Models in Policy-Making

Don Coletti and Stephen Murchison, Research Department

- *Because of the lag in the effect of monetary policy on spending and inflation, policy decisions are necessarily based upon an uncertain view of how the future will unfold.*
- *At the Bank of Canada, the staff use economic models mainly to help construct forecasts of the most likely evolution of the Canadian economy, particularly the extent of future inflationary pressures. Many of these models also produce recommended paths for the target overnight interest rate.*
- *Economic models represent a deliberate abstraction from a complex reality. They combine those behavioural relationships believed to be responsible for the bulk of macroeconomic fluctuations, while omitting those deemed less important. This process of differentiation allows economists to make predictions that are reasonably accurate and that can be more easily understood and communicated.*
- *The models used at the Bank are flexible tools that can be adapted to incorporate different assumptions or additional information obtained from other sources.*
- *A multiple-model approach helps to mitigate the effects of model uncertainty.*

> *As central bankers go about their day-to-day business of implementing monetary policy, they must look ahead and anticipate what is likely to happen down the road. They have to work with assumptions and make judgment calls about future economic developments and about the timing and final outcome of any monetary policy action they take.*
> David Dodge, Governor of the Bank of Canada
> (26 June 2001)

The objective of Canadian monetary policy is to keep the 12-month rate of change in the consumer price index (CPI) at the 2 per cent target midpoint of a 1 to 3 per cent range over the medium term. Fulfilling this objective would be straightforward if changes in monetary policy affected inflation immediately. In such a world, the Bank would only have to determine what current inflationary pressures were and set policy accordingly. But historical experience in Canada suggests that interest rate changes can take from 18 to 24 months to work their way through the economy and significantly affect inflation.[1]

The time delay between monetary policy actions and inflation outcomes implies that in setting policy today, the Bank must take a view on the extent of inflationary pressure that will prevail 18 to 24 months from now.

1. These lags appear to be due to the gradual adjustment of spending and prices to changes in interest rates in the economy. One possible description of the transmission mechanism of monetary policy is as follows: first, changes in interest rates gradually lead to changes in spending and sales. Second, changes in spending and sales, which can themselves directly influence prices, lead to changes in production and employment. Finally, these changes in production can also lead to changes in prices and, hence, to changes in inflation.

Thus, the Bank must forecast those factors believed to influence inflation, including monetary policy itself.

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Staff at the Bank of Canada use economic models along with judgment to forecast the most likely evolution of the Canadian economy and to derive the recommended setting for monetary policy that will keep forecast inflation close to the 2 per cent target midpoint. These recommendations are an important input into the overall decision-making process.

Why Models?

> *Economic theory does make unrealistic assumptions . . . . But this propensity to abstract from reality results from the incredible complexity of the economic world . . . . Abstraction from unimportant details is necessary to understand the functioning of anything as complex as the economy.*
> William Baumol and Alan Blinder (1994)

Economic models are mathematical representations of the economy that are designed to be simplifications of a complex reality. These so-called "virtual economies" combine the behavioural relationships that are thought to cause most macroeconomic fluctuations, while omitting those deemed less important. This selection process helps economists to understand how the economy works and to use this understanding to predict future economic outcomes.

By using an economic model, a policy-maker can assess the impact of a particular economic development (e.g., higher world commodity prices) or policy choice (e.g., lower taxes or interest rates) on the economy without having to actually face the shock or implement the policy. But more importantly, economic models impose structure and eliminate fuzzy thinking by forcing economists to formalize views that may be based largely on intuition.

Cast in this light, economic models can be interpreted as reflecting a set of thoughts about how a particular economy functions. But models are much more than just a catalogue of what we think we already know. They are also a means by which researchers can validate their beliefs. For instance, by simulating the virtual economy over a particular period of history, given the policy choices made during that period, and then comparing the outcome with actual events, researchers can evaluate how well their model describes reality. These types of experiments provide economists with a disciplined approach to learning from past errors (Gorbet 1973; Maxwell 1975, 1976).

