

Dynamic General-Equilibrium Models and Why the Bank of Canada is Interested in Them

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- *This article describes the new macroeconomic research methodology associated with dynamic general-equilibrium models (DGEMs). It places this methodology in perspective by discussing its origins, describing its main features, and highlighting its contribution to economic research work at the Bank of Canada.*
- *DGEMs are based on the principle that macroeconomic modelling should consist of aggregating into a macroeconomic whole the many choices made by individual economic agents whose behaviour is being studied.*
- *Because it originated in microeconomic theory, the interpretation that DGEMs offer for fluctuations in economic activity places great stress on the individual reactions of agents to changes, actual or expected, in the economic environment in which they operate.*
- *DGEMs thus approach macroeconomic analysis from a different perspective, one that broadens the range of analytical tools available to the monetary authorities.*
- *The Bank of Canada's Quarterly Projection Model (QPM) already embraces certain features of DGEMs, and the Bank is pursuing its research to improve the properties of these models and adapt them to its particular needs.*

The 1980s saw a major breakthrough in the field of macroeconomic modelling. The first models to emerge from this breakthrough, known as “real-business-cycle models,” sparked some controversy. Their builders were criticized for focusing their analysis on only one type of shock and one type of economic structure and for failing to recognize any active role for monetary policy. From the viewpoint of central bank economists, it was difficult to see how these models could make any positive contribution to the discussion of monetary policy. Two decades later, this controversy has largely dissipated, although there remains considerable uncertainty about the nature of economic fluctuations and about the most effective methodological approach for studying them. The main reason is that the innovation in methodology underlying real-business-cycle models—the notion that a macroeconomic model must consist of an aggregated set of microeconomic problems—has been adopted by many economists in various fields of specialization. Moreover, research conducted using this methodology has led to the modelling of many economic structures and potential sources of shocks. It has therefore been demonstrated that this new methodology can provide economists with a balanced and powerful analytical framework, and the term “dynamic general-equilibrium models” (DGEMs) has replaced the earlier “real-business-cycle models” to designate this methodology and the models derived from it.

Because they rely primarily on microeconomic theory in their construction, DGEMs are an excellent supplement to the tools generally used by central banks, and the Bank of Canada has been interested in them for some years. Several of the features of DGEM

methodology are found in the structure of the Quarterly Projection Model (QPM), the principal model of the Canadian economy used by the Bank. Moreover, the Bank is pursuing research to adapt these models to the particular needs of its own macroeconomic analysis and thereby equip the institution with the best possible analytical tools.

Models, Modelling, and Methodology

Economic models are simplified and artificial versions of reality that are used by economists to help them understand the functioning of the economy, to identify the essential economic mechanisms, and to forecast (as well as possible) its future behaviour. For example, the Bank of Canada has to anticipate events that are likely to affect its conduct of monetary policy over the coming quarters and then decide on the best way to react. By using economic models, the Bank has strengthened its capacity to identify these events and has improved its understanding of the mechanisms through which the impact of its actions is transmitted to various sectors of the economy.

Models cannot provide a complete picture of reality, of course, and each model will highlight certain characteristics of the economy, while ignoring others. The sectors of the economy studied will thus differ from one model to the next. While one model may stress the financial aspects of economic activity (loans, corporate indebtedness, etc.), another may focus on the labour market (unemployment, wages, etc.). In addition, some models are designed to ensure the best possible short-term forecasting capability, while others are intended to identify underlying trends that will influence the economy for several years, or even decades, to come.

Models also differ in the methodological approach underlying their construction. In this respect, an important point of distinction lies in the importance of theory as opposed to that of empirical observation. Thus, some models rely primarily on the study of data, and they interpret economic fluctuations in light of their statistical properties. Other models attempt, instead, to interpret these fluctuations by using theories about the behaviour of economic agents. For example, an empirical model might seek to identify (using time series) the essential statistical components of changes in the inflation rate and so arrive at a prediction of future inflation trends. The theoretical approach, in contrast, will attempt to develop a series of hypotheses about the rules that firms employ in

deciding whether to increase the price of their products, leading to a model of the determination of inflation. A specific question can be examined with both these models, and since they reflect different strategies, each will shed a different light on the question.

