0.38	-0.05	0.33	-0.05
US confidence indicator	0.26	-0.06	0.27	0.04	0.19	-0.06
US ISM	-0.03	-0.12	0.14	0.03	0.14	-0.03
New orders	0.49	-0.01	-0.07	0.06	0.00	-0.13
Building permits	0.16	0.08	0.01	-0.08	0.11	0.00
Housing starts	0.21	0.02	0.02	-0.04	0.08	0.01
Financial indicators						
Share traded (Toronto stock exchange)	0.18	0.04	-0.09	-0.03	-0.03	-0.04
Value of share (Toronto stock exchange)	0.23	0.03	-0.09	-0.03	-0.04	-0.05
Money supply (real terms)	0.24	-0.10	0.29	-0.09	0.29	-0.10
Stock price index TSE 300	0.20	-0.08	0.21	-0.08	0.21	-0.07
Exchange rate	-0.01	-0.09	0.13	0.00	0.03	0.06
Hard indicators						
Durable goods sales	0.37	-0.02	0.20	-0.02	0.28	-0.02
Shipment-to-inventories ratio	0.26	-0.02	0.15	0.02	0.19	-0.02
Average work week manufacturing	0.11	-0.05	0.21	-0.09	0.14	0.01
Employment business sector	0.19	0.04	0.22	-0.02	0.13	-0.01
Housing index	0.17	-0.03	0.09	-0.03	0.17	-0.03
Employment	0.32	0.08	0.32	0.00	0.10	-0.08
Full-time employment	0.26	0.04	0.24	-0.03	0.13	-0.01
Part-time employment	0.02	0.04	0.04	0.04	-0.07	-0.09
Average hourly earning	0.06	-0.06	-0.20	0.03	0.09	0.11
Average weekly hours	-0.03	-0.07	0.08	-0.03	-0.02	0.01
CPI inflation	-0.15	0.02	-0.20	0.08	-0.19	0.04
Core inflation	-0.23	0.03	-0.20	0.09	-0.16	0.11
Industry price index	0.02	0.00	0.01	-0.01	0.02	0.01
Wage in the construction sector	-0.04	0.12	-0.02	0.03	-0.13	-0.06
New housing price index	0.17	-0.01	0.09	0.01	0.08	-0.03
Export	0.38	0.09	-0.08	-0.04	-0.01	-0.05
Import	0.42	-0.03	-0.16	-0.02	0.07	-0.01
Total inventories	0.10	-0.06	-0.02	0.10	0.12	-0.04
Production of motor vehicles	0.30	0.13	-0.06	-0.17	-0.01	0.06
Other estimate of motor vehicles sales	0.28	0.05	-0.05	-0.08	-0.01	0.05
Retail trade, furniture and appliances	0.22	0.00	0.12	-0.07	0.21	-0.08
Retail sales	0.42	0.05	-0.09	-0.08	-0.01	0.03
Large retailers' sales	-0.21	-0.24	0.03	0.18	0.14	-0.01
Wholesale sales	0.48	0.02	-0.04	-0.05	0.11	-0.04
Oil supply	0.10	-0.08	-0.07	-0.04	0.03	0.06
Unemployment rate	-0.23	-0.02	-0.20	0.03	-0.10	0.00
Commodities prices	0.15	0.00	0.06	0.07	-0.01	-0.03
Employment public sector	0.16	0.19	-0.04	0.04	0.04	0.01
Export price	0.05	-0.06	0.00	0.02	0.04	0.02
Import price	-0.01	-0.09	0.13	0.00	0.03	0.06
Terms of trade	0.07	0.02	-0.12	0.02	0.02	-0.03
Net trade	0.12	0.25	0.08	-0.03	-0.04	-0.07
Trade balance	0.19	0.31	0.03	-0.04	-0.08	-0.16
Industrial production (lag)	0.11	-0.10	0.11	-0.10	0.29	0.01

Table 2. **Variables that have been pre-selected**

	Business	Non-business
Soft and financial indicators	Confidence indicator, US confidence indicator, US ISM, new orders, money supply, exchange rates, building permits	–
Hard indicators	Employment, durable goods sales, employment full time, exports, imports, production of motor vehicles, retail sales, wholesale sales, industrial production (lagged), trade balance, net trade, terms of trade	Employment in the public sector

Estimation results

Model selection

Once a first set of variables is defined, the best model is selected according to a Schwarz criterion. The selected specification (*i.e*. variables entering the model as well as the lags retained) differs at each period, as well as the estimated coefficient. For instance, when two quarters (six months) are to be forecast, six different models are chosen, each one being used for one month.

