BANK OF CANADA
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Bank of Canada Review

Special Issue: Real-Financial Linkages

Summer 2011

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ISSN 0045-1460 (Print)
ISSN 1483-8303 (Online)
Printed in Canada on recycled paper

Bank of Canada Review

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Cover

Sumerian Cuneiform Tablet

Raewyn Passmore, Assistant Curator, Currency Museum

Produced over four thousand years ago, the tablet pictured on the cover is the oldest object in the National Currency Collection.

Cuneiform script, the earliest known system of writing, was invented toward the end of the fourth millennium BC in what is now southern Iraq. It began as a series of mnemonic pictographs—recognizable pictures of objects—used to document transactions or keep lists of commodities. Over centuries, it evolved into a sophisticated system of abstract symbols representing phonetic syllables. By the Old Babylonian Period (c. 1700 BC) it was in use throughout the Near East.

Despite this remarkable advance, literacy was not widespread, and specially trained scribes formed an elite class. Apart from important inscriptions carved in stone, most documents were created by pressing a cut reed stylus into a tablet of wet clay. The tablets were then fired or allowed to dry. Once hardened, they were nearly indestructible.

During the Third Dynasty of Ur, the Sumerian King Shulgi (c. 2094–47 BC) imposed extensive administrative reforms that resulted in an explosion of bureaucratic documents. Tablets have been found that record loans and debts; the sale of houses, land, and livestock; marriage agreements and dowries; instructions from merchants to their agents; inventories and stock lists—in fact anything that we might record in writing today.

This cultural affinity for documentation, coupled with the durability of clay, yielded a legacy of thousands of tablets that record all aspects of life in Ancient Mesopotamia and reveal in startling detail the roots of later economic systems.

The economy of Ancient Iraq was based on agriculture. While rich in grains—primarily barley—and wool, the land was deficient in other necessities, and foreign trade was vital for economic growth. Raw and processed commodities were exchanged for salt, stone and timber, as well as gold, silver, copper and various luxury goods.

The central focus of every Sumerian city was the temple. The valuable objects belonging to the shrine acted as the city's store of wealth, often serving as capital for foreign trade and domestic business ventures. The temple also acted as a bank for the surrounding community, offering loans at a rate of 20 per cent—relatively low compared with the annual lending rates standardized under the code of King Hammurabi (c. 1792–50 BC) of 25 per cent on silver and 33 per cent on barley (both of which were used as currency).

As part of his major internal reforms, Shulgi established the town of Puzrish-Dagan (now called Drehem in southern Iraq) as a centre for the distribution of livestock to temples throughout the region. The tablet on the cover is a receipt for animals that were released from the stockade in Puzrish-Dagan by an individual called Nansha to be used as a special offering to deities. It is dated "the 17th day of the month A'kiti in the second year following the destruction of the city of Kimash," or the fourth year of the reign of Shulgi—roughly 2090 BC.

The tablet on the cover is part of the National Currency Collection, Bank of Canada. It measures about 4.5 cm by 3.5 cm.

Photography by Gord Carter.

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Introduction

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Real-Financial Linkages

Césaire Meh, Guest Editor

The Bank of Canada has been conducting research to improve its understanding of the linkages between financial and macroeconomic developments. In the wake of the recent global financial crisis, the Bank has intensified its research efforts in this area. In particular, a research priority over the medium term is to improve the theoretical and empirical models to deepen the Bank's understanding of the impacts of domestic and international financial developments on the Canadian economy and on the monetary policy transmission mechanism, as well as the effects of developments in the real economy on the financial system. Bank staff and researchers at other institutions have been developing macroeconomic frameworks that take into account the balance sheets of financial intermediaries and households, as well as multiple interest rates and credit spreads.[1] These efforts will enhance the Bank's ability to assess new developments in the financial system, the relationship between monetary policy and financial stability, and the impacts of alternative policy interventions on financial stability and economic activity. This special issue of the *Review* summarizes some of the Bank's recent research on real-financial linkages. It includes two articles that describe large-scale macroeconomic policy models that now explicitly incorporate important features of the financial sector and two articles that focus on the role of banks' balance sheets in economic activity and the role of mortgage financing in the determination of house-price dynamics.

In times of financial turmoil with widening liquidity premiums and credit spreads, models featuring a single interest rate are constrained in their ability to guide policy-makers. José Dorich, Rhys Mendes and Yang Zhang, in the article "Introducing Multiple Interest Rates in ToTEM," describe changes to the interest rate structure in the Bank of Canada's main projection and policy-analysis model. These changes allow an independent role for long-term interest rates, as well as for the risk spreads that generate differences in the interest rates faced by households, firms and the government. This multiple interest rate structure broadens the range of policy questions that the model can explicitly address and improves its ability to explain the data. As an example, the authors employ this new structure to simulate the effects on the Canadian economy of shocks to the risk spreads on interest rates comparable to those that developed during the recent financial crisis. They also use the model to assess the macroeconomic impact of higher minimum capital requirements for commercial banks, as specified in the new Basel III rules.

The recent global crisis also underscored the interdependence of major economies generated through linkages among financial institutions and markets, in addition to the traditional trade linkages. In "The BoC-GEM-Fin: Banking in the Global Economy," Carlos de Resende and René Lalonde present a new version of the Bank's large multi-country model that captures the international transmission of shocks through their effects on bank capital and via financial-accelerator effects. The authors describe the Bank of Canada's version of the Global Economy Model (GEM) modified to incorporate an articulated banking system that features an interbank market and cross-border lending.[2] The authors then use BoC-GEM-Fin to examine the responses of selected U.S. and Canadian macroeconomic variables to an adverse financial shock originating in the U.S. banking system and to study the economic effects of higher minimum capital requirements in Canada and the rest of the world.

1 For a recent literature review on real-financial linkages, see P. Bergevin, P. Duguay and P. Jenkins, "When Nightmares Become Real: Modelling Linkages between the Financial Sector and the Real Economy in the Aftermath of the Financial Crisis," *CD Howe Institute Commentary* (forthcoming).

2 BoC-GEM-Fin is used primarily for global policy simulations.

To complement the discussion of the Bank's large-scale policy models, the next two articles examine issues related to the role of commercial banks' balance sheets in economic activity and the role of mortgage financing in house-price dynamics. These economic issues are seen to be important for understanding the recent financial crisis.

In "Bank Balance Sheets, Deleveraging and the Transmission Mechanism," Césaire Meh investigates the role of bank capital in propagating and amplifying economic and financial shocks, as well as the potential implications of countercyclical capital buffers for the transmission of shocks. The author shows that the bank-capital channel can amplify and propagate shocks. The extent of the amplification depends on the capitalization of the banking system: economies with higher-capitalized banks are better able to absorb shocks. The article also argues that countercyclical capital buffers can increase the resilience of the banking system, but that they will also affect the transmission mechanism of monetary policy. Stabilizing an economy with a better-capitalized banking system will require less-aggressive movements in the policy rate.

Ian Christensen, in "Mortgage Debt and Procyclicality in the Housing Market," focuses on the role that loans backed by housing collateral play in amplifying housing booms and, more generally, procyclicality in the housing market. The author uses a model developed to include borrower and lender households, as well as a housing market, to examine the impact of altering the loan-to-value (LTV) ratio (either permanently or countercyclically) on the volatility of house prices and mortgage debt. He concludes that models developed at the Bank of Canada and elsewhere demonstrate that an LTV ratio that is set at a lower level would dampen procyclicality in the housing market. Varying the LTV ratio for mortgages in a countercyclical fashion would further reduce this procyclicality.

Supplementary article

As the Government of Canada's fiscal agent, the Bank of Canada provides strategic policy advice on the management of the federal government's debt, in addition to being responsible for conducting debt-management operations. In "Developing Canada's Medium-Term Debt Management Strategy," Marc Larson and Etienne Lessard review the evolution of the debt strategy over the past 20 years and outline the complex process of developing a sound strategy that balances various cost and risk considerations. This review includes an examination of the tools and practices used to develop the new medium-term debt-management strategy, such as the modelling approach, various debt-management metrics and market consultations.

Introducing Multiple Interest Rates in ToTEM

José Dorich, Rhys R. Mendes and Yang Zhang, Canadian Economic Analysis Department

- *Standard dynamic stochastic general-equilibrium (DSGE) models, including the first version of ToTEM, typically incorporate a single domestic interest rate. In these models, time variation in term premiums and risk spreads is not an important determinant of macroeconomic fluctuations.*
- *Empirical evidence suggests that both short- and long-term rates, as well as the risk spreads faced by households and firms, have significant effects on aggregate demand.*
- *The Bank of Canada has developed a new version of ToTEM that incorporates multiple interest rates, as well as several other modifications.*
- *This new structure allows Bank staff to use ToTEM to study a broader array of policy questions than was previously possible. For example, staff recently employed the model to assess the macroeconomic impact of higher requirements for bank capital and liquidity.*

Until recently, in keeping with standard practice in DSGE macroeconomic modelling, the Bank of Canada's main model for projection and policy analysis, ToTEM, had a single domestic interest rate.[1] This short-term rate was treated as the instrument of monetary policy, and its current value and expected future path were key determinants of the behaviour of economic agents in the model. However, the events of the recent global financial crisis highlighted the role that changes in credit market conditions, including risk spreads, can play in macroeconomic developments. This has led to accelerated work on multiple interest rate models at the Bank of Canada and elsewhere. This article provides an overview of the introduction of multiple interest rates in ToTEM.

Economic models are simplified representations of reality, designed to assist the understanding and analysis of economic outcomes. Economists choose the dimensions along which they simplify their models to render them tractable, but still useful. Judicious choice of the simplifications allows the model to provide insights into the functioning of the economy without obscuring the analysis with unnecessary detail. One common simplification is to abstract from the variety of different interest rates that prevail in practice, by adopting a single interest rate.

In reality, however, households, firms and the government all face different interest rates. That is, there are time-varying spreads between the interest rates available to private agents and those available to the government. Changes in these spreads can influence macroeconomic developments. Moreover, the expected future path of short-term interest rates is

1 Two key antecedents of large macroeconomic models like ToTEM are those of Christiano, Eichenbaum and Evans (2005) or Smets and Wouters (2007). For textbook models see Woodford (2003) and Galí (2008).

not a perfect proxy for long-term rates. Thus, variations in the term premium—the difference between long-term rates and the expected path of short-term rates—may have implications for the macroeconomy.

Consequently, Bank staff developed a new version of ToTEM (ToTEM II) that includes a richer interest rate structure in addition to several other changes (see **Box**).[2] In particular, ToTEM II includes both long- and short-term rates, as well as different risk spreads that lead to differences in the interest rates faced by households, firms and the government. These changes broaden the range of policy questions that the model can address and improve its ability to explain the data.

The article begins with a description of the changes to the interest rate structure in ToTEM II. The implications of shocks to risk spreads and term premiums during the recent financial crisis are then reviewed. Finally, as an example, the new model is used to examine the macroeconomic implications of changes to the requirements for capital and liquidity in the banking sector.