It goes without saying that economic models are constantly evolving, although not always at the same pace. The decision to make changes to any model generally results from a decline in its explanatory capability or its predictive power. Sometimes economists may suggest fundamental changes to the basic structure of a model, basing their argument on considerations of methodology. The Bank of Canada is no exception, and since the mid-1960s it has been constantly revising and improving the principal models it uses to study the Canadian economy.¹

It should be clear from the foregoing that an economic model is, for all practical purposes, an analytical method that portrays an extremely simplified picture of the real world. The study of any kind of model, therefore, requires an examination of the methodology with which it is associated.

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The basic principle of the DGEM is that the modelling of any economic activity, even at a scale as large as the economy of a country, should start with a series of microeconomic problems (at the scale of individuals) which, once resolved, are aggregated to represent the macroeconomic reality described by the model. The macroeconomy is, according to this approach, merely the logical extension of the microeconomy, rather than some distinct and separate entity that relies on the

1. The RDX1 model, constructed in the late 1960s, was replaced first by RDX2 in the early 1970s, then by RDXF in the early 1980s, and finally by QPM in the early 1990s. See Duguay and Longworth (1998) for a history of economic modelling at the Bank of Canada and Poloz (1994) for a description of QPM and its use in the conduct of monetary policy.

hypothesis that economic activity at the national level can be understood through a series of aggregated curves, in particular IS-LM curves and the Phillips curve.²

A DGEM thus consists of a precise statement of the choices facing different economic players (firms and households, governments, and the central bank) featured in the model, the preferences of these players, the planning horizon that they adopt and, finally, the exact nature of the uncertainty with which they have to cope. This uncertainty relates to the possible values of the different variables likely to influence the economic environment.

To make a judicious choice, economic agents must form an opinion (in other words, develop expectations) about the probable future path of these variables. These expectations are assumed to be “rational,” a technical term expressing the idea that households are knowledgeable observers of the economic scene and that, although unforeseen events may catch them off guard, they will not be continuously surprised to see such events repeat themselves with a certain regularity.

The model builder then assumes that, taking account of these different preferences, individual agents will adopt decision-making rules that maximize their utility (an economic term meaning the level of an agent's welfare), in the case of households, and their profits, in the case of firms. These individual decision-making rules are then aggregated, and it is this aggregation that represents, once equilibrium in the different markets is ensured,³ the implications of the model with respect to the major variables traditionally studied in macroeconomics, such as consumption and investment.

It is important to note that this very general methodological framework does not in any way prejudge the type of shock to be studied, the economic structure assumed (whether there is perfect competition or an alternative), or the effectiveness of government or central bank policies. The only constraint that this methodology imposes on an economist seeking to analyze a particular problem is that of describing explicitly

how the problem influences the choices of the various economic agents included in the model and of accounting for this influence in establishing their decision-making rules.

The Methodological Breakthrough of the 1970s

The 1970s were fairly difficult times for the Canadian economy. During much of that decade, economic growth was weak, and inflation and unemployment rates were relatively high. It was also a time of testing for the economic models then in use, which had difficulty explaining the behaviour of the Canadian economy as well as that of other economies. The persistence of simultaneously high unemployment and inflation rates, in particular, was contrary to the projections of those models, according to which the two rates should move in opposite directions. This disappointing performance was one of the factors that led to change in thinking among many academic economists and to the birth of real-business-cycle models.

The other line of thinking was more philosophical. Many economists had serious misgivings about some of the basic features of the models and felt that their shortcomings cast doubt on any contribution they might make to economic discussion. These reservations related mainly to the weight given to empirical observation in constructing the models and interpreting their results.

To ensure that their models were able to analyze the complex economic reality as thoroughly as possible, model builders often incorporated hundreds of equations and variables. The daunting size of the models made it very difficult to perform an economic or econometric analysis of the mechanisms and sectors through which a shock was transmitted to the entire artificial economy represented. At the same time, although in theory all decisions of economic agents are interrelated, the models were constructed by sector (consumption, investment, etc.), and these sectors were not grouped into any coherent whole. Thus, to improve the predictive power of the models, their builders modified them by adding variables to a given sector but without taking account of intersectoral linkages.

The tenuous anchoring of these models in microeconomic theory also caused a major problem in simulation exercises. The models were formalized using

2. Already common in advanced macroeconomic courses, the DGEM approach is now beginning to appear in introductory courses as well. Textbooks by Abel, Bernanke, and Smith (1995, 18–22) and by Barro and Lucas (1994, 27–37) are both good examples.