Furthermore, once created, models help eliminate misunderstanding by forcing researchers to communicate in a common language. In this way, models encourage fruitful debate by forcing those with opposing points of view to explain and defend the logic of their views in a common language. Models thus help to isolate the source of disagreements about a forecast by allowing those involved to separate the differences in their assumptions regarding factors determined outside the model (e.g., geopolitical developments, oil prices, etc.) from any differences in their view about the structure of the economy (Meyer 1997a).

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Finally, economic models help settle debates that cannot be settled by theory alone. Economic theory often suggests that potentially offsetting influences are at work in the economy. When combined with statistical methods, models help economists quantify the relative importance of each factor, thereby providing an estimate of the net impact of these offsetting influences. For example, suppose that we want to estimate the effect of a tax cut on government revenues. Although a tax cut has a direct negative effect on tax revenues it also has a positive indirect effect, because lowering taxes tends to stimulate economic activity, and tax revenues are positively related to economic activity. An economic model can be used to help quantify these two offsetting factors.

Why Multiple Models?

The staff at the Bank prefer to use several economic models, rather than just one. This approach is taken for two main reasons.

The first concerns the uncertainty regarding the correct economic paradigm (Selody 2001). In economics, there is no laboratory (as there is in physical sciences) in which researchers can alter key economic variables one at a time (e.g., external economic conditions, domestic monetary policy) and then directly observe their impact on the economy. As a result of this inability to run controlled experiments, there is considerable debate in academic and policy circles about which economic paradigm best represents the way in which monetary policy affects inflation. By using several models, based on competing paradigms, as tools to provide alternative policy recommendations, Bank staff help guard against large policy errors that could result from relying on a single economic paradigm that might be incorrect.

The second reason for a pluralistic approach to economic modelling stems from the fact that, being a simplification of a complex reality, no one model can answer all questions. A model's structure varies according to its intended purpose. For example, pure forecasting models are designed exclusively to exploit regularities in the historical data, and they typically fail to identify the underlying forces of equilibration in the economy. Provided historical correlations remain unchanged, these models often perform quite well as short-term forecasting devices. Over a longer-term horizon, however, the economy's underlying equilibrating forces become important. Thus, the usefulness of these purely statistical models tends to diminish with the length of the forecast horizon.

Issues related to monetary policy typically require a medium-term perspective. Thus, a clearer representation of the equilibrating forces in the economy is necessary (Poloz, Rose, and Tetlow 1994). How consumers and producers in the model form their expectations about future economic conditions is particularly important. One of the main channels through which monetary policy is believed to affect inflation is through peoples' expectations of future inflation. These are believed to be significantly influenced by the expected behaviour of monetary policy-makers. Pure forecasting models, which typically fail to isolate this channel, can yield misleading answers when there is a change in policy framework, particularly when the new framework does not reflect the average behaviour of policy over recent history. The move to an inflation-targeting regime, which Canada made in the early 1990s, is perhaps the most important recent change in policy framework (Longworth 2002).

Bank staff have developed a range of economic models. Some models clearly place policy analysis at the forefront, while others place greater emphasis on short-run forecast accuracy.

What Models Does the Bank Use?

There are several ways to categorize the models currently used at the Bank. Models could be divided according to the underlying paradigm upon which they are based. Alternatively, they could be organized according to their intended purpose—pure forecasting versus policy analysis. This division is somewhat more difficult, however, since "forecast" and "policy analysis" really describe the two extremes of what is, in reality, a continuum. Many of the Bank's most useful models are effective because they successfully combine elements of both design philosophies. Finally, models can be categorized according to a set of common characteristics or a shared purpose. In what follows, the Bank's models are divided into three categories: single-equation / indicator models; small multi-equation, reduced-form models; and medium-sized, dynamic-general-equilibrium models (DGEMs).[2]

Single-equation/indicator models

Bank economists have developed a number of single-equation models that are used to make short-run predictions of inflation, output growth, and the exchange rate.[3] The main inflation equation used is an updated version of a model developed by Fillion and Léonard (1997). In this model, core inflation is a function of expected inflation, the output gap, and past and current changes in indirect taxes, oil prices, and the real exchange rate. Expected inflation is constructed to be consistent with the monetary policy regime, as determined in earlier work using Markov-switching models for the inflation process (Ricketts 1996).