The significance of the explanatory variables is likely to change with the horizon considered and each time the dataset is updated. Still, the following variables are found to be useful advanced indicators of real GDP growth most of the time:

- *For business GDP*: the US confidence indicator, new orders and the Canadian confidence indicator for the soft and financial indicators are found to be useful indicators. Amongst the hard indicators, employment, retail sales, lagged industrial production, production of motor vehicles and the terms of trade appear to play a significant role.
- *For non-business GDP*: Employment in the public sector – the only variable that was selected – is found to be helpful to predict non-business GDP. However, the significance of this indicator is not systematic and, given this poor result, a simple autoregressive model was also tried. It appears that the results would not be significantly modified with this simplification.

Forecast performance

The estimated model is then used to forecast GDP on a monthly basis. Associated standard errors (RMSFE) and forecast directional accuracy (FDA) both in- and out-of-sample are computed using recursive out-of-sample forecasts on a monthly basis.[10] Monthly RMSFE and FDA are then converted into quarterly measures using standard formulae. Results for both in- and out-of-sample estimations are found to be very similar and only out-of-sample diagnosis are reported in Table 3.

10. The out-of-sample period is set to start in January 1998.

Table 3. **Comparison of out-of-sample forecasting performance**

		AUTOM		AUTOQ	
		RMSFE	FDA	RMSFE	FDA
Zero month known	Current quarter	0.46	0.71	0.37	0.71
	Next	0.52	0.72	0.38	0.60
1 month known	Current quarter	0.27	0.71	0.37	0.71
	Next	0.52	0.72	0.38	0.60
2 months known	Current quarter	0.12	0.70	0.37	0.71
	Next	0.52	0.71	0.38	0.60

		HARD		MIXED		SOFT	
		RMSFE	FDA	RMSFE	FDA	RMSFE	FDA
Zero month known	Current quarter	0.43	0.72	0.41	0.74	0.42	0.72
	Next	0.54	0.70	0.51	0.72	0.51	0.72
1 month known	Current quarter	0.22	0.74	0.21	0.75	0.21	0.75
	Next	0.45	0.73	0.44	0.73	0.46	0.73
2 months known	Current quarter	0.10	0.74	0.10	0.74	0.09	0.75
	Next	0.43	0.73	0.43	0.73	0.44	0.72

		VAR		CONSENSUS	
		RMSFE	FDA	RMSFE	FDA
Zero month known	Current quarter	0.38	0.75	0.40	0.74
	Next	0.51	0.73	0.50	0.72
1 month known	Current quarter	0.22	0.77	0.20	0.76
	Next	0.50	0.73	0.44	0.74
2 months known	Current quarter	0.09	0.79	0.09	0.77
	Next	0.47	0.73	0.42	0.73

The following conclusions can be drawn:

- When no monthly information on GDP is known in the current quarter, there is little gain in using a monthly model. Indeed, high volatility of monthly data may imply a less satisfactory predictive performance. In terms of FDA, by contrast, indicator-based models always perform better than the quarterly autoregressive model, especially for the next quarter. Amongst monthly models, indicator-based models (using either soft or hard indicators) have lower standard errors than a monthly autoregressive model.

- Monthly models appear to outperform a quarterly autoregressive model once one month or two months of information on GDP is known in the current quarter. This suggests that monthly indicators contain useful information. The accuracy of the monthly models increases when new monthly information becomes available and is particularly high (compared to other G7 models based on quarterly models) for the current quarter when two months are known. This is mostly attributable to the business GDP models. Indeed, forecasting non-business GDP with an autoregressive process would not change the results significantly.

- There is no obvious gain in adopting a monthly model for one-quarter ahead forecasts. One possibility could thus be to forecast the current quarter using the monthly model, and then use this projection as if they were real data in a quarterly model. This alternative would have the advantage of being able to use information available only at the quarterly frequency for the one-quarter ahead forecast, but has the drawback of complicating the procedures. Given that performance of the quarterly autoregressive model and the monthly indicator model are quite close, such a complication may not be worthwhile.