3. When the aggregation of desired levels of consumption of a good differs from that of the forecast production levels of that good, the economy is not in equilibrium.

equations that linked the explained variables to a number of explanatory variables, some of which, such as public expenditure or tax rates, were dependent on the decisions of public authorities. What these equations produced, then, was forecasts of the effects that a change in one of the explanatory variables would have on one of the variables to be explained. In a famous article published in 1976, Robert Lucas insisted that this type of forecast was probably invalid because the very structure of the model's equations could be affected by a change in the explanatory variable. For example, the equation describing the trade-off between the inflation rate and the unemployment rate, i.e., the Phillips curve, was not stable, in the sense that by attempting to reduce the unemployment rate at the cost of letting the inflation rate rise, the trade-off itself disappeared.

According to Lucas, the idea that these equations should be stable was based on the mistaken hypothesis that economic agents do not modify their behaviour when current or expected economic conditions change. Lucas maintained that, for example, an initial jump in inflation would lead economic agents to expect further jumps, and that this would diminish the potential trade-off between unemployment and inflation. What was needed, then, was a model that could take into account the rational behaviour of economic agents.⁴

In short, academics pursuing the development of this new methodology set out to build models of relatively small scale, solidly anchored in microeconomic theory, and with greater inter-sectoral consistency. They attempted to apply the principle that macroeconomic analysis should focus on the behaviour of knowledgeable agents, whose choices are a function of the present and future economic environment in which they operate.

Real-Business-Cycle Models of the 1980s

The first application of this methodology is found in an article published in 1982 by Kydland and Prescott, which gave rise to real-business-cycle models. To simplify their analysis as far as possible, the authors introduce only two types of agents (households and firms) into their model, and focus on only one type of

shock. The government and the central bank are notably absent. The economic structure, again very simple, is assumed to reflect perfect competition and price flexibility.⁵

Households seek to maximize their utility and in so doing choose in each period how many hours of work to offer and how to divide their income between consumption and savings. In making these choices, they recognize that their savings have an effect on their future consumption—since higher savings now make it possible to consume more at some point in the future—but they are also aware that this effect depends on future interest rates. This is where their expectations about the future come into play. As for firms, they seek to maximize their profits, and with this in mind they will decide how many employees to hire and what investments to make, given the expected trend in wages and their required rate of return on capital.

The only shocks affecting this small, artificial economy are those that affect the factors of production. These shocks, which may be considered as coming from the supply side (indeed, this highly simplified model excludes any shock from the demand side), will mean that during some periods it will be relatively less costly for a firm to produce at the going wage rate, while in other periods it will be relatively more expensive to do so.⁶ It was this exclusive focus on technological, as opposed to monetary or financial, shocks that gave rise to the term “real-business-cycle models.”

Once they have identified and aggregated all the decisions taken by households and firms in the face of these technology shocks, Kydland and Prescott present a simulation of the paths of economic activity in this small, artificial economy. They then compare the simulated paths with those observed in recent U.S. history. To the surprise of many economists (for whom such a simple model, exposed solely to supply shocks, must miss many of the essential elements of macroeconomic modelling), the model was able to successfully reproduce many important features of economic fluctuations.

4. The original formulation of the “Lucas critique” is found in Lucas (1976). A less-technical summary is found in Chapter 2 of Lucas (1987).

5. According to this hypothesis, no individual agent has sufficient weight to exert an influence on prices, wages, or interest rates.

6. For example, many economists believe that new information technologies have reduced production costs for U.S. firms in recent years.

The scenario offered by real-business-cycle models, then, is one where economic fluctuations result solely from optimal choices made by households and firms under conditions of perfect competition, in reaction to the supply-side shocks described above. Within this scenario, the central bank's actions have little effect, and its stabilization efforts will do nothing to increase the welfare of economic agents. These conclusions ran counter to the widely held opinion of both academic and central bank economists, who believed not only that central bank measures had very real effects on the economy, but also that it was both possible and desirable to moderate economic fluctuations by applying an appropriate monetary policy.⁷

From Real-Business-Cycle Models to DGEMs

These disagreements were largely overcome during the 1990s, when the models based on this new methodology proved able to accommodate different views about the origin of economic fluctuations.