Dion (1999) constructs numerous indicator models of core inflation. These models use such explanatory variables as average prices for resale housing in four

2. DGEMs are based on the principle that macroeconomic modelling should begin with the economic problems faced by individual agents. It is the aggregate of all of these decisions that forms the macroeconomic reality (Maclean 2001).

3. To monitor GDP growth in the current and subsequent quarters, Bank economists also analyze incoming monthly data on such real variables as employment, manufacturing shipments and orders, exports, imports, retail trade, inventories, and monthly GDP at basic prices.

major cities, the ratio of unfilled orders to shipments in manufacturing, the Bank of Canada commodity price index in U.S. dollars, and several components of the CPI.

One of the aggregate demand equations used at the Bank is based on Duguay (1994). In this equation, output growth is explained by past and current changes in real interest rates, the real exchange rate, real commodity prices, and the stance of fiscal policy, and by U.S. output growth.

One of the Bank's most well-known, single-equation models is that developed by Amano and van Norden (1995),[4] which is used to forecast the Canada / U.S. real exchange rate. They find evidence that medium-run movements in the real exchange rate can be explained by the terms of trade. Real interest rate differentials across the two countries account for much of the short-run fluctuation in the exchange rate.

Recently, Bank researchers have started using artificial neural networks to forecast economic variables, in particular real GDP (Tkacz 2001). The model currently used explains the four-quarter growth rate in real GDP by the spread between long-term and short-term interest rates, the real short-term interest rate, and the growth rate of M1 over the past four quarters expressed in real terms.

Small multi-equation, reduced-form models

Several small, multi-equation models are currently employed at the Bank for various purposes. One such model is NAOMI, the North American Open-Economy Macroeconometric Integrated model. This is a fully estimated reduced-form macroeconomic model (Murchison 2001b) that was originally developed at the Department of Finance.[5] The Canadian portion of the NAOMI model consists of six behavioural equations that determine output growth, core and GDP inflation, the real exchange rate, and short- and long-term interest rates.[6] Prices and output are determined using the expectations-augmented Phillips curve paradigm.[7] According to this paradigm, there is an economy-wide potential level of output or production, around which the economy's actual output fluctuates. Monetary policy is able to influence real interest rates because prices are not completely flexible in the short run. Real interest rates in turn influence spending in the economy. Lower real interest rates tend to encourage spending and borrowing, while higher rates tend to have the opposite effect. The aggregate level of spending, in turn, influences production. Finally, the gap between actual production and the economy's capacity to produce is a key determinant of inflation. In addition to this so-called "output gap," current inflation is hypothesized to be influenced by the expectations of consumers and producers about future inflation. Inflation expectations are important because pricing decisions made today typically remain in effect for some period of time. Consequently, expected economic conditions over the duration of the price change must be considered.

Expectations in the NAOMI model are modelled as being purely adaptive. For example, expectations about future inflation are based exclusively on the recent behaviour of inflation itself. In this sense, the model assumes that people use a fairly limited set of information when forming their expectations. This assumption makes it easier to achieve more accurate short-run forecasts, since it greatly diminishes the complexity of the model. The NAOMI model's primary role is to provide the staff with additional guidance on the near-term evolution of the Canadian economy at the macro level.

As discussed earlier, uncertainty about the "right" economic paradigm has led to the simultaneous creation of several models that reflect competing viewpoints on how the economy functions. The staff at the Bank of Canada make an alternative monetary policy recommendation based in part on the "active money" paradigm, in which changes to the supply of money and credit are thought to be critical to price-setting behaviour (Laidler 1999; Maclean 2001).

This view of the transmission mechanism is embodied in the M1-Vector-Error-Correction Model (M1-VECM). The M1-VECM is based on Hendry (1995), who finds a unique long-run relationship between M1, real GDP, the consumer price index, and the overnight (one-day) rate of interest. The model explains changes in these four variables by lagged changes in these variables, the error-correction term (called the M1 gap), and a set of other short-run explanatory variables.[8] Simulations

4. See also Lafrance and van Norden (1995).

5. NAOMI was built with accurate short-term forecasting as its primary objective. The model-selection procedure used to fulfil this objective is outlined in Murchison (2001a).

6. The U.S. side of the model is still under development and is not currently used at the Bank of Canada.

7. The original Phillips curve was specified in terms of the change in nominal wages and the unemployment rate (Phillips 1958). In the NAOMI model, the Phillips curve model is applied to the aggregate economy rather than just the market for labour.