- The consensus model appears to outperform all the other monthly models in most cases. One explanation is that it smoothes the volatility of the monthly forecasts by averaging. The only exception is for the current quarter when no monthly information on GDP is known, in which case a conditional VAR is slightly better.

Table 4. **Diebold Mariano test**

	Benchmark: Monthly autoregressive model									
	One-month forecast									
	HARD		MIXED		SOFT		VAR		CONSENSUS	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	1.06	0.27	1.13	**0.01**	1.10	0.06	1.33	**0.00**	1.17	**0.00**
1 month know	1.26	0.10	1.28	**0.02**	1.32	**0.01**	1.33	**0.00**	1.36	**0.00**
2 months known	1.28	0.16	1.28	0.16	1.31	**0.01**	1.34	**0.00**	1.38	**0.00**
	Two-month forecast									
	HARD		MIXED		SOFT		VAR		CONSENSUS	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	1.05	0.51	1.14	**0.02**	1.05	0.36	1.07	0.08	1.11	**0.00**
1 month know	1.18	0.32	1.25	**0.05**	1.15	0.37	1.07	0.09	1.23	**0.00**
2 months known	–	–	–	–	–	–	–	–	–	–
	Three-month forecast									
	HARD		MIXED		SOFT		VAR		CONSENSUS	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	1.04	0.35	1.07	0.11	1.03	0.55	1.03	0.28	1.07	**0.02**
1 month know	–	–	–	–	–	–	–	–	–	–
2 months known	–	–	–	–	–	–	–	–	–	–

	Benchmark: Consensus model							
	One-month forecast							
	HARD		MIXED		SOFT		VAR	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	0.91	**0.01**	0.96	0.10	0.94	0.12	1.13	**0.02**
1 month know	0.92	**0.04**	0.93	**0.00**	0.96	0.41	0.97	0.10
2 months known	0.92	0.09	0.92	0.09	0.95	0.34	0.97	0.09
	Two-month forecast							
	HARD		MIXED		SOFT		VAR	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	0.94	0.27	1.03	0.36	0.94	**0.02**	0.96	0.06
1 month know	0.97	0.47	1.02	0.57	0.94	**0.03**	0.87	**0.00**
2 months known	–	–	–	–	–	–	–	–
	Three-month forecast							
	HARD		MIXED		SOFT		VAR	
	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue	DM stat	Pvalue
Zero month known	0.97	0.46	1.00	1.00	0.96	0.14	0.97	**0.03**
1 month know	–	–	–	–	–	–	–	–
2 months known	–	–	–	–	–	–	–	–

Note: The DM stat is the ratio of the MSFE of the benchmark model over the MSFE of the competing model. A ratio above 1 (resp. below 1) indicates that the benchmark model performs better (resp. worse) than the competing model. A *p*value above 0.1 suggests the difference between the two models is not statistically significant. *P*values below 0.05 are in **bold**.

To investigate whether one monthly model was performing significantly better than the other, Diebold Mariano tests were performed. In these tests, the ratio of the forecast errors of two competing models (*e.g.* model 1 over model 2) is computed. When the ratio is significantly greater (resp. lower) than 1, model 2 (resp. model 1) is more precise. Results are reported in Table 4. In the upper panel, indicator-based models are compared with the monthly autoregressive panel, and in the second panel the benchmark is the consensus model.

- Although standard errors are generally found to be lower in the indicator-based models than in the monthly autoregressive model, differences do not appear to be statistically significant most of the time. One notable exception is for the consensus model, which is found to systematically outperform the monthly autoregressive model.

- Amongst indicator-based models, there is little evidence that the consensus model performs significantly better than the others, even though this can be the case at some points in time.

Track record of the model

Ex ante statistical tests provide only partial information on the performance of a forecasting model, and it is important to check how the model has performed in real time. The Canadian model has been used for almost a year in the context of the bi-annual Economic Outlook. Using eight vintages of data, it is thus possible to compute the "real-time" forecasting performance of the model for the current quarter, even though these results should be interpreted with caution and will need to be re-assessed when more data become available. For the very same reasons, it is too soon to examine performance of the model for the forthcoming quarter.