It is now accepted that the major contribution of the models has been in the area of methodology, and throughout the past decade academic economists (and sometimes central bank economists) have successfully used the new technology to address a broad range of macroeconomic issues, including labour market behaviour, the links between economic activity in two countries, the influence of fiscal policy, and the possibility of relaxing assumptions of perfect competition and continuous market clearing.⁸

At the same time, the shocks built into the new models were extended beyond technology shocks to include elements from a range of other sources of economic fluctuations, particularly from the demand side. Thus, the effects of shocks in public spending, in agents' preferences, and in the terms of trade were simulated in environments similar to that envisioned by Kydland and Prescott.

In one area of particular interest to central banks, researchers have managed to construct models that include nominal rigidities in terms of individual decision-making within the structure of the artificial econ-

omies, so that prices become less flexible, and shocks originating in monetary policy or financial markets become an important source of economic fluctuations. In models of this type, central banks can influence economic activity and even, under certain conditions, achieve useful stabilization.⁹ This broadening of the application of the methodology has led its users to shift from the expression "real-business-cycle models" to "dynamic general-equilibrium models."

At the same time, a wide variety of factors have led economic model builders in central banks to modify their modelling strategies. They now place greater importance on microeconomic fundamentals in their macroeconomic models and on modelling agents' expectations, even if the approach is not always that of DGEMs. A consensus has now emerged in academic and central bank circles to the effect that DGEMs can provide a powerful analytical framework for economic discussion that leaves room for many different points of view. Before turning to a more detailed study of how these models are used in the Bank of Canada, we shall examine the advantages and disadvantages of these models.

Assessment of the DGEM Methodology

Economic models are built to help users understand and interpret the economic world, to persuade them that one mechanism is important while others are less so or not at all, and to assess the soundness of economists' intuitive opinions—in other words, to move economic theory forward.

The features of DGEMs make them an ideal vehicle for pursuing these objectives. The small scale of the models, their solid foundation in theory, the consistency among the different sectors and decisions that they describe all mean that it is relatively easy to identify a shock and trace its impact and its method of transmission to different sectors of the economy. These models also allow us to interpret fluctuations in economic activity, using relatively straightforward microeconomic reasoning to identify, for example, the responses of individual agents to economic incentives present in their current environment or expected in the future.

7. Examples of such relatively negative opinions on real-business-cycle models are contained in "Recommended Further Reading" at the end of this article.

8. An overview of the range of subjects addressed with the help of DGEM methodology can be found in "Recommended Further Reading" at the end of this article.

9. Some of these recent DGEMs reproduce curves that lie at the basis of conventional macroeconomic models, such as the Phillips curve. Consistent with Lucas' observations, however, these curves reflect the behaviour of economic agents, and the models can thus be used to explain shifts in the curve and its structure.

A further advantage of the methodology is that it explicitly includes the concept of utility in formalizing the model. This allows researchers to make meaningful comparisons between two types of economic policy, by measuring them directly against the welfare of economic agents. From these comparisons, we can draw fairly precise, quantitative conclusions about the conditions that will determine the soundness of alternative policies.

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As Lucas has pointed out, economic agents may modify their behaviour in the wake of shifts in economic policy or changes in their environment. For example, a technological innovation such as the introduction of banking accounts paying daily interest has the potential to alter the decisions of economic agents about how much cash to hold. Moreover, a policy change, such as the introduction of official inflation targets, will probably lead agents to reassess their expectations and will thus help to modify economic reality. Since DGEMs include the behaviour of economic agents in their structure, they are, in principle, immune to the Lucas critique and should be able, over time, to predict some of the shifts that take place in economic activity.

The great variety of agents involved in the macroeconomic setting defined by DGEMs allows the study of questions that relate to the observed heterogeneity of reality; for example, the influence that economic policy can have on the distribution of incomes within the economy. Finally, since the model's forecasts cover the entire planning horizon for economic agents, they offer a unified explanation over the short and long term, in contrast to other approaches where these two horizons must be envisioned with different models.

A major factor in the success of any model is the degree of accuracy with which it can forecast the future trend of economic variables. Although it was thought that, given their small scale and their high degree of abstraction, DGEMs could never produce

accurate predictions, recent work such as Kim (2000), suggests that their performance in this regard is better than expected.

Certain features of DGEMs are sometimes greeted with skepticism. Their high degree of abstraction and the assumed rationality of economic agents are often criticized.