8. These include the change in the exchange rate, the change in U.S. short-term interest rates, the lagged output gap, and the difference between real interest rates in Canada and the United States.

with this model can be used to determine the interest rate changes that would be necessary to bring inflation back to the midpoint of the inflation-control target range over a two-year horizon.

Several other money-based models are used to assess risks to the forecasts of the M1-VECM. They are summarized in Maclean (2001).

To carry out a forecast of the Canadian economy, Bank staff are required to have a forecast of key U.S. variables such as real GDP, inflation, and interest rates, as well as a forecast of world commodity prices. In forming a view on the future evolution of the U.S. economy, the staff draw on information gathered from several sources, including the forecasts and analyses produced by other organizations. The principal model used to forecast the U.S. economy at the Bank is the United States Model (USM), a small, estimated, reduced-form model of the U.S. economy (Lalonde 2000). The core of this model consists of three equations: an expectations-augmented Phillips curve equation; an aggregate demand equation; and a monetary policy reaction function. A key input into the U.S. projection is the measure of U.S. potential output. For the USM, a structural VAR (SVAR) model is used to generate potential output (Lalonde 1998).

Medium-sized, dynamic general-equilibrium models (DGEMs)

The staff economic projection for Canada is produced using a single, core model that reflects the mainstream view of the key macroeconomic linkages in the economy. In September 1993, the staff of the Bank of Canada began using the Quarterly Projection Model (QPM) for this purpose (Poloz, Rose, and Tetlow 1994). Compared with most other central bank models used for similar purposes, the QPM is relatively small. This reflects a conscious decision to abstract from the sector-specific details of the Canadian economy in order to focus on the core macro linkages in a theoretically consistent framework that respects long-run budget constraints. Instead of the aggregate price level being determined by the sum of prices from various sectors, as was the case with certain previous models at the Bank of Canada, each with its own special causal structure, aggregate price determination is currently viewed as principally a macro phenomenon (Coletti et al. 1996). Although the model continues to evolve over time, its general characteristics have remained broadly unchanged.

At the heart of the QPM is a steady-state model (Black et al. 1994). The steady-state model describes the determinants of the long-run choices made by profit-maximizing firms and successive generations of consumers, given the policy choices of the fiscal authority, all in the context of an open economy having important linkages with the rest of the world. The behaviour of these agents, given their long-run budget constraints and the market-clearing conditions of an open economy, determines the long-run equilibrium or steady state to which the dynamic model converges.

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The dynamic version of the QPM (Coletti et al. 1996) describes the adjustment path of the economy to the steady state. According to this model, agents' decisions are strongly influenced by their expectations about the future. This type of behaviour stems from the assumption of multiperiod contracts and costly adjustment. Agents are assumed to have incomplete knowledge of the true structure of the economy when forming expectations. Nevertheless, they form expectations in a more sophisticated manner than in the NAOMI model or the USM. Overall, expectations formation plays a key role in the dynamic response of the model.

Equilibrium in the model is defined in terms of stocks (e.g., the stock of productive capital and the stock of total government debt). This has important implications for the dynamic behaviour of the corresponding flows (business fixed investment and government deficits) and, consequently, for overall model dynamics.

A key role of the monetary authority in the model economy is to establish an anchor for inflation expectations. More specifically, monetary policy is conducted using a forward-looking policy rule that requires the monetary authority to adjust its policy instrument so as to bring inflation expectations and, therefore, inflation itself, in line with the targeted rate. The monetary policy instrument in the QPM is the short-term interest rate, which influences spending

through its effect on the slope of the yield curve.[9] Through an uncovered-interest-parity condition, movements in the short-term nominal interest rate also affect the nominal exchange rate and, hence, import prices and inflation. Inflation is influenced directly by the gap between actual and potential output and by expectations about future inflation.

Finally, fiscal policy in the QPM, like monetary policy, is characterized by a set of objectives that is consistent with achieving a sustainable equilibrium. In particular, the fiscal authority picks target levels for government expenditures on goods and services and public debt as a ratio of GDP. Taxes (net of transfers to households) and the budget balance adjust to achieve these targets.