Actual and simulated RMSFEs, computed as a simple average of out-of-sample RMSFEs, are reported in Table 5. Overall the Canadian model has performed relatively well: the average error of the consensus model for the current quarter is below 0.2 percentage points (on average for seven forecasts undertaken). This is lower than the estimated standard error of the model when zero or one month of data are known. This is also on the lower band of the average error of the other quarterly G7 indicator models developed in Sédillot and Pain (2005).

The quarterly autoregressive model continues to exhibit worse results than the other models. The hard indicator-based model also appears to be less accurate than the other monthly models, but there does not seem to be significant difference between the remaining models. It is nonetheless worth noting that the monthly autoregressive model has performed better than expected in light of its simulated out-of-sample errors, although it is unclear whether it will continue to do so in future forecasting exercises.

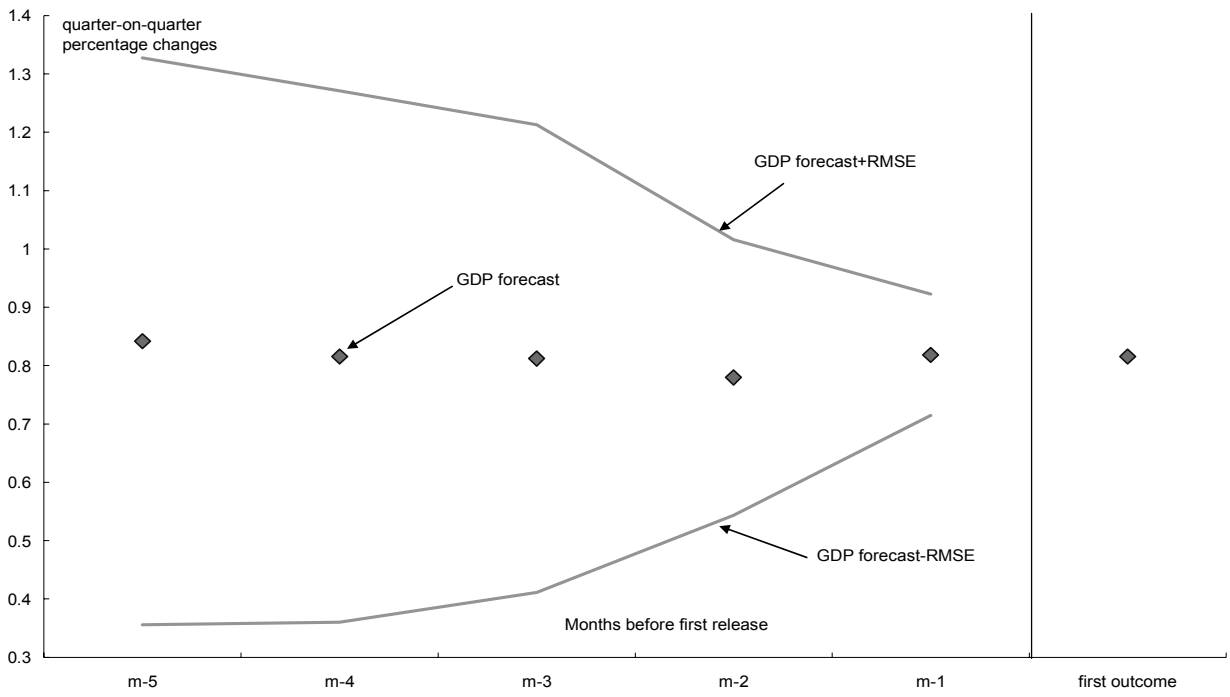
In addition, one main feature of the model is its unexpected stability as illustrated by the small variation in forecasts from one update to the other, despite the high volatility of monthly data (Figure 1). As a result, it appears possible to get a relatively good idea of the current but also of the next quarter as soon as the current quarter is completed,[11] and this despite the relative large confidence bands when the first estimations are made. This is particularly useful as the first publication of the quarterly national accounts occurs only two months after the end of the quarter. Moreover, there is no systematic over- or under-evaluation of real GDP by the model. These results will nonetheless need to be further investigated as soon as more comprehensive real-time tests can be undertaken.