A simple model such as that described in the previous section is certainly very abstract, and the great variety of situations among households and firms in the real economy might seem to defy any attempt at such extreme simplification. There are two kinds of answer to this charge. First, research is now underway to develop computer programs that will allow us to build much more complex models. We already have DGEMs involving a great variety of goods, of shocks (or of transmission mechanisms for shocks), and of economic agents, all of which make their representation of economic activity much more complex. Second, a high degree of abstraction is not in itself a sign of weakness. A model is, after all, a simplified version of the real economy, and it is often designed to shed light on a particular mechanism or sector of the economy rather than to offer a full explanation of economic phenomena. It may be an advantage to keep the model simple and small, so that it can be manipulated more readily and allow us to understand these mechanisms more thoroughly. Moreover, it may be that some quite simple mechanisms lie at the source of most observed economic fluctuations. It would be better in that case to have a series of small models, rather than one cumbersome and complex model that superimposes a whole range of mechanisms, of greater or lesser importance, in its representation of economic activity.

DGEMs accord a high degree of rationality to economic players, particularly once the basic principles stated above have been transposed mathematically. Can this hypothesis be reconciled with consumer behaviour that often seems fairly irrational? The question can be answered in two ways. First, while consumers may indeed buy certain things on impulse, the fact remains that major purchases will be made only after considerable and careful reflection.¹⁰ Moreover, when it comes to deciding on investments, firms will behave

10. The process by which households go about purchasing a house comes immediately to mind. Home buyers will take many considerations into account before making a decision, and their expectations will play a key role, particularly as they relate to the future stability of their income and the future trend of mortgage interest rates.

logically and will be influenced by their expectations about such things as the demand for their products in the years ahead. It is thoughtful behaviour of this kind that is reflected in the mathematical definition of rationality used in the models. Second, even if they are not convinced by the principle of rationality, economists can find in this hypothesis a useful tool of comparison with models that take other approaches.

DGEMs and Economic Research at the Bank of Canada

An important feature of macroeconomic research at the Bank of Canada is the variety of viewpoints and analytical methods that come into play. DGEMs emphasize individual choices as a means of understanding macroeconomic reality and therefore complement the other analytical tools used by central banks. It is not surprising, then, that the Bank of Canada has been interested in DGEMs for some years.

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The principal model that the Bank of Canada uses to study the Canadian economy, QPM, incorporates several of the methodological principles of dynamic general equilibrium (Black et al. 1994 and Coletti et al. 1996.) In fact, the model is built around a nucleus in which the microeconomic choice between consumption and savings occupies an important place. Moreover, the equations that make up the model incorporate many variables relating to expectations, in particular, expectations about future interest rates, so the model contains a significant forward-looking component. On the other hand, while small in comparison with its predecessors, QPM is still a significant size, and many of the elements essential for simulating the economic trends projected by the model do not rely on direct links to microeconomic theory. QPM is thus a hybrid, halfway between two types of model, and it

demonstrates the Bank's willingness to accept the new methodology expressed in DGEMs.

However, QPM is used for only a portion of the Bank's economic research. That research deals with a great variety of issues, and DGEMs are very helpful in broadening understanding about many of them.

Bank economists use DGEMs in their research to model the process of mortgage and commercial credit allocation and the process of money creation by the commercial banks. The works of Amano, Hendry, and Zhang (2000) and Yuan and Zimmerman (2000) are recent examples of such work. The two processes in question, which are absent from the environment described by the QPM, may harbour important mechanisms for transmitting the effects of central bank measures throughout the economy, but they are still not fully understood.

The explicit inclusion of the notion of utility in DGEMs, as discussed above, makes it easier to perform cost-benefit studies of economic policies under consideration, and these models are therefore frequently used in research involving this type of analysis. The advantages of low inflation, for example, were studied by Black, Coletti, and Monnier (1998), while Macklem et al. (2000) have analyzed the advantages of a flexible exchange rate system. Research is also underway to apply this approach to the examination of different types of Taylor rules¹¹ that could be of interest to the monetary authorities. Finally, DGEMs could contribute significantly to the debate about whether the central bank should target the level of prices rather than the inflation rate.

Since the Bank of Canada is increasingly concerned about issues of financial stability and macrofinancial risk management, it is likely that its research teams in these areas will be making greater use of DGEMs.

While DGEMs have not been commonly used as forecasting tools, recent progress with these models suggests that central banks may employ them for such service, by developing DGEMs that incorporate several shocks and several sectors and that have solid predictive powers.