The QPM benefits from conditioning information derived from structural models such as the Terms-of-Trade Model (TOTMOD) (Macklem 1992, 1993). The TOTMOD is a multi-sector, DGEM that is particularly useful for analyzing the medium-to-long-run aggregate and sectoral implications of fluctuations in the relative price of resource-based commodity exports. Given the importance and prevalence of commodity-price fluctuations in recent Canadian history, the TOTMOD serves a useful role in informing the staff's judgment.

The Projection Process—More than Just Models

> *Models and historical regularities are important underpinnings of any pre-emptive policy. Such a policy depends on forecasts because you are attempting to avoid problems that would occur if you failed to act. But judgment is essential too, and more so when historical regularities are called into question.*
> Laurence H. Meyer, Former Governor, United States Federal Reserve Board (1997b)

It is important to note that staff judgment is incorporated in all forecasting exercises, especially when looking at near-term developments. In particular, the staff uses judgment when it can identify an important role for factors that have been omitted from the model. For instance, suppose that GDP growth turned out to be lower than forecast by the economic model. The staff would try to identify the factors responsible, make a judgment as to their expected persistence, and adjust the model accordingly. If the staff judged that the unforecast weakness of real GDP growth was a negative demand shock, they would accordingly subtract from the model's forecast of demand. The model would then translate this reduction in demand into weaker inflation pressure that would give rise to a recommendation for a lower path of interest rates, everything else being equal. This approach affords the staff the flexibility to modify certain aspects of the forecast, while at the same time allowing the model to determine the implications of the added judgment in a consistent manner.

Another reason to add judgment to the projection can arise from the analyses carried out by sectoral experts. Since the main models used by Bank staff emphasize macro relationships rather than sectoral detail, the staff sometimes impose judgment on macro models to reflect specific information coming from sectoral specialists. The models then forecast the aggregate implications of specific sectoral developments.

In addition to aiding the staff in producing a baseline economic projection, models are frequently used to generate what are referred to as risk scenarios. These "what if" scenarios are forecasts that analyze the monetary policy implications of an alternative set of assumptions for those variables that are determined outside the model. For example, suppose Canada has just witnessed a rapid and significant fall in the price of its natural resource exports. Suppose further that the staff have assumed this decline to be temporary in the projection but that they are, at the same time, highly uncertain about the expected duration of the shock. In such a circumstance, a risk scenario could be produced that treats the price decline as longer-lasting. This would give the staff an idea of the range of possible inflation outcomes and therefore the range of appropriate monetary policy responses. Alternative scenarios examine the implications for key economic variables, such as output growth and inflation, of changes in the timing and / or magnitude of interest rate changes relative to the staff's base-case projection.

As discussed by Macklem (2002) in this issue, information from a wide variety of sources is compiled and analyzed in the process of arriving at recommendations for monetary policy. Key among these sources is the suite of economic models maintained by the Bank's staff. As our knowledge of the economy, not to mention the technology of model-building, continues to evolve, so will our economic models.

9. The slope of the yield curve is defined as the difference between a measure of short-term and long-term interest rates, adjusted for a measure of the term premium.

Literature Cited

Amano, R. and S. van Norden. 1995. "Terms of trade and real exchange rates: the Canadian evidence." *Journal of International Money and Finance* 14: 83–104.

Baumol, W. and A. Blinder. 1994. *Microeconomics*. Fort Worth, TX: The Dryden Press.

Black, R., D. Laxton, D. Rose, and R. Tetlow. 1994. *The Bank of Canada's New Quarterly Projection Model, Part 1: The Steady-State Model: SSQPM*. Technical Report No. 72. Ottawa: Bank of Canada.

Coletti, D., B. Hunt, D. Rose, and R. Tetlow. 1996. *The Bank of Canada's New Quarterly Projection Model, Part 3: The Dynamic Model: QPM*. Technical Report No. 75. Ottawa: Bank of Canada.

Dion, R. 1999. "Indicator Models of Core Inflation for Canada." Bank of Canada Working Paper No. 99–13.

Dodge, D. 2001. "Canada's Monetary Policy Approach: It Works for Canadians." Remarks by David Dodge, Governor of the Bank of Canada, to the Edmonton Chamber of Commerce. Edmonton, Alberta, 26 June 2001. *Bank of Canada Review* (Summer): 51–56.