11. Indeed, monthly GDP is generally published with circa a 60 days' lag.

Table 5. **Actual and simulated errors (based on seven real-time forecasts)**

	Actual RMSFE	Simulated RMSFE
AUTOM	0.11	0.29
AUTOQ	0.20	0.37
HARD	0.16	0.25
MIXED	0.13	0.24
SOFT	0.11	0.24
VAR	0.13	0.23
CONSENSUS	0.12	0.23

Figure 1. **Evolution of forecast for 2006Q1**

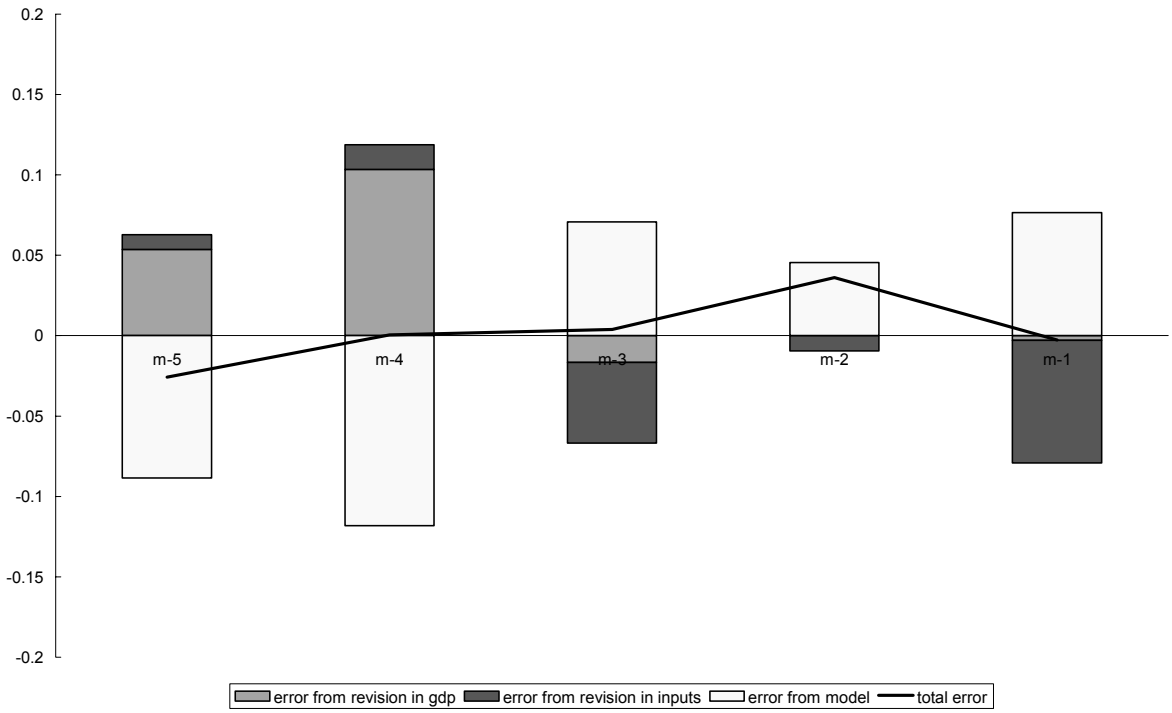


To provide more information on the real-time performance of the model, it is interesting to divide forecasting errors into three components:

- Errors due to revisions in monthly GDP data;
- Errors due to revisions in inputs (*i.e.* monthly indicators used in the various models);
- And errors in the estimated model (computed as a residual between the total error and the two sources of errors from data).

Errors from data revisions are generally compensated by errors in the model so that the final error is relatively small (Figure 2). Moreover, there is no systematic under or over-prediction from any type of errors. Errors from the estimated model are most of the time larger than errors from data revisions and explain at least 50 per cent of the sum of absolute errors in this example (typically between 50 and 80 per cent). Nonetheless errors due to data revisions remain significant, although the respective importance of revisions in GDP data or in monthly indicators varies over time. This is broadly consistent with findings on quarterly models for other countries or regions (*e.g*. Diron (2006) for the euro area).

Figure 2. **Decomposition of errors**



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Annex 1

Description of the variables

All variables are seasonally adjusted and are from the CANSIM database.