Interest Rates and Aggregate Demand

In standard DSGE macroeconomic models, including the first version of ToTEM, aggregate demand is affected by the evolution of just one interest rate: the short-term, risk-free real interest rate. This one interest rate determines the degree of intertemporal substitution by firms and households in their decisions to invest, spend, save and work. For example, a relatively high interest rate provides households with an incentive to postpone consumption. Instead, they will tend to save more in order to take advantage of the higher interest rates. Relatively low interest rates have the opposite effect.

In ToTEM, as in most other DSGE macroeconomic models, short- and long-term, risk-free assets are assumed to be perfect substitutes. This implies that the expected rates of return on these two types of asset will be equalized by arbitrage. Suppose the long-term asset under consideration has a maturity of 5 years (20 quarters), while the short-term asset has a maturity of 1 quarter. The long-term interest rate (i_t^L) will be equal to the average of the expected short-term rate (i_t) over the subsequent 20 quarters:[3]

$$i_t^L = \frac{1}{20}\sum_{j=0}^{19} E_t i_{t+j}.$$

A long-term rate that is exactly equal to the average path of expected future short-term rates is said to be consistent with the *pure expectations theory of the term structure*.

In models such as ToTEM, households and firms are forward looking, which implies that their consumption and investment decisions are influenced not only by the current interest rate, but also by the entire expected path of rates. This result, combined with the assumption of perfect asset substitutability, made it redundant to explicitly model the long-term interest rate in ToTEM.

The new model allows long-term interest rates to play a meaningful role in economic decisions

Models with a single interest rate cannot be used to address questions about the effects of changes in term premiums or risk spreads.[4] ToTEM II has been designed to permit analysis of these issues. The new model allows long-term interest rates to play a meaningful role in economic decisions, over and above the traditional role of short-term rates. ToTEM II also includes the risk spreads faced by households and firms on long- and short-term interest rates. These risk spreads are assumed to be exogenous and are defined as the difference between the effective interest rate facing firms and households and the risk-free rate.[5]

2 For a description of ToTEM, see Murchison and Rennison (2006). Fenton and Murchison (2006) provide a non-technical overview of ToTEM. For information on the new features introduced in ToTEM II, see Dorich et al. (forthcoming).

3 The relationship given in the main text is a linear approximation. The underlying non-linear relationship requires the gross long-term rate ($1+i_t^L$) to be equal to the expectation of the *geometric* average of current and future gross short-term rates. This relationship also holds only when all accrued interest is paid at maturity, i.e., a zero-coupon security.

4 Because the original version of ToTEM did not incorporate multiple interest rates, the impact of shocks to interest rate spreads and term premiums could not be identified; it was confounded with the impact of other shocks. Nevertheless, through the use of judgment, at times informed by alternative models, Bank staff did take account of such shocks. Moreover, during the financial crisis, a prototypical version of the interest rate structure described in this article was incorporated into ToTEM. This modified version was used to analyze the impact of spread shocks, among other things.

5 The risk-free rate is the rate of interest on an asset that is free of default and other types of risk. In practice, no asset may be completely free of risk, and the risk-free rate is usually equated with the interest rate on government securities or a rate related to the central bank's policy rate.

ToTEM II: An Updated Version of the Bank of Canada's Quarterly Projection and Policy Analysis Model

The Terms-of-Trade Economic Model, or ToTEM, has served as the Bank's main projection and policy analysis model since December 2005 (Murchison and Rennison 2006; Fenton and Murchison 2006). An updated version of the model (ToTEM II) replaced ToTEM in June 2011. The model has been improved along a number of dimensions, including the introduction of multiple interest rates. Changes related to interest rates are described in detail in the main text. Here, we briefly summarize some of the other new elements of ToTEM II. The features of ToTEM II are fully documented in Dorich et al. (forthcoming).

Estimation

In ToTEM II, a substantial number of the model's parameters have been estimated using Classical Maximum Likelihood methods. This is in contrast to ToTEM's parameter values, which were all chosen manually so that ToTEM could replicate selected moments of the data or stylized facts. This change has considerably improved the model's forecasting behaviour.

Introduction of variables for residential and inventory investment

ToTEM did not include explicit variables for investment in residential structures and inventories. In practice, "consumption" was treated as a conglomerate, defined as the sum of three components of the National Income and Expenditure Accounts (NIEA): consumption, residential investment and inventory investment. Thus, residential and inventory investment entered ToTEM through this conglomerate consumption variable. This practice was a continuation of the approach adopted when the Bank introduced the Quarterly Projection Model (ToTEM's predecessor) in 1993.

ToTEM II includes separate variables for NIEA consumption, residential investment and inventory investment. Demands for these three goods are treated separately, with their own shocks and interest elasticities. ToTEM II also accounts for the relevant stock-flow relationships. These changes permit analysis of a wider range of shocks.

Changes to price- and wage-setting behaviour

Both ToTEM and ToTEM II have sticky nominal prices and wages (all nominal prices and wages are not re-optimized every period). In ToTEM, when a firm re-optimized its nominal price, it did so in a fully rational, forward-looking manner. In ToTEM II, some firms behave in a forward-looking manner, while others follow a simple rule of thumb in the spirit of Galí and Gertler (1999). Analogous changes were also made to the structure of wage determination in ToTEM II. The presence of rule-of-thumb agents gives staff the flexibility to estimate the extent of forward-looking behaviour in price and wage setting.[1]

Use of a closure condition on household net wealth

In ToTEM, as in many other small-open-economy DSGE models, the country-specific interest rate risk premium is a function of Canada's net foreign asset (NFA) position relative to its steady state. This ensures a stationary dynamic path for the NFA-to-GDP ratio since the risk premium will move the exchange rate to whatever level is required to return the NFA-to-GDP ratio to its steady state.

In ToTEM II, the closure condition on net foreign assets is replaced by a closure condition on household net wealth. A household's discount factor in ToTEM II depends on the ratio of household net wealth to disposable income relative to its steady state. Thus, households become more patient when their net wealth is low relative to the desired level, and vice versa. Household net wealth is derived from the household's budget constraint and incorporates housing wealth, holdings of government debt, stock market wealth evaluated at the "fundamental" shadow value of capital (assuming that equity prices move proportionately with expected earnings), and net claims on foreign assets. As a result, developments in the housing market, such as house-price movements, have a direct impact on consumption via this net-wealth gap.

1 For a discussion of the implications of rule-of-thumb behaviour for the discounting of future economic conditions, see Amano, Mendes and Murchison (2009).

In order to allow long-term interest rates to have an independent effect on aggregate demand in ToTEM II, Bank staff made two modifications: (i) they abandoned the traditional assumption of perfect asset substitutability, and (ii) they introduced a subset of households who participate only in the long-term asset market. The first change breaks the perfect link between long-term rates and the expected path of short-term rates, while the second change ensures that some households always base their decisions on long-term rates.

Imperfect asset substitutability, in the spirit of Tobin (1969), was introduced in ToTEM II using the approach suggested by Andrés, López-Salido and Nelson (2004). Households are modelled as viewing short- and long-term securities as imperfect substitutes. They incur some disutility from holding long-term assets and therefore demand a premium to do so.[6] This breaks the perfect arbitrage between the two assets and allows the long-term rate to deviate from the level implied by the pure expectations theory of the term structure. This deviation is the term premium (tp_t). The relationship between long- and short-term rates in ToTEM II is given by:

$$i_t^L = \frac{1}{20}\sum_{j=0}^{19} E_t i_{t+j} + tp_t.$$

The presence of the term premium implies that long-term rates can vary independently of the expected path of short-term rates.

Nevertheless, as mentioned earlier, this modification alone is not enough to allow long-term interest rates to have an independent effect on aggregate demand: households can simply sidestep the market for long-term assets and implement their consumption plans by trading in a sequence of short-term assets. The term premium merely compensates households for the marginal disutility associated with holding long-term assets, leaving them indifferent between returns on the two types of assets.

For this reason, ToTEM II includes a subset of households who participate only in the market for long-term assets. These households can be thought of as a proxy for agents who save primarily through vehicles such as pension funds (which invest heavily in long-term assets), or who borrow through longer-term instruments such as fixed-rate mortgages. The presence of households with restricted asset market participation ensures that the consumption decisions of this subset of households are driven by long-term rates. This, in turn, implies that the consumption equation in ToTEM II depends on both short- and long-term interest rates.[7]

The importance of long-term rates in the ToTEM II consumption equation is not presumed, but estimated. This weight has been estimated using several different econometric techniques, including the full-information techniques used to estimate other parameters in ToTEM II, as well as techniques using the generalized method of moments for single-equation linear models. All of these estimates indicate that long-term rates have a significant effect on consumption, independent of the expected path of short-term rates.

The effective interest rates faced by households are modelled as functions of the risk-free rates and risk spreads:

$$i_{H,t} = i_t + stsp_t,$$

$$i^L_{H,t} = i^L_t + ltsp_t,$$

where $i_{H,t}$ and $i^L_{H,t}$ are the short- and long-term rates applicable to households, $stsp_t$ is an exogenous risk spread on household short rates, and $ltsp_t$ is an exogenous risk spread on long rates.

The short-term and long-term rates faced by firms are related to the risk-free rate and the exogenous risk spreads in the same way as those for households. However, the risk spreads on firms' debt are allowed to differ in magnitude from those associated with households.

The assumption of *exogenous* risk spreads is an important limitation of the interest rate structure in ToTEM II. We would expect risk spreads to be related to endogenous variables such as leverage ratios. Modelling such relationships would allow macroeconomic shocks and policies to affect risk spreads, and may therefore have implications for the policy prescriptions that emerge from the model. Other authors have modelled risk spreads as endogenous, but only in environments without an independent

6 The disutility associated with holding long-term assets represents the increased risk and the lower liquidity associated with these assets that are not explicitly modelled but that would lead to a time-varying term premium.

7 One alternative to this approach would be to directly assume that certain components of demand (e.g., durable consumption and residential investment) are affected primarily by longer-term rates.

role for long-term rates.[8] Bank staff are currently exploring the introduction of endogenous interest rate spreads in ToTEM II.

The impact of shocks to interest rate spreads during the crisis

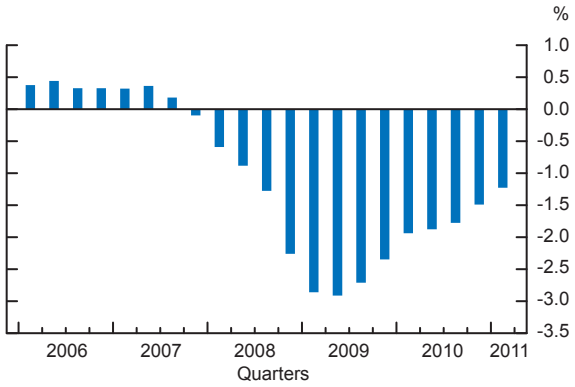
In the United States and many other economies, a large and persistent tightening of credit market conditions played a key role in transmitting the recent global financial crisis to the real economy. Credit market conditions also tightened in Canada. This general tightening included a widening of interest rate spreads during the crisis. ToTEM II provides a lens through which to assess the impact of these higher spreads on the Canadian economy.