Duguay, P. 1994. "Empirical Evidence on the Strength of the Monetary Transmission Mechanism in Canada: An Aggregate Approach." *Journal of Monetary Economics* 33: 39–61.

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

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.

Gorbet, F.W. 1973. "Econometric models: Some comments on their use in policy analysis." *Bank of Canada Review* (October): 3–14.

Hendry, S. 1995. "Long-Run Demand for M1." Bank of Canada Working Paper No. 95–11.

Lafrance, R. and S. van Norden. 1995. "Exchange rate fundamentals and the Canadian dollar." *Bank of Canada Review* (Spring): 17–33.

Laidler, D. 1999. "Passive Money, Active Money, and Monetary Policy." *Bank of Canada Review (*Summer): 15–25.

Lalonde, R. 1998. "Le PIB potentiel des États-Unis et ses déterminants : la productivité de la main-d'œuvre et le taux d'activité." Bank of Canada Working Paper No. 98-13.

———. 2000. "Le modèle USM d'analyse et de projection de l'économie américaine." Bank of Canada Working Paper No. 2000-19.

Longworth, D. 2002. "Inflation and the Macroeconomy: Changes from the 1980s to the 1990s." *Bank of Canada Review* (Spring): 3–18.

Macklem, R.T. 1992. "Terms-of-Trade Shocks, Real Exchange Rate Adjustment, and Sectoral and Aggregate Dynamics." In *The Exchange Rate and the Economy*, 1–60. Proceedings of a conference held at the Bank of Canada, 22–23 June 1992. Ottawa: Bank of Canada.

———. 1993. "Terms-of-Trade Disturbances and Fiscal Policy in a Small Open Economy." *Economic Journal* 103: 916–36.

———. 2002. "Information and Analysis for Monetary Policy: Coming to a Decision." *Bank of Canada Review*, this issue.

Maclean, D. 2001. "Analyzing the Monetary Aggregates." *Bank of Canada Review* (Summer): 31–43.

Maxwell, T. 1975. "Validation of macroeconometric models: Some reflections on the state of the art." *Bank of Canada Review* (November): 9–16.

———. 1976. "Assessing the performance of macro–econometric models in policy analysis." *Bank of Canada Review* (May): 3–11.

Meyer, L. 1997a. "The Role for Structural Macroeconomic Models." Remarks by Governor Laurence H. Meyer of the U.S. Federal Reserve Board of Governors to the AEA Panel on Monetary and Fiscal Policy, New Orleans, Louisiana, 5 January 1997. Available at <http://www.federalreserve.gov/boarddocs/speeches/1997/19970105.htm>.

———. 1997b. "Conduct of Monetary Policy." Remarks by Governor Laurence H. Meyer of the U.S. Federal Reserve Board of Governors before the Committee on Banking and Financial Services, U.S. House of Representatives, 23 July 1997. Available at <http://www.federalreserve.gov/boarddocs/testimony/1997/19970723.htm>.

Murchison, S. 2001a. "NAOMI: A New Quarterly Forecasting Model. Part I: Proposed Model Selection Strategy." Department of Finance Working Paper No. 2001–19.

———. 2001b. "NAOMI: A New Quarterly Forecasting Model. Part II: A Guide to Canadian NAOMI." Department of Finance Working Paper No. 2001–25.

Phillips, A.W. 1958. "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957." *Economica* 25: 283–99.

Poloz, S., D. Rose, and R. Tetlow. 1994. "The Bank of Canada's New Quarterly Projection Model (QPM): An Introduction." *Bank of Canada Review* (Autumn): 23–38.

Ricketts, N. 1996. "Real short-term interest rates and expected inflation: Measurement and interpretation." *Bank of Canada Review* (Summer): 23–40.

Selody, J. 2001. "Uncertainty and Multiple Perspectives." In *Monetary Analysis: Tools and Application*, 31–46. H.-J. Klöckers and C. Willeke, eds. Frankfurt: European Central Bank.

Tkacz, G. 2001. "Neural Network Forecasting of Canadian GDP Growth." *International Journal of Forecasting* 17: 57–69.