11. Taylor rules are an expression of the idea that central banks should conduct themselves in accordance with very simple rules, linking fluctuations in short-term interest rates directly to a limited number of variables such as the latest observed rates of inflation and the output gap. For a survey of the literature on this topic, see Armour and Côté (1999–2000).

Conclusion

The Bank of Canada places a high priority on fostering dialogue and collaboration between the Bank's economists and those in the academic world. Research conducted with the help of DGEMs should contribute to strengthening that dialogue, since much of the academic research on macroeconomic issues now uses this methodology. In the near future, the more refined research tools and the broader range of models that will result from such dialogue, should give the Bank a range of tools that is better suited to the many

challenges that face the conduct of monetary policy.¹² Users will then be able to choose the model that best meets their needs in light of their own preferences, the particular context in which they are working, and the specific question they are addressing.

12. Engert and Selody (1998) discuss why it might be useful for the Bank of Canada to have two or more types of models, rather than a single model.

Literature Cited

- Abel, A., B. Bernanke, and G. Smith. 1995. *Macroeconomics*. Canadian Edition. Don Mills, Ontario: Addison-Wesley Publishers Limited.
- Amano, R., S. Hendry, and G.-J. Zhang. 2000. "Financial Intermediation, Beliefs, and the Transmission Mechanism." In *Money, Monetary Policy, and Transmission Mechanisms*, 283–311. Proceedings of a conference held by the Bank of Canada, November 1999. Ottawa: Bank of Canada.
- Armour, J. and A. Côté. 1999–2000. "Feedback Rules for Inflation Control: An Overview of Recent Literature." *Bank of Canada Review* (Winter): 43–54.
- Barro, R. and R. F. Lucas. 1994. *Macroeconomics*, First Canadian Edition. Boston, Mass.: Irwin.
- 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.
- Black, R., D. Coletti, and S. Monnier. 1998. "On the Costs and Benefits of Price Stability." In *Price Stability, Inflation Targets, and Monetary Policy*, 303–42. Proceedings of a conference held by the Bank of Canada May 1997. 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.
- Duguay, P. and D. Longworth. 1998. "Macroeconomic models and policymaking at the Bank of Canada." *Economic Modelling* 15: 357–75.
- Engert, W. and J. Selody. 1998. "Uncertainty and Multiple Paradigms of the Transmission Mechanism." Bank of Canada Working Paper No. 98-7.
- Kim, J. 2000. "Constructing and estimating a realistic optimizing model of monetary policy." *Journal of Monetary Economics* 45: 329–59.
- Kydland, F. and E. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50: 1345–70.
- Lucas, R.E. 1976. "Econometric Policy Evaluation: A Critique." *Carnegie-Rochester Conference Series on Public Policy* 1: 19–46.
- . 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.
- Macklem, T., P.N. Osakwe, M.H. Piore, and L.L. Schembri. 2000. "The Economic Consequences of Alternative Exchange Rate and Monetary Policy Regimes in Canada." In *Revisiting the Case for Flexible Exchange Rates*. Proceedings of a conference held by the Bank of Canada, November 2000 (forthcoming).
- Poloz, S. 1994. "The Bank of Canada's new Quarterly Projection Model (QPM): An introduction." *Bank of Canada Review* (Autumn): 23–38.
- Yuan, M. and C. Zimmermann. 2000. "Credit Crunch, Bank Lending and Monetary Policy: A Model of Financial Intermediation with Heterogeneous Projects." In *Money, Monetary Policy, and Transmission Mechanisms*. Proceedings of a conference held by the Bank of Canada, November 1999. Ottawa: Bank of Canada.

Recommended Further Reading

Real-business-cycle models

King, R. G., C. Plosser, and S. Rebelo. 1988. "Production, Growth and Business Cycles I. The Basic Neoclassical Model." *Journal of Monetary Economics* 21: 195–232.

Technical discussion of real-business-cycle models

Plosser, C. I. 1989. "Understanding Real Business Cycles." *Journal of Economic Perspectives* 3: 51–77.

A simplified explanation of real-business-cycle methodology. Offers a modelling example and comes out in favour of these models.

Laidler, D. 1986. "The New-Classical Contribution to Macroeconomics." *Banca Nazionale del Lavoro Quarterly Review*, 156: 27–56.