Gross Domestic Product (GDP) at basic prices, by NAICS:

- All industries; 1997 constant dollars; (Dollars – Millions) – v2036138
- Business sector industries; 1997 constant dollars; (Dollars – Millions) – v2044335
- Non-business sector industries; 1997 constant dollars; (Dollars – Millions) – v2044338
- Industrial production; 1997 constant dollars; (Dollars – Millions) – v2044343
- Retail trade; 1997 constant dollars; (Dollars – Millions) – v2036359
- Wholesale trade; 1997 constant dollars; (Dollars – Millions) – v2036358

Business indicators:

Leading indicators:

- Composite index of 10 indicators; Smoothed (Index, 1992 = 100) – v7688
- Retail trade, furniture and appliances; Smoothed (1992 Dollars – Millions) – v7684
- Durable goods sales excluding furniture and appliances; Smoothed (1992 Dollars – Millions) – v7685
- Money supply; Smoothed (1992 Dollars – Millions) – v7682
- Stock price index, TSE 300; Smoothed (Index, 1975 = 1000) – v7678
- New orders, durable goods; Smoothed (1992 Dollars – Millions) – v7683
- Shipment to inventory ratio, finished products; Smoothed (Ratio) – v7686
- Average work week, manufacturing; Smoothed (Hours) – v7677
- Business and personal services employment; Smoothed (Persons – Thousands) – v7679
- Housing index; Smoothed (Index, 1992 = 100) – v7680
- United States composite leading index; Smoothed (Index, 1992 = 100) – v7681

Other:

- Production of new motor vehicles; Total, motor vehicles (Units) – v2835
- Other estimates of new motor vehicle sales; Total, new motor vehicles; Units; (Units) – v2676
- Survey of large retailers; Canada; Total commodities (Dollars – Thousands) – v822787

- Supply and disposition of crude oil and equivalent; Total supply (Cubic metres – Thousands) – v17953
- Shipments/inventories, orders/inventory to shipment ratios, NAICS; Manufacturing :
  - New orders, estimated values of orders received during month; (Dollars – Thousands) – v800913
  - Total inventory, estimated values of total inventory at end of the month; (Dollars – Thousands) – v803227

Labour markets:

- Employment; Both sexes; 15 years and over; (Persons – Thousands) – v2062811
- Employment full-time; Both sexes; 15 years and over; (Persons – Thousands) – v2062812
- Employment part-time; Both sexes; 15 years and over; (Persons – Thousands) – v2062813
- Unemployment rate; Both sexes; 15 years and over; (Rate) – v2062815
- Public sector employees; Both sexes; (Persons – Thousands) – v2066969

Wages and prices:

- Average hourly earnings for hourly-paid employees (SEPH); Industrial aggregate excluding unclassified (Dollars) – v1597782
- Average weekly hours for hourly-paid employees, including overtime (SEPH); Industrial aggregate excluding unclassified (Hours) – v1597443
- Consumer price index, 2001 basket content; All-items (Index, 1992 = 100) – v735319
- Consumer price index, 2001 basket content; All-items excluding food and energy (Index, 1992 = 100) – v735600
- Industry price indexes, by major commodity aggregations and stage of processing; Total, all commodities (Index, 1997 = 100) – v1574377
- Construction union wage rate indexes; Composite; Basic construction union wage rate indexes (Index, 1992 = 100) – v734336

Housing:

- New housing price indexes; Total (house and land); 1997 = 100 (Index) – v21148160
- Housing starts, all areas; (Units – Thousands) – v730390
- Building permits, values by activity sector; Total residential and non-residential (Dollars – Thousands) – v4667

Balance of payments:

- Exports, total of all merchandise (Dollars – Millions) – v191490
- Imports, total of all merchandise (Dollars – Millions) – v183406
- Price index; Paasche current weighted; Imports, total of all merchandise (Index, 1997 = 100) – v2000007

- Price index; Paasche current weighted; Exports, total of all merchandise (Index, 1997 = 100) – v2001030

Financial variables:

- Foreign exchange rates in Canadian dollars; United States dollar, noon spot rate, average (Dollars) – v37426
- Commodity price index, United States dollar terms; Total, all commodities (Index, 82-90 = 100) – 36382
- Toronto stock exchange statistics; Total volume; Shares traded (Shares – Thousands) – v6379
- Toronto stock exchange statistics; Total volume; Value of shares traded (Dollars – Millions) – v6384

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