We use ToTEM II to simulate the effects of the shocks to spreads that occurred during the crisis. The model suggests that the widening of spreads did not play a major role in generating the economic downturn in Canada. Nevertheless, it is important to bear in mind that many potential linkages between the financial sector and the real economy are not explicitly modelled in ToTEM II. In particular, the model does not include a banking sector, nor does it embed the possibility of quantity restrictions or changes in the non-price terms and conditions of credit. The analysis in this section captures only the effects of changes in spreads. Financial shocks that are not explicitly modelled in ToTEM II will be subsumed in the identified effects of other shocks. For example, quantity restrictions on credit could be a contributing factor underlying the identified negative shocks to domestic demand.

We would expect changes in spreads to have their greatest impact on the most interest-sensitive components of aggregate demand: business and residential investment. **Chart 1** and **Chart 2** show the change in these variables (relative to trend) that ToTEM II attributes to spread shocks. In both cases, the estimated impact of the spread shocks is modest.

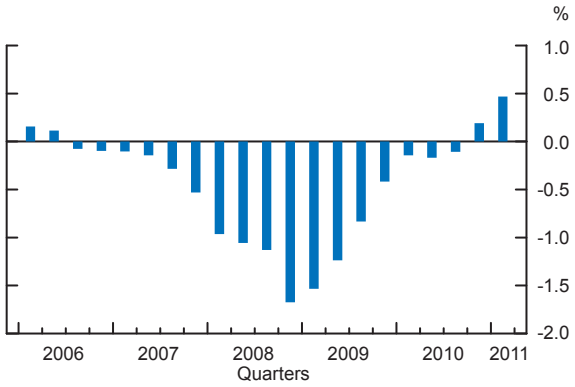
According to ToTEM II, widening spreads are estimated to have caused business investment to decline to around 3.0 per cent below trend, before starting to recover. During the recession, however, actual business investment fell to more than 20 per cent below trend. Thus, our calculations suggest that less than one-fifth of the decline in business investment can be attributed to greater spreads.

Chart 1: Business investment
Deviation from trend



Source: ToTEM II simulations

Chart 2: Residential investment
Deviation from trend



Source: ToTEM II simulations

The fraction of the decline in residential investment caused by increased spreads is similarly small. The increases in spreads are estimated to have caused residential investment to decline to around 1.5 per cent below trend. In contrast, actual residential investment fell to more than 16 per cent below trend.

Thus, in Canada, the declines in business and residential investment were not primarily due to the increases in interest rate spreads faced by households and firms. Rather, ToTEM II attributes an important role to domestic-demand shocks and the decline in economic activity in the rest of the world. The sharp contraction of the global economy had a substantial impact on Canada by causing a deterioration in net exports and the terms of trade. This, in turn, reduced the incomes of Canadian households and firms and contributed to weaker business and residential investment.

8 For example, Bernanke, Gertler and Gilchrist (1999) derive a model in which the risk spread a firm must pay to borrow is a function of its leverage ratio. Similarly, Basant Roi and Mendes (2007) assume that the risk spread faced by a household depends on the household's ratio of debt to housing wealth.

Domestic-demand shocks also played a key role. In ToTEM II, the shocks to consumption and investment demand are modelled as shocks to household preferences and shocks to the production technology, respectively. In practice, these shocks were probably substitutes for unmodelled financial shocks, as well as shocks to uncertainty and confidence. In particular, the severity of the financial crisis in the rest of the world may have had an adverse impact on confidence and uncertainty among Canadian households and firms. The confidence and uncertainty effects, in turn, may have been a drag on consumption and investment. But regardless of their microeconomic interpretation, shocks to domestic demand made important contributions to the decline in aggregate demand.

Overall, the story that emerges from ToTEM II suggests that the recession was not primarily the result of changes in risk spreads in Canada.[9] Rather, according to the model, shocks in the rest of the world played a central role, as did shocks to domestic demand (possibly including the effects of unmodelled financial shocks).

Application: Assessing the Macroeconomic Impact of Higher Bank Capital and Liquidity Requirements

The recent international banking crisis has sparked renewed interest in issues of macroprudential regulation. For instance, in 2010, the Basel Committee on Banking Supervision (BCBS) proposed an increase in the minimum required levels of capital and liquidity for the banking system.[10] This proposal aimed to reinforce the stability of the banking sector, thereby reducing the probability of a banking crisis in the future.[11] However, the benefits of a less-leveraged and more liquid banking system must be weighed against the associated economic costs. For instance, during the transition toward tighter capital and liquidity requirements, banks could reduce the supply of credit or increase interest rate spreads—actions that would have a negative impact on economic activity.

To help determine the appropriate calibration of the BCBS proposal, the Financial Stability Board and the BCBS conducted two studies to evaluate the macroeconomic impact of higher capital and liquidity requirements. These studies assessed the benefits and costs of the new standards over (i) the longer-term period when the proposals are fully implemented, and (ii) the initial transition period, during which the new standards will be introduced. Bank of Canada staff participated in both international studies. The Bank also carried out its own assessment of the implications of these new standards for the Canadian financial system and economy.

In this section, we review how ToTEM II was used to assess the transitional macroeconomic impact of higher steady-state capital and liquidity requirements for the Canadian banking system. Two different proposals were considered: (i) an increase of 1 percentage point in the banks' capital ratio, and (ii) an increase of 25 per cent in the liquid asset ratio.[12] We examine the impact of these proposals under the assumption that they are implemented over a four-year period.

Since the structure of ToTEM II does not directly incorporate a banking sector, a two-step approach proposed by the Macroeconomic Assessment Group of the Bank for International Settlements was followed to assess the macroeconomic impact of tighter regulation.[13] First, the impact of higher capital and liquidity requirements on the interest rate spreads faced by households and firms was estimated using linear regression models.[14] The paths of the spreads implied by the regression models were then imposed in ToTEM II to generate simulated paths for key macroeconomic variables.

Before turning to the results, it is important to re-emphasize that the BCBS proposals are envisaged as part of a coordinated set of international regulatory changes. In the results presented below, however, we assume that regulatory requirements in the rest of the world remain unchanged. Global tightening of regulatory requirements could amplify the effects of the changes in Canada. De Resende and Lalonde (2011) use the BoC-GEM-FIN model to examine the effects of global tightening of regulatory requirements for Canada in an article in this issue of the *Review*.

9 It is possible, however, that the credit market effect is not fully captured by the increase in spreads. Banks and other lenders may have also restricted quantitative access to credit. Insofar as they did ration credit, the ToTEM II analysis may understate the full impact of financial developments.

10 See BIS (2010).

11 There have also been other proposals aimed at strengthening the stability of the banking sector. For instance, Basel III considers the adoption of countercyclical capital buffers. Meh (2011) examines how such an initiative would affect the transmission and propagation of shocks in an article in this issue of the *Review*.

12 Details on the methodology used to evaluate the macroeconomic impact of higher capital and liquidity requirements can be found in Dorich and Zhang (2010).

13 For details on this two-step approach, see BIS (2010).

14 For details on the regression methodology, see Bank of Canada (2010).

An increase of 1 percentage point in the capital ratio

The increase in the capital ratio generates an increase in the spreads on short- and long-term interest rates faced by households and firms. According to the regression models, an increase of 1 percentage point in the capital ratio ultimately leads to an increase of 14 basis points in the spreads as banks adjust their lending behaviour (**Table 1**).

Table 2 presents the transitional impact of this change in the capital ratio on output, consumption, investment, exports, imports, the policy rate and core inflation.[15] The increase in interest rate spreads causes an increase in the effective interest rates faced by households, which gives households an incentive to postpone consumption. This leads to a 0.7 per cent decrease in consumption, relative to its baseline level, four years after implementation.[16]

Table 1: Impact of regulatory policies on interest rate spreads
Measured in basis points

	Years after implementation				
	0.5	1.0	2.0	4.0	6.0
Capital target increases 1 percentage point	1.1	2.6	6.1	13.1	14.0
Liquidity ratio increases 25 per cent	1.1	2.8	6.4	13.9	14.9

Table 2: Impact of a 1-percentage-point increase in the capital ratio

	Years after implementation			
	0.5	1.0	2.0	4.0
Output	-0.1	-0.1	-0.2	-0.3
Consumption	-0.3	-0.4	-0.6	-0.7
Investment	-0.3	-0.5	-0.6	-0.7
Exports	0.3	0.4	0.6	0.4
Imports	-0.2	-0.3	-0.4	-0.5
Policy rate (bps)	-5.5	-5.0	-2.0	-2.0
Inflation (bps)	-2.3	-1.0	1.0	0.0

Note:
1. All quantity variables are expressed as a percentage deviation from the baseline.
2. The policy rate is expressed as a basis-point deviation from the baseline at an annual rate.
3. The inflation rate is expressed as a basis-point deviation from the baseline of the year-over-year basis-point change in the level of core consumer prices.

15 The availability of alternative sources of financing for non-financial corporations may weaken the impact of changes in the banking sector on economic activity. In the simulations presented here, it is assumed that the higher spreads will be passed on to all households and firms. However, large corporate firms could issue debt in capital markets at a lower cost.

16 The baseline level refers to the level that would prevail without any new regulatory measure.

The increase in spreads affects investment through two different channels. First, the effective rate at which firms discount future real profits increases. This means that the net present value of future profits is reduced and, consequently, the demand for investment is reduced. Second, the reduction in the demand for consumption reduces the demand for capital by firms that produce consumption goods and services. These two effects cause investment to drop 0.7 per cent below its baseline level after four years.

In the model, the decline in consumption and investment puts downward pressures on output and prices. This, in turn, leads to a small temporary reduction in the policy rate in order to stabilize inflation during the transition. On the trade side, the reduction in the policy rate generates a depreciation in the real exchange rate, making Canadian exports cheaper for the rest of the world. Exports consequently increase by 0.4 per cent four years after implementation. Moreover, the real depreciation of the Canadian dollar, combined with decreased consumption and investment demand, causes imports to decrease by 0.5 per cent over four years.

The decrease in consumption and investment, partially offset by the increase in net exports, leads to a decrease of 0.3 per cent in the gross domestic product, relative to the baseline, four years after the implementation of the new capital ratio. If, however, the regulatory changes are implemented globally, then the impact on output could be greater because of a weaker offset from net exports. De Resende and Lalonde (2011) discuss the implications of global implementation in greater detail.

An increase of 25 per cent in the liquid asset ratio

The increase in the liquid asset ratio translates into wider interest rate spreads faced by households and firms. According to the linear regression models, an increase of 25 per cent in the liquid asset ratio results in an increase of 15 basis points in spreads in the long run. The magnitude is roughly speaking equal to the impact of higher capital requirements on spreads. The impact of greater liquidity requirements on interest rate spreads is estimated to be very similar to the impact of tighter capital requirements. Hence, the estimated macroeconomic impact of these two regulatory measures is quantitatively very similar.

Comparing costs and benefits

In this article, we have considered only the transitional costs of higher capital and liquidity requirements. A complete assessment of the proposals requires the transitional costs to be added to the long-term costs and then weighed against the expected benefits. The benefits come in the form of a reduced probability of future financial crises, as well as a decrease in the severity of any future crises, smoother economic cycles and lowered risk of overinvestment problems. Based on conservative estimates of the costs of financial crises, Bank of Canada (2010) finds that the benefits of the proposed regulatory changes would outweigh the costs. This is true even if the only source of benefits is a reduced probability of crises.

Conclusions

The introduction of a richer interest rate structure in ToTEM has made it possible to study a broader range of policy questions in the model. It has also contributed to improved empirical performance in ToTEM II. Nevertheless, Bank staff are currently exploring avenues for further enhancing linkages between financial developments and the real economy in ToTEM II. In the short run, the staff plan to investigate the possibility of making the risk spreads depend on endogenous variables.

Literature Cited

Amano, R., R. Mendes and S. Murchison. 2009. "Endogenous Rule-of-Thumb Price Setters and Monetary Policy." Bank of Canada Manuscript.

Andrés, J., D. López-Salido and E. Nelson. 2004. "Tobin's Imperfect Asset Substitution in Optimizing General Equilibrium." *Journal of Money, Credit and Banking* 36 (4): 665–90.

Bank for International Settlements (BIS). 2010. "Assessing the Macroeconomic Impact of the Transition to Stronger Capital and Liquidity Requirements." Macroeconomic Assessment Group Interim Report (August).

Bank of Canada. 2010. "Strengthening International Capital and Liquidity Standards: A Macroeconomic Impact Assessment for Canada." Bank of Canada Report (August).

Basant Roi, M. and R. Mendes. 2007. "Should Central Banks Adjust Their Target Horizons in Response to House-Price Bubbles?" Bank of Canada Discussion Paper No. 2007-4.

Bernanke, B., M. Gertler and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." In *Handbook of Macroeconomics*, edited by J. Taylor and M. Woodford, 1341–93. Amsterdam: North-Holland.

Christiano, L., M. Eichenbaum and C. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113 (1): 1–45.

de Resende, C. and R. Lalonde. 2011. "The BoC-GEM-Fin: Banking in the Global Economy." *Bank of Canada Review* (this issue): 11–21.

Dorich, J., M. Johnston, R. Mendes, S. Murchison and Y. Zhang. Forthcoming. "ToTEM II: An Updated Version of the Bank of Canada's Quarterly Projection Model."

Dorich, J. and Y. Zhang. 2010. "Assessing the Macroeconomic Impact of Stronger Capital and Liquidity Requirements in Canada: Insights from ToTEM." Bank of Canada Manuscript.

Fenton, P. and S. Murchison. 2006. "ToTEM: The Bank of Canada's New Projection and Policy-Analysis Model." *Bank of Canada Review* (Autumn): 5–18.

Galí, J. 2008. *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*. Princeton, New Jersey: Princeton University Press.

Galí, J. and M. Gertler. 1999. "Inflation Dynamics: A Structural Econometric Analysis." *Journal of Monetary Economics* 44 (2): 195–222.

Meh, C. 2011. "Bank Balance Sheets, Deleveraging and the Transmission Mechanism." *Bank of Canada Review* (this issue): 23–34.

Murchison, S. and A. Rennison. 2006. "ToTEM: The Bank of Canada's New Quarterly Projection Model." Bank of Canada Technical Report No. 97.

Smets, F. and R. Wouters. 2007. "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach." *American Economic Review* 97 (3): 586–606.

Tobin, J. 1969. "A General Equilibrium Approach to Monetary Theory." *Journal of Money, Credit and Banking* 1 (1): 15–29.

Woodford, M. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton, New Jersey: Princeton University Press.

The BoC-GEM-Fin: Banking in the Global Economy

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- *The 2007–09 financial crisis demonstrated the significant interdependence between banks and the real economy. To capture this relationship, policy models must take into account the role of financial shocks and the influence of the banking system on the propagation and amplification of real shocks.*
- *The Bank of Canada's Global Economy Model with Financial Frictions (BoC-GEM-Fin) is a multi-regional dynamic stochastic general-equilibrium model of the world economy that features a banking system, including an interbank market and cross-border lending. Analysis based on the model helps us understand and quantify*
  - *the impact of shocks to the U.S. banking sector on credit conditions and real economic activity in Canada.*
  - *the observed positive co-movement between consumption and investment within each economy and across economies. Explaining the latter is notoriously difficult for models that rely only on traditional trade linkages.*
  - *the short-term impact on output of changes in the regulatory limits to bank leverage in Canada.*

The 2007–09 financial crisis dramatically demonstrated the interdependence between the financial sector and the real economy and the interconnectedness of the global economy. It became apparent that the existing policy models, which treat the banking sector as a passive element in the economy—simply intermediating funds from savers to borrowers—could not explain the causes and effects of the crisis, nor indicate the appropriate policy response.

The crisis triggered a wave of studies aimed at incorporating an active banking system into standard macroeconomic models

Indeed, the crisis triggered a wave of studies aimed at incorporating an active banking system into standard macroeconomic models. This article describes one such initiative, the Bank of Canada's version of the Global Economy Model with Financial Frictions (BoC-GEM-Fin).[1]

The two key-features of the model are (i) a multi-regional dimension and (ii) the explicit modelling of the interaction between the banking system and the real economy. A multi-region model captures the spillover of shocks across economies. With all of the regional blocks connected by bilateral trade, exchange rates and financial linkages, the international transmission of shocks is an important propagation mechanism. In addition, rather than being a frictionless bridge between savers and

1 Other studies conducted at the Bank, even prior to the financial crisis, that highlight the importance of financial channels for the macroeconomy include Christensen and Dib (2006), Meh and Moran (2010) and Christensen, Meh and Moran (2010).

borrowers, banks in the BoC-GEM-Fin play two important roles: propagating, even amplifying, the effects of real shocks; and serving as sources of financial shocks. Cross-border lending by banks provides an additional mechanism for the international transmission of shocks. These features not only add realism to the model, but also permit the study of the international transmission of shocks (including banking sector shocks), monetary policy in the presence of banking-system distress and the macroeconomic effects of bank regulation.

The article is organized as follows. First we describe the model, focusing on the banking sector. We then present the response of selected Canadian and U.S. macroeconomic variables to a "credit crunch" (i.e., an exogenous reduction in the supply of loans) in the United States and discuss recent related research based on BoC-GEM-Fin. We conclude with a look at future development and applications of the model.

BoC-GEM-Fin

The BoC-GEM-Fin follows the Bank's long tradition of using state-of-the-art economic models as analytical tools in the policy-decision-making process.[2] The model is a multi-sector dynamic stochastic general-equilibrium (DSGE) model in which economic agents make consumption, savings, pricing and production decisions based on optimizing behaviour. In this class of models, the supply and demand profiles for goods, labour, capital and financial assets are explicitly modelled, implying endogenous paths for prices that clear those markets.

The model is a multi-sector DSGE model in which economic agents make decisions based on optimizing behaviour

The model features a multi-region world economy in which bilateral trade and exchange rates are fully endogenous.[3] The five regional blocks are Canada, the United States, emerging Asia, the commodity-exporting countries and the rest of the world.[4] The prices of oil and non-energy commodities are determined in global markets, providing an important mechanism for the transmission of foreign shocks, particularly to commodity-oriented economies, such as Canada. Each regional block consists of households; a multi-tiered production sector, which includes risk-neutral entrepreneurs, capital producers, monopolistically competitive retail firms and perfectly competitive wholesale firms; and a fiscal and a monetary authority.[5, 6]

The calibration of the model's parameters—to map the model to the data—is described in more detail in Lalonde and Muir (2007) and de Resende et al. (forthcoming). In general, calibration is based on the statistical properties of relevant data, as well as on values estimated in microeconomic studies and used in other DSGE models.

This article focuses on two key changes in the BoC-GEM-Fin, relative to the previous version of the model (BoC-GEM); namely the introduction of (i) the so-called "financial-accelerator mechanism" (Bernanke, Gertler and Gilchrist 1999) and (ii) active banks that interact in an interbank market and lend to domestic and foreign entrepreneurs, based on Dib (2010 a, b). Below, we briefly describe the changes introduced to the real side of the economy, focusing on households and entrepreneurs—where the supply and demand of credit originate, respectively—and then describe the banking sector—where supply and demand of credit meet.

This linkage between households' savings and loans to entrepreneurs is one of the important changes relative to the previous version

Households work, consume final goods and save. Savings can be held in domestic and U.S. government bonds, domestic bank deposits and domestic bank capital. Deposits and bank capital are the primary source of funds for intermediation in the banking system, where they become loans to finance investment projects. This linkage between households' savings and loans to entrepreneurs—through the banking system—is a major component of the supply

2 See Duguay and Longworth (1998).
3 The model builds on a previous version, BoC-GEM (Lalonde and Muir 2007, 2009), which itself is based on the original GEM developed at the International Monetary Fund. See Pesenti (2008).
4 The residual economy represents the European Union (EU), Japan and Africa. A six-region version of the model, with a separate block for Japan, is currently under development.
5 The government levies taxes and spends on non-tradable, consumption and investment goods, while the monetary authority follows a Taylor-type rule in reaction to core inflation.
6 The production structure is essentially the same as that in the BoC-GEM.

of credit in the BoC-GEM-Fin and one of the important changes relative to the previous version.

Entrepreneurs purchase capital using their own resources—*entrepreneurial net worth*—and bank loans. They rent the purchased capital to firms, where it will be used to produce goods. While the link from savings to loans is important for the supply of credit, the entrepreneurs' decisions determine the demand for credit.[7] Because capital purchases require some external funding (bank loans), the demand for credit in the BoC-GEM-Fin is directly tied to the entrepreneurs' demand for capital. Any disruption to the credit supply reduces the funds available to entrepreneurs, depressing investment and output.

The loan contract between entrepreneurs and banks reflects a source of *financial friction*, namely *asymmetric information*. In particular, entrepreneurs experience shocks to investment projects that only they—not the banks—observe. Thus, borrowing entrepreneurs know the return on their investment, but banks do not. This lack of information is costly for banks because when an adverse shock is severe enough—an unsuccessful investment project—entrepreneurs may default on bank loans. Banks can pay a monitoring cost (e.g., credit-risk specialists) to help identify the threshold level of the shock that triggers default and, in the event of default, pay agency costs (e.g., lawyers) to retrieve part of the principal plus the liquidation value of the unsuccessful project.

A contract that resolves the problem of asymmetric information must constrain the amount of loans desired by entrepreneurs, while fully compensating the banks for the risks involved. Note that, for a given value of entrepreneurial net worth, a greater desire to purchase capital implies that entrepreneurs must rely increasingly on loans to fund their projects. From the bank's viewpoint, this increases the risk associated with the loan. In the BoC-GEM-Fin, the loan contract implies a risk premium that depends inversely on the entrepreneurs' leverage ratio, i.e., the ratio between loans and internal funding (net worth).[8]

The banking system

The banking sector within the BoC-GEM-Fin is based on Dib (2010a, b) and features two types of optimizing, monopolistic competitive banks: *deposit banks* and *lending banks*. These two types of banks may be thought of as single banks, each having two distinct profit-maximizing operational divisions. One division acts purely as a deposit bank, collecting fully insured deposits from households, paying a deposit interest rate and optimally allocating the deposits into two types of assets: risky interbank loans or government bonds. The second division, a corporate loans division, acts as a lending bank, using the funds borrowed from its own depositors and other domestic banks, together with bank capital raised from households, to supply loans to entrepreneurs (domestic and foreign), and charging a lending interest rate.

Deposit banks allocate deposits between domestic interbank lending and domestic government bonds. Given their asset portfolio, the rate of return earned by deposit banks is a weighted average of the risk-adjusted interbank rate and the rate on government bonds. The financial frictions affecting deposit banks are the monitoring and agency costs associated with potential default on interbank loans. The monopoly power of individual banks determines the deposit rate as a markdown over the net marginal return on their assets. The distortions introduced by the probability of default and the monopoly power of banks create a wedge between the deposit rate and the interbank rate. Optimization motivates deposit banks to allocate a higher share of deposits to risky interbank loans when the interbank rate increases relative to the rate on government bonds, and as either the probability of default on interbank loans or the marginal costs associated with monitoring and agency issues decrease.

Lending banks borrow in the interbank market and raise bank capital. Banks use these funds to provide loans to entrepreneurs. From the viewpoint of households, bank capital is a risky asset whose return is uncertain because the gross return is known only after the investment decision takes place, and lending banks may divert their profits to non-productive activities (e.g., large bonuses for bank managers) instead of paying the expected return to investors. During intermediation, lending banks optimally decide the lending rate, the share of borrowed funds that will not be repaid (default on interbank loans), the fraction of the return on bank capital that will be diverted, the demand for bank capital and the supply of loans.[9]

7 Entrepreneurs are solely responsible for the demand for credit in the economy. Future versions of the model will include credit to households.

8 The relationship between the risk premium and net worth is captured by a reduced-form equation, following Dib (2010a, b).

9 The BoC-GEM-Fin, unlike the previous version, provides implications for multiple interest rates: deposit, lending, interbank and policy rates.

As with deposit banks, some degree of monopoly power allows lending banks to set rates as a markup over their marginal cost (i.e., the costs of interbank borrowing and raising bank capital). Financial frictions also apply to lending banks when deciding (i) the optimal share of interbank loans to be defaulted and (ii) the optimal fraction of the return on bank capital to be diverted. These decisions may result in legal costs and fees that increase with the amounts involved. The higher these penalties are, the less the likelihood of default and/or diverted returns. However, a higher policy interest rate increases the net benefit of default and the likelihood of profits being diverted. These distortions generate a wedge between the interbank rate and the lending rate, and affect the propagation of shocks in the model.

When lending banks decide their optimal demand for bank capital and the amount of loans supplied to entrepreneurs, they are, in fact, determining their desired *bank leverage ratio*, defined as the ratio of loans to bank capital. The optimal bank leverage ratio decreases as the lending rate rises (less demand for loans in equilibrium) and increases with the marginal cost of raising bank capital (less bank capital in equilibrium). In the BoC-GEM-Fin, lending banks must satisfy a maximum leverage ratio (or minimum capital requirement) established by regulators. Agents use this regulatory cap on bank leverage to benchmark banks' current capital ratio, so that well-capitalized banks (i.e., less leveraged) can issue equity at a lower cost. Thus, banks have an incentive to keep a "capital buffer" above the minimum required by regulation. As well, the upper limit on leverage becomes an additional instrument available to policy-makers, and changes in that limit have important implications for bank behaviour, affecting the supply of loans, interest rates, investment and output. If banks exceed that limit, they must deleverage, either by reducing risky loans or by raising additional bank capital.[10]

In the BoC-GEM-Fin, the banking sector also plays an important role in the international transmission of shocks. Without the banking system, shocks originating in one region propagate to another region exclusively through bilateral trade flows, adjustments in exchange rates and changes in the prices of oil and non-energy commodities. The presence of cross-border lending in the BoC-GEM-Fin means that changes in credit conditions in one region will affect borrowing costs in another region, with consequences for investment and output beyond those related to the trade channel.[11]

In the BoC-GEM-Fin, the banking sector also plays an important role in the international transmission of shocks

The demand for credit depends heavily on entrepreneurial net worth. Wealthier entrepreneurs require fewer bank loans for their projects. However, the lower cost of external financing because of greater net worth induces a higher demand for loans. Net worth has two important properties: (i) it is procyclical; i.e., it tends to increase with profits and asset prices, which in turn, rise during economic booms and fall during recessions; and (ii) it is persistent, since it takes time to accumulate. Given the loan contract described earlier, these properties imply movements in the risk premium that are countercyclical and long lasting, contributing to the amplification and propagation of shocks. Consider, for example, a demand-driven economic boom that increases consumption, output and profits, and leads to greater entrepreneurial net worth. New loan contracts reflect the reduction in the banks' exposure to risk, and entrepreneurs pay lower risk premiums. As external funding becomes more affordable, entrepreneurs invest more, inducing a second-round boost to aggregate demand, output and net worth, which reduces the risk premium even further, and so on. The initial demand shock is amplified through the interaction of banks and entrepreneurs. This is the **financial-accelerator mechanism**.

The **debt-deflation mechanism** is another channel affecting the demand for credit and the propagation of shocks in the BoC-GEM-Fin. Since all debt contracts, including bank loans, are denominated in nominal terms, unanticipated price-level increases depress the real value of debt. Wealth is transferred from creditors to debtors. Therefore, higher unexpected inflation increases the net worth of indebted entrepreneurs, reduces the risk premium and increases investment and output. Notice that

10 The gain from keeping more capital than required by the regulation of leverage ratio, as well as the agency and monitoring costs, in the banking system of the BoC-GEM-Fin is captured in a reduced form, following Dib (2010a, b).

11 The international financial channels may still not be fully captured in the current version of the model, which features only direct cross-border lending to entrepreneurs but not lending between banks in different regions. Bank staff are working on a future version that will incorporate international interbank lending.

this channel reinforces the financial-accelerator mechanism following demand shocks that drive up both output and inflation, but dampens its effect after a positive supply shock that raises output but reduces inflation.

On the supply side of credit, the main mechanism at work is the **bank-capital channel**. Shocks that affect asset prices also alter the value of bank capital. To keep their capital-adequacy ratio within regulatory limits and adjust the desired capital buffer, banks optimally change their actual leverage ratio. This has implications for the supply of loans, which in turn, will affect investment and output.

Model Properties and Policy Experiments

Shocks to the U.S. banking sector

To illustrate some of the models' properties, we examine the response of selected variables to an exogenous persistent fall in the supply of loans in United States.[12] The shock can be interpreted as an exogenous tightening of credit standards in the United States, as observed during the recent financial crisis—a "credit crunch." Our discussion focuses on the responses of the U.S. and the Canadian economies.

In the United States, such a drop in the supply of loans leads to increases in both the U.S. lending rate and the risk premium, a fall in investment and a recession (**Chart 1**). Since borrowing becomes more expensive, entrepreneurs reduce their purchases of capital goods. The corresponding decline in investment leads to lower economic activity and inflation. As household income falls, consumption follows. With less demand for goods and lower sales, the demand for capital decreases, and entrepreneurial net worth starts falling, inducing a second-round increase in the risk premium (financial-accelerator mechanism). In addition, the unanticipated decrease in U.S. inflation raises the real value of entrepreneurs' bank loans (debt-deflation mechanism), reinforcing the initial fall in net worth and adding to the initial increase in the risk premium. Both mechanisms amplify the decline in economic activity.[13]

The tighter credit conditions in the United States are transmitted to Canada (and other regions) through three channels (**Chart 2**). First, the decline in U.S. economic activity reduces U.S. imports from all regions, negatively affecting output abroad—the traditional trade channel. This is especially true for Canada, given its close trade relationship with the United States. Second, slower economic activity in the United States and in the rest of the world reduces the demand for oil and non-energy commodities. The prices of these commodities fall, creating a negative wealth effect in commodity-exporting regions like Canada. This commodity-price channel exacerbates the decrease in Canadian consumption and output. These two channels reduce the net worth of Canadian entrepreneurs, triggering the financial-accelerator mechanism, which generates negative second-round effects on Canadian investment and output. As inflation falls in Canada, the debt-deflation mechanism further amplifies the economic downturn. Note that the larger decrease in U.S. output (and inflation) relative to that in Canada leads to a larger drop in U.S. policy rates. This difference in interest rates causes the Canadian dollar to appreciate in real terms against the U.S. dollar in the short term. Eventually, the effect of lower commodity prices dominates, implying a real depreciation of the Canadian dollar.

Simulations with the BoC-GEM-Fin suggest that the transmission of shocks originating in the U.S. banking sector to the global economy—particularly Canada—is very important

The third transmission channel is the bilateral flow of bank loans. Since Canadian entrepreneurs finance some of their capital acquisition by borrowing from U.S. lending banks, the U.S. credit crunch directly affects their access to external funding.[14] Beaton, Lalonde and Snudden (2010) show that this channel typically explains roughly 20 per cent of the fall in Canadian output that follows the reduction in U.S. loans.[15] Consistent with the observations of the recent financial crisis, simulations with the BoC-GEM-Fin suggest that the transmission of shocks

12 For a detailed description of the response of the model to other stylized shocks, see de Resende et al. (forthcoming).

13 The reaction of monetary policy to lower inflation—a reduction in interest rates—partially offsets the full impact of the credit crunch.

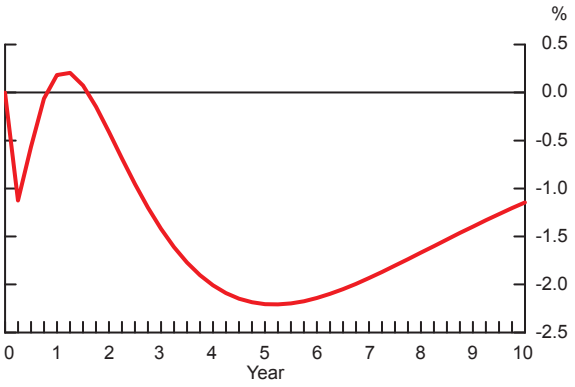
14 Because the shares of loans demanded by domestic entrepreneurs from domestic and foreign banks are currently fixed, Canadian banks do not make up for the loss in loans supplied by foreign banks. A future version of the model will allow those shares to be optimally decided.

15 In this case, the fall in Canadian output is about two-thirds of that in U.S. output.

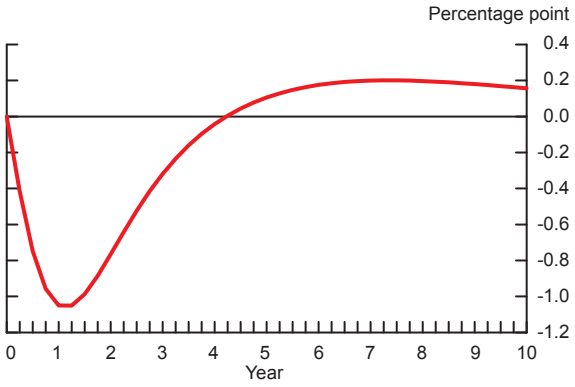
Chart 1: Effects on the United States of an exogenous reduction in U.S. bank loans

Deviation from control

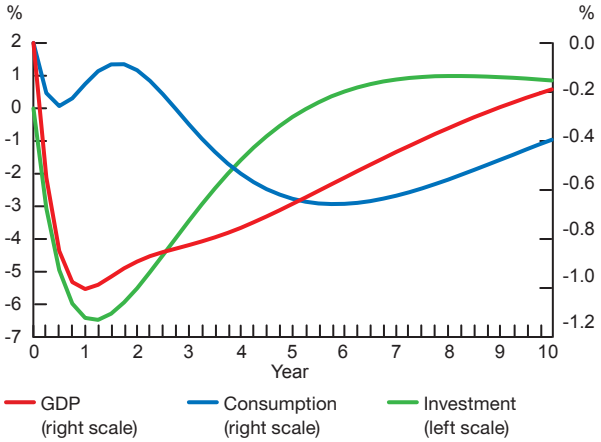
a. Bank loans



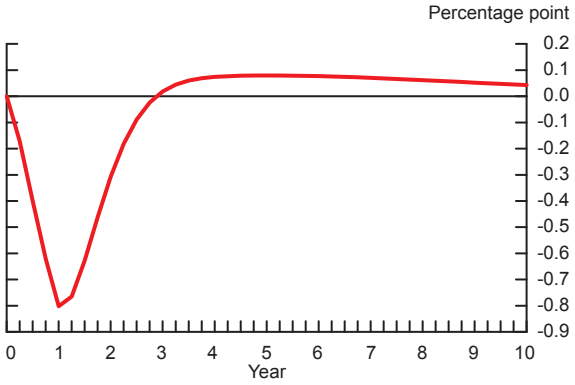
b. Policy rate



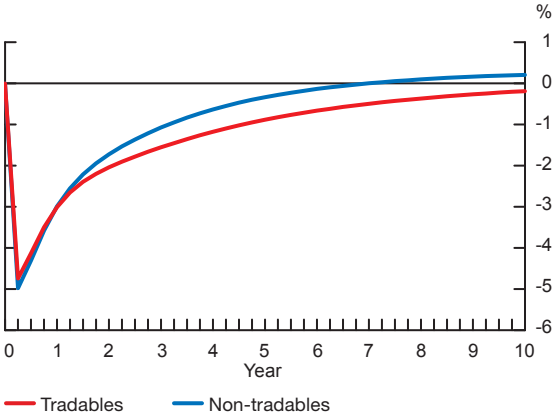
c. Output



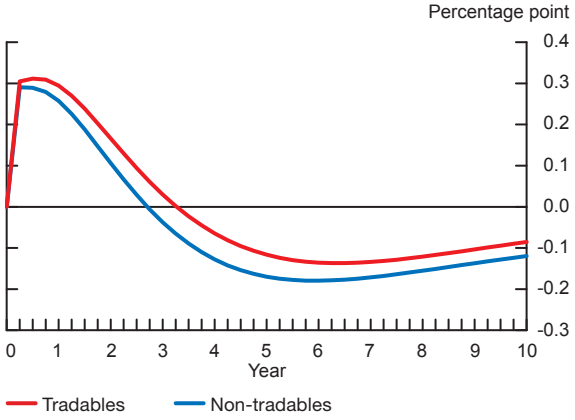
d. Core inflation



e. Net worth



f. Risk premiums

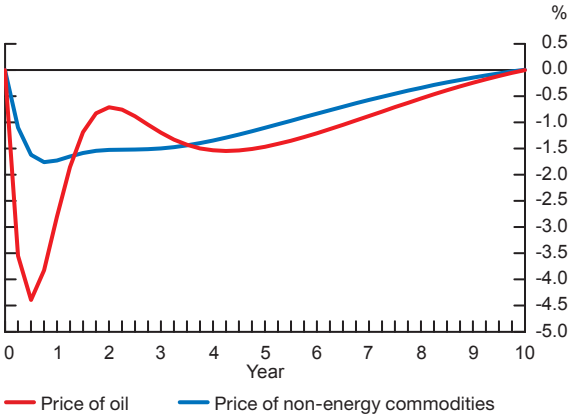


Source: BoC-GEM-Fin simulations

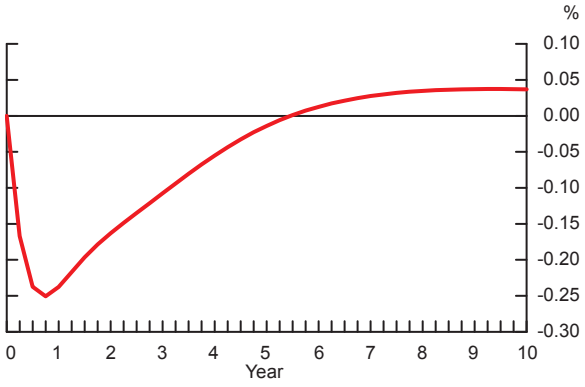
Chart 1: (cont'd)

Deviation from control

g. Price of oil and non-oil commodities



h. Total U.S. imports

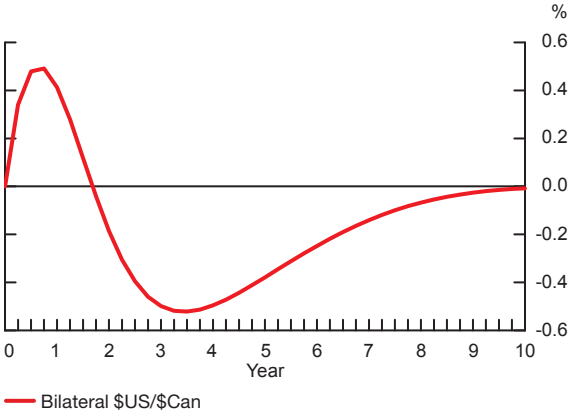


Source: BoC-GEM-Fin simulations

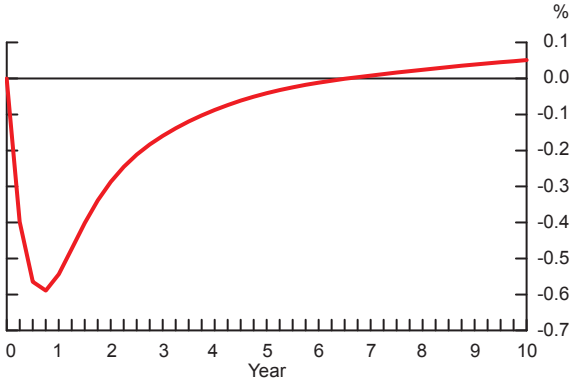
Chart 2: Effects on Canada of an exogenous reduction in U.S. bank loans

Deviation from control

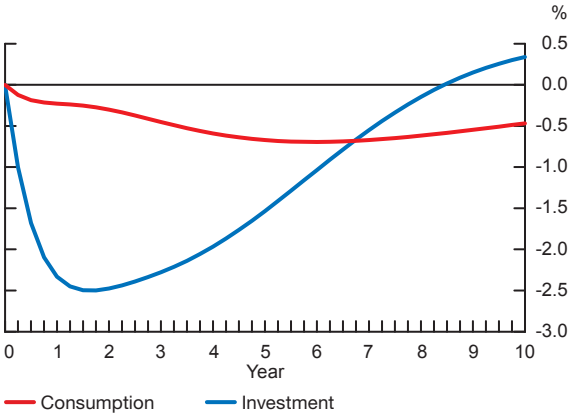
a. Exchange rate



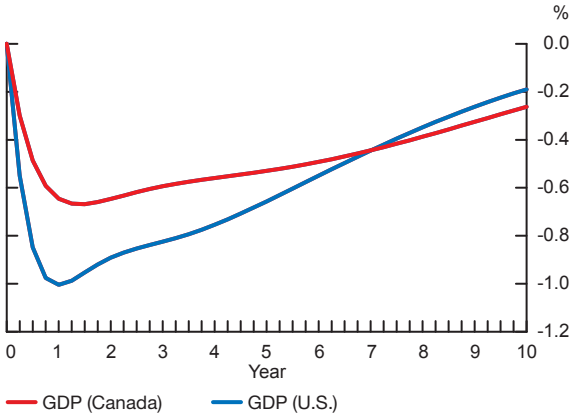
b. Exports



c. Output



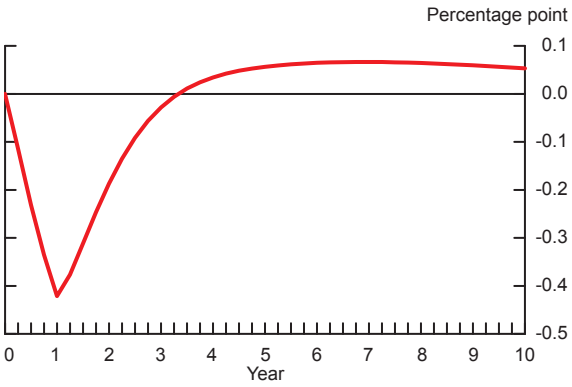
d. GDP, Canada and United States



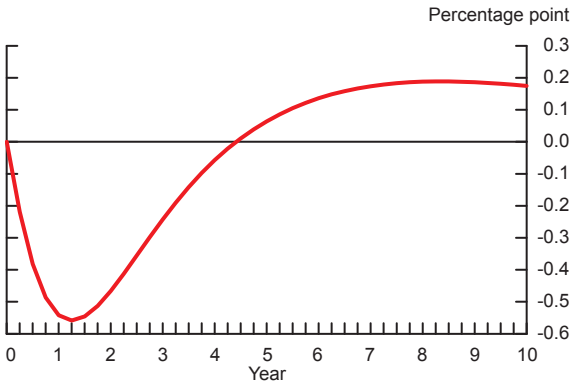
Source: BoC-GEM-Fin simulations

Chart 2: Effects on Canada of an exogenous reduction in U.S. bank loans (cont'd)
Deviation from control

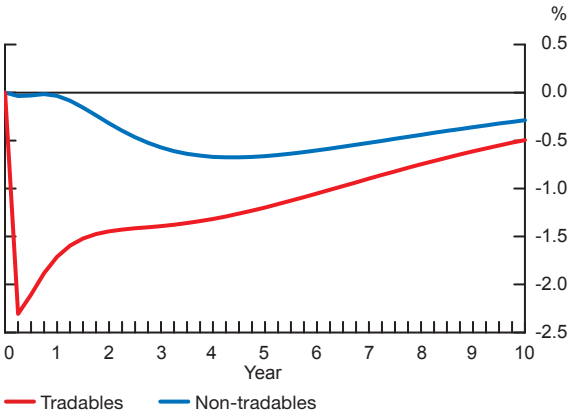
e. Core inflation



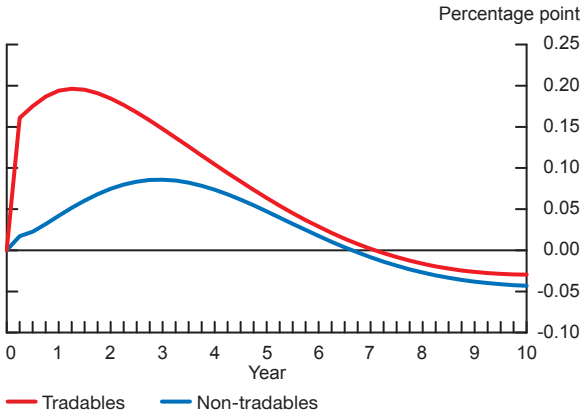
f. Policy rate



g. Net worth



h. Risk premiums



Source: BoC-GEM-Fin simulations

originating in the U.S. banking sector to the global economy—particularly Canada—is very important. Similar conclusions hold for other types of shocks to the U.S. banking sector, such as increases in the probability of default in the interbank market (i.e., the collapse of Lehman Brothers).

Recent applications of the BoC-GEM-Fin

The global economic and financial dimensions of the recent crisis have raised many questions that can be better addressed by a model of the global economy with financial frictions, like the BoC-GEM-Fin.

The role of real-financial linkages in propagating U.S. shocks to Canada

The importance of cross-border financial linkages is illustrated by Beaton, Lalonde and Snudden (2010), who use the BoC-GEM-Fin to address two questions:

1. How are U.S. banking sector shocks transmitted to the Canadian economy?
2. What is the role of financial frictions in the transmission of real shocks originating in the United States to the Canadian economy?

The authors simulate two types of shocks to the U.S. banking sector: (i) a reduction in the supply of bank loans and (ii) an increase in the probability of default in the interbank market. To answer question 2, the authors simulate demand and productivity shocks in the U.S. economy and compare the responses of the U.S. and Canadian economies with those obtained when financial frictions are excluded from the model.

The results suggest that the shocks to the U.S. banking sector have important effects on credit conditions and real activity in Canada. As discussed previously, the response of Canadian output to shocks in the U.S. banking sector is sizable and can be explained by channels associated with the real side of the economy and with the international flow of bank loans. Moreover, financial frictions from the

supply (bank-capital channel) and demand (financial accelerator) of credit can amplify the responses of the U.S. and Canadian economies to all types of shocks that affect U.S. real variables. One final result illustrates how the financial shocks and frictions in the BoC-GEM-Fin help to explain the observed positive co-movement between consumption and investment within each economy and between the two economies. Explaining these co-movements is notoriously difficult with models that rely on only the traditional trade linkages.

Inflation targeting versus price-level targeting: banking sector shocks and the lower bound on interest rates

The Bank of Canada has recently conducted several studies on the merits of the current monetary policy framework based on inflation targeting (IT), relative to a framework based on a price-level target (PLT). These studies (for example, Coletti and Lalonde 2007–08; Kryvtsov, Shukayev and Ueberfeldt 2008) focus mainly on the responses to standard real shocks, and do not consider shocks originating in the banking system. The choice between IT and PLT received renewed interest during the recent crisis, and it has been suggested that PLT might be more successful in limiting the variability in inflation and economic activity when the desired policy rate is close to the zero lower bound (Ambler 2009).

Beaton, Evans and Lalonde (forthcoming) analyze the relative performance of the two regimes in reducing the variance of inflation and the output gap in the presence of shocks to the U.S. and Canadian banking sectors. In light of the recent global crisis, it is crucial to understand the relative merits of IT/PLT under shocks to the banking system, something that could not be accomplished with previous versions of the model.

Their results confirm previous findings that, in the context of monetary policy based on optimized interest rate rules, PLT generates more macroeconomic stability than IT when the economy is hit by shocks that cause inflation and output to move in the same direction, such as demand shocks. Those shocks, like banking sector shocks, imply a more favourable trade-off between inflation and output gap variability faced by the central bank (Coletti and Lalonde 2007–08).

Because the new model incorporates the banking system, the authors consider the best monetary policy response under both IT and PLT in the event of a "banking crisis" that pushes nominal interest rates close to the zero lower bound. Their results suggest that, with PLT, the trough in the output gap and inflation during a banking crisis would be substantially reduced, relative to IT. The explanation is that when nominal interest rates are close to zero, the only practical way to reduce the real interest rate (i.e., the nominal interest rate minus expected inflation) and mitigate the fall in output is by generating higher expected inflation, something more easily achieved under PLT. The lower real interest rate under PLT, relative to IT, reduces the severity of the recession. Finally, depending on the severity of the crisis, the authors find evidence that, under PLT, policy rates need to be maintained at the lower bound for a shorter period.[16] The benefit of PLT in the presence of banking sector shocks is also associated with the fact that PLT is better at minimizing the distortions caused by the debt-deflation mechanism on risk premiums (Dib, Mendicino and Zhang 2008).

Regulation of bank capital

Following the recent financial crisis, policy-makers investigated policies to mitigate the destabilizing effects of excessive leverage in the banking system. One important aspect of the "macroprudential rules" currently being considered is the implementation of tighter bank-capital requirements.[17] Using the BoC-GEM-Fin, de Resende, Dib and Perevalov (2010) study the short-term cost of this type of regulatory policy for Canada. The size of the change and timing of implementation follow the discussions of the Basel Committee on Banking Supervision, Basel III (BCBS 2010; BIS 2010). The authors show that a permanent increase of 2 percentage points in the minimum capital-to-loans ratio (i.e., a lower cap on the banks' leverage ratio) imposed on banks in all regions produces the following results:

- Canadian output falls because of an increase in the risk premium and a decrease in investment. This temporary effect on output reduces the long-term benefits—mainly the lower probability of a severe banking crisis—associated with the tighter regulation.[18]

16 Note that these results are robust to optimized rules that exclude the "smoothing coefficient" (i.e., a response to the lagged interest rate). These results are not unconditional, however, since they hold for the particular type of shock in queston (i.e., the banking sector shock) but not necessarily for other types of shocks. The PLT/IT comparison also abstracts from many of the challenges that PLT might face in practice, for example, credibilty and communicating it to the public.

17 See BCBS (2010), BIS (2010) and Gauthier, He and Souissi (2010)

18 See the interim report by the BCBS (BIS 2010). In addition, Bank of Canada (2010) shows that after subtracting the estimated long-run and transition costs of requiring banks to carry more capital and liquidity, the net gains in present-value terms would be approximately 13 per cent of GDP.

- When the changes in regulatory policy are implemented worldwide, the temporary drop in Canadian output is larger than it would be if the changes were introduced only in Canada. These spillover effects may increase the average negative effect on Canadian output by as much as 0.9 percentage point.
- Reducing the phase-in period for implementation of the new regulatory policy from four years to two years implies an additional decrease of 0.3 percentage point in output. Increasing the phase-in to six years reduces the decrease in output by 0.1 percentage point.
- The monetary policy response is very important. If monetary policy does not react to inflation outcomes for one year,[19] such that the policy rate does not fall as fast as it would otherwise, the resulting higher real interest rate increases the negative effect of the change in capital regulation.

19 That is, either by lowering the policy rate or by using quantitative- or credit-easing instruments in response to the decline in inflation resulting from the slowdown in economic activity.

Conclusions and Future Developments

The BoC-GEM-Fin is currently being used to study a number of interesting policy questions, including the relative merits of countercyclical bank-capital requirements—i.e., rules that allow banks to have more leverage during recessions, with stricter requirements during economic booms—as well as the macroeconomic effects of a monetary policy framework based on leaning against financial imbalances.

The BoC-GEM-Fin has already proven to be a very useful analytic tool, and further improvements are being incorporated. These include an international interbank market and household credit. These additional features will provide new channels for the international propagation of real and financial shocks and allow a more in-depth study of the behaviour of household balance sheets in times of financial distress.

Literature Cited

Ambler, S. 2009. "Is It Time for Price-Level Targeting?" *Economic Affairs*, 29 (3): 35–39.

Bank for International Settlements (BIS). 2010. "Assessing the Macroeconomic Impact of the Transition to Stronger Capital and Liquidity Requirements." Macroeconomic Assessment Group Interim Report (August).

Bank of Canada. 2010. "Strengthening International Capital and Liquidity Standards: A Macroeconomic Impact Assessment for Canada." Bank of Canada Report (August).

Basel Committee on Banking Supervision (BCBS). 2010. "An Assessment of the Long-Term Economic Impact of Stronger Capital and Liquidity Requirements." LEI Report (August).

Beaton, K., B. Evans and R. Lalonde. Forthcoming. "The Relative Merits of Inflation Targeting versus Price-Level Targeting: Banking Sector Shocks, Banking Crises and the Lower Bound of Interest Rates." Bank of Canada Discussion Paper.

Beaton, K., R. Lalonde and S. Snudden. 2010. "The Propagation of U.S. Shocks to Canada: Understanding the Role of Real-Financial Linkages." Bank of Canada Working Paper No. 2010-40.

Bernanke, B., M. Gertler and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." In *Handbook of Macroeconomics*, edited by J. Taylor and M. Woodford, 1341–93. Amsterdam: North-Holland.

Christensen, I. and A. Dib. 2006. "Monetary Policy in an Estimated DSGE Model with a Financial Accelerator." Bank of Canada Working Paper No. 2006-9.

Christensen, I., C. Meh and K. Moran. 2010. "Bank Leverage Regulation and Macroeconomic Dynamics." Bank of Canada and Université Laval. Manuscript.

Coletti, D. and R. Lalonde. 2007–08. "Inflation Targeting, Price-Level Targeting, and Fluctuations in Canada's Terms of Trade." *Bank of Canada Review* (Winter): 35–43.

Literature Cited (cont'd)

de Resende, C., A. Dib, R. Lalonde and S. Snudden. Forthcoming. "The Bank of Canada's Version of the Global Economy Model with Financial Frictions (BoC-GEM-Fin)." Bank of Canada Technical Report.

de Resende, C., A. Dib and N. Perevalov. 2010. "The Macroeconomic Implications of Changes in Bank Capital and Liquidity Requirements in Canada: Insights from the BoC-GEM-Fin." Bank of Canada Discussion Paper No. 2010-16.

Dib, A. 2010a. "Banks, Credit Market Frictions, and Business Cycles." Bank of Canada Working Paper No. 2010-24.

———. 2010b. "Capital Requirement and Financial Frictions in Banking: Macroeconomic Implications." Bank of Canada Working Paper No. 2010-26.

Dib, A., C. Mendicino and Y. Zhang. 2008. "Price Level Targeting in a Small Open Economy with Financial Frictions: Welfare Analysis." Bank of Canada Working Paper No. 2008-40.

Duguay, P. and D. Longworth. 1998. "Macroeconomic Models and Policy Making at the Bank of Canada." *Economic Modelling* 15 (3): 357–75.

Gauthier, C., Z. He and M. Souissi. 2010. "Understanding Systemic Risk: The Trade-Offs between Capital, Short-Term Funding and Liquid Asset Holdings." Bank of Canada Working Paper No. 2010–29.

Kryvtsov, O., M. Shukayev and A. Ueberfeldt. 2008. "Adopting Price-Level Targeting under Imperfect Credibility: An Update." Bank of Canada Working Paper No. 2008-37.

Lalonde, R. and D. Muir. 2007. "The Bank of Canada's Version of the Global Economy Model (BoC-GEM)." Bank of Canada Technical Report No. 98.

———. 2009. "BoC-GEM: Modelling the World Economy." *Bank of Canada Review* (Summer): 43–53.

Meh, C. and K. Moran. 2010. "The Role of Bank Capital in the Propagation of Shocks." *Journal of Economic Dynamics and Control* 34 (3): 555–76.

Pesenti, P. 2008. "The Global Economy Model: Theoretical Framework." *IMF Staff Papers* 55 (2): 243–84.

Bank Balance Sheets, Deleveraging and the Transmission Mechanism

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- *The depletion of bank capital and the subsequent deleveraging by banks played an important role in the severity of the recent global financial crisis.*
- *The bank-capital channel—the endogenous response of bank capital to economic developments—can magnify and propagate monetary policy actions and other shocks. The strength of this amplification depends on the banking system's capitalization: the less capitalized the banking system is, the more bank lending, output and inflation respond to shocks.*
- *While effective capital regulation will increase the resilience of the banking sector to economic shocks, it will also affect the monetary policy transmission mechanism. In particular, the stabilization of an economy with a better-capitalized banking system will require less-aggressive movements in the policy rate. Moreover, achieving the stabilization benefits of countercyclical capital buffers requires proper coordination with monetary policy.*

The recent global financial crisis underscored the important role of banks and other financial institutions in transmitting and amplifying economic and financial shocks. The responses of banks, especially in the United States and Europe, to substantial decreases in their capital positions helped to turn the initial shock to the U.S. subprime-mortgage market into a global cataclysm.[1] These forces, which peaked after the failure of Lehman Brothers, are viewed as key determinants in the collapse of aggregate expenditure in the autumn of 2008 and the resulting large contraction in employment and output. Understanding these phenomena and their implications for public policy is important and requires the use of a macroeconomic framework in which financial intermediation matters for resource allocation.

This article investigates the influence of bank capital on economic fluctuations, using a macroeconomic framework that incorporates an explicit role for financial intermediation. The analysis focuses on the role of bank capital in the amplification and propagation of shocks and examines how weaker bank balance sheets can make an economy more vulnerable to adverse shocks. It also studies how new macroprudential initiatives such as countercyclical capital buffers—whose purpose is to make the banking sector more resilient to stress—will affect the transmission mechanism of monetary policy and other shocks to the real economy.

The first section of the article summarizes the macroeconomic models of Meh and Moran (2010) and Christensen, Meh and Moran (2010) that incorporate a banking sector. The second section shows how endogenous movements in bank capital—the bank-capital channel (see **Box**)—can amplify and

1 Note that the loss of liquidity in financial markets also contributed to the severity of the crisis.

propagate shocks to output and inflation. The third and fourth sections respectively examine how the transmission of shocks depends on the capitalization of the banking system and how financial shocks originating in the banking sector can substantially affect the real economy. The fifth section illustrates the important implications that countercyclical capital buffers could have for the transmission and the magnification of shocks.[2] The last section concludes by highlighting areas where further research is needed. Indeed, this article abstracts from elements, such as boom-bust dynamics and associated non-linearities that may be important in the discussion of the relationship between bank balance sheets and the transmission mechanism. The article should therefore be viewed as a useful first step in understanding the interaction between bank capital and the transmission mechanism, as well as the implications of countercyclical capital buffers for monetary policy.

A Macroeconomic Framework with Banking

This section outlines the macroeconomic framework with banking that is used to analyze the role of bank capital in economic fluctuations. This framework, based on Meh and Moran (2010) and Christensen, Meh and Moran (2010), is particularly suited to this exercise since the condition of bank balance sheets is determined endogenously through the important role of bank capital in mitigating asymmetric-information problems between bankers and their creditors.[3]

The model includes several nominal and real frictions, in the spirit of standard New Keynesian models (Christiano, Eichenbaum and Evans 2005).[4] Households choose their consumption and leisure to maximize expected lifetime utility and deposit their savings in banks.[5] Monopolistically competitive firms use capital and labour to produce differentiated intermediate goods and face sticky prices. These differentiated intermediate goods are then assembled by competitive firms to obtain the final good. Monetary policy is assumed to follow a Taylor rule with interest rate smoothing. Such a rule stipulates that the monetary authority adjusts the policy rate gradually in response to deviations of the inflation rate from the target and the output gap.

Entrepreneurs require external funds to make investments. As a result, banks intermediate funds between households (dispersed depositors, the ultimate lenders) and firms (entrepreneurs, the ultimate borrowers).[6] This intermediation process, however, is complicated by two sources of moral hazard. The first affects the relationship between banks and firms and arises because firms may choose to invest in risky projects that yield private benefits but have a low probability of success. The second source of moral hazard pertains to the relationship between banks and households, and stems from the fact that banks (to which households delegate the monitoring of firms) may not monitor appropriately, since monitoring is costly and not publicly observable.

The solution to the model involves an optimal configuration of financial contracts under asymmetric information, building on the seminal work of Holmstrom and Tirole (1997).[7] Banks spend resources to monitor the behaviour of firms and require that firms invest their own funds (net worth) in projects. In turn, a higher level of bank capital lessens the moral-hazard problem between banks and depositors, and thus the banking sector faces less-stringent conditions in its funding market. Since raising new bank capital is costly (see **Box**), bank capital is determined, in the short run, primarily by retained earnings (internal funds).

In Meh and Moran (2010), the capital-asset ratio necessary to mitigate the asymmetric-information problems is determined solely through market discipline. In contrast, Christensen, Meh and Moran (2010) allow for an exogenous regulatory capital requirement that can be time varying to increase the resilience of the banking system. The model can therefore accommodate countercyclical capital buffers (such as those in Basel III) whereby banks are required to maintain a higher capital-asset ratio in good times than in bad times. Under such a rule, banks can draw down their

2 Boivin, Kiley and Mishkin (2010) examine the evolution of the monetary policy transmission mechanism over time.

3 This model was used to contribute to policy debate at the Bank for International Settlements (BIS 2010) and the Bank of Canada (Bank of Canada 2010).

4 Following the crisis, many papers emerged to take into account the balance sheets of banks in New Keynesian models. See, for example, Dib (2010); Van den Heuvel (2008); Angelini, Neri and Panetta (2011); and Gertler and Karadi (2011). Also see de Resende and Lalonde (this issue) for the use of the Bank of Canada Global Economic Model augmented with banking (BoC-GEM-Fin) and Aikman and Vlieghe (2004).

5 In the model, households do not face financial frictions. Examples of models where households face collateral constraints include Iacoviello (2005) and Christensen (this issue). Building models that feature both bank capital and household balance sheets is left for future research.

6 The present framework focuses on the traditional loan book and not on capital-market activities.

7 This optimal financial contract stems from a principal-agent problem featuring a moral-hazard issue, in that bank actions are not publicly observable. Because of this asymmetric information, the Modigliani-Miller theory does not hold in the model.

The Bank-Capital Channel: An Illustration

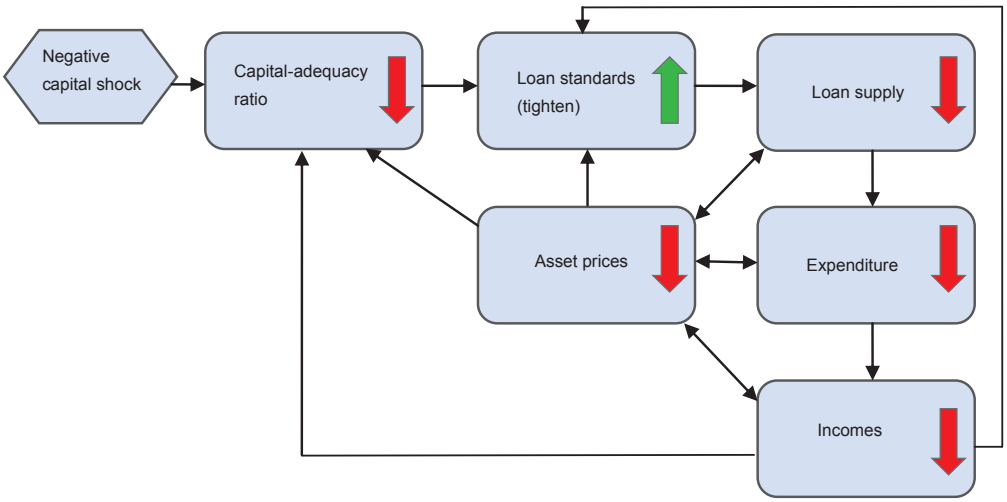
The bank-capital channel is the channel through which monetary policy actions or other shocks affect bank lending by their impact on bank capital. Van den Heuvel (2007a) was one of the first authors to highlight this channel in the context of the monetary policy transmission mechanism. Shocks to aggregate demand and supply, as well as conditions in real estate markets, may influence loan losses (or loan values) and, if not buffered by profits, can affect the level of bank capital. Adverse (favourable) shocks to the balance sheets of banks or financial institutions can entail sharp contractions (expansions) in credit, which can in turn magnify the effects of such shocks on output and inflation (**Figure A**). For example, after negative shocks, banks deleverage by reducing bank lending, which is achieved by tightening their loan standards and increasing credit spreads.

Two broad factors contribute to the strength of this channel. First, some borrowers are highly dependent on banks or financial institutions for credit. This dependence implies that if the supply of bank loans is severely disrupted, these borrowers face sizable difficulties and costs in finding and forming relationships with new lenders, and must therefore curtail their expenditures. The second factor is the difficulty that banks face in trying to fully insulate their supply of lending in response to such shocks, given the difficulty of raising capital, especially in times of financial stress. The costs of raising capital can come, for example, from adverse-selection problems and possible pecuniary costs associated with share purchases and equity issuances (Jermann and Quadrini forthcoming).

The bank-capital channel resembles the theory of the financial-accelerator mechanism (Bernanke, Gertler and Gilchrist 1999; Kiyotaki and Moore 1997). But they are inherently different: the bank-capital channel focuses on how the balance sheets of banks constrain the supply of credit, while the financial-accelerator mechanism focuses on how the balance sheets of the ultimate borrowers constrain the amount they are able to borrow.

Although this article does not aim to explain the recent subprime-mortgage market crisis, it is interesting to observe that the bank-capital channel studied here can qualitatively replicate some of the broad dynamics of the recent crisis. For example, the fall in the perceived quality of banks causes a prolonged deterioration in bank capital, a tightening of loan standards, a rise in credit spreads, a fall in bank lending, and a subsequent persistent drop in output. The model, however, is silent on the role of liquidity problems in the severity of the crisis.

Figure A: Illustration of how a shock to bank capital affects the economy



Source: Adapted from Bayoumi and Melander (2008)

capital when negative shocks arise and continue operating with less pressure to reduce assets. In the exercises that follow, the time-varying capital requirement is adjusted in response to the credit gap (deviation of private credit-to-GDP ratio from its long-run trend). The Basel Committee on Banking Supervision recently advocated the credit gap as a useful indicator of financial vulnerability.[8]

The Importance of the Bank-Capital Channel in the Amplification and Propagation