Critique of the vision of the macroeconomy underpinning real-business-cycle models. Although the author expresses sympathy for the methodology, he presents his objections to some of the assumptions used, most notably that of perfect price flexibility.

Mankiw, N.G. 1989. "Real Business Cycles : A New Keynesian Perspective." *Journal of Economic Perspectives* 3: 79–90.

A simplified explanation of real-business-cycle methodology. Expresses some doubts about the practical significance of technology shocks as defined in these models and about the ability of the models to contribute substantively to macroeconomic thinking.

Chatterjee S. 1995. "Productivity Growth and the American Business Cycle." *Business Review*. Federal Reserve Bank of Philadelphia (September-October): 13–22.

A simplified explanation of real-business-cycle models and the lessons they hold for the conduct of monetary policy.

Hairault, J.-O. 2000. "Le courant des cycles réels," In: *Analyse Macro Économique 2*, J.-O. Hairault ed., Éditions La Découverte, Paris.

A simplified explanation of real-business-cycle methodology. Contains modelling examples. Expresses doubts about the importance of technology shocks and suggests that it is the methodology underlying these models that constitutes their principal contribution to macroeconomic research.

Use of the methodology in various areas of specialization during the transition period

Cooley, T., ed. 1995. *Frontiers of Business Cycle Research*. Princeton: Princeton University Press.

Advanced macroeconomic textbook. The first three chapters deal with the basic DGEM methodology, while the following nine chapters offer examples of its use in examining various issues, including the labour market, monetary shocks as a source of fluctuations, monopolistic competition, open economies, etc.

Paquet, A. 1995. "Dépenses publiques et taxation proportionnelle dans les modèles du cycle réel." *L'Actualité économique* 71: 122–62.

An overview of DGEMs focusing on government-generated shocks. Presents a modelling example and an intuitive analysis of the effect of these shocks.

Cho, J.-O. and L. Phaneuf. 1995. "Monnaie et cycles." *L'Actualité économique* 71: 163–92.

Overview of DGEMs focusing on monetary shocks. Contains several examples of models and stresses the importance of properly modelling nominal rigidities in this type of DGEM.

Devereux, M.B. 1997. "Real exchange rates and macroeconomics: evidence and theory." *Canadian Journal of Economics* 30: 773–808.

Reviews the empirical performance of exchange rates and the various DGEMs that are used in an attempt to explain their behaviour.

Bernanke, B., M. Gertler, and S. Gilchrist. 1998. "The Financial Accelerator in a Quantitative Business Cycle Framework." NBER Working Paper No. 6455.

Presents a model simulating shocks arising from frictions in the financial-intermediation process between banks and firms.

Hendry, S. and G.J. Zhang. 1998. "Liquidity Effects and Market Frictions." Bank of Canada Working Paper No. 98-11.

Presents several models, each containing a different combination of nominal rigidities, and examines the effects of central bank actions for each of these combinations.

Surveys that put the methodology and the current degree of consensus on it into perspective

Lucas, R.E. 1987. *Models of Business Cycles*. Oxford: Basil Blackwell.

A short and highly readable book describing the Lucas critique and the rationale for constructing and using DGEMs.

Romer, D. 1996. *Advanced Macroeconomics*. New York: The McGraw-Hill Companies Inc.

Intermediate-level macroeconomics textbook. Chapter 4 deals with real-business-cycle models, and Chapter 6 discusses the nominal rigidities underlying recent DGEMs.

Goodfriend, M. and R. King. 1997. "The New Neo-Classical Synthesis and the Role of Monetary Policy." NBER Macroeconomics Annual. Cambridge Mass.: The MIT Press.

Discusses the current degree of consensus on DGEMs equipped with monetary shocks and the lessons they hold for monetary policy.

Danthine, J.-P. 1998. "À la poursuite du Graal : le successeur d'IS-LM est-il identifié?" *L'Actualité économique* 74: 607–20.

Assesses the DGEM research program: gaps and avenues for further exploration.

Parkin, M. 1998. " Presidential Address : Unemployment, inflation, and monetary policy." *Canadian Journal of Economics* 31: 1003–32.

Assesses recent macroeconomic research and its consequences for the course of monetary policy. Describes DGEMs and suggests avenues for further progress.

Internet

The QM&RBC site, maintained by Christian Zimmermann of UQAM, provides a wide variety of links to sites dealing with dynamic general-equilibrium models and to researchers working on their development. Address: <http://dge.repec.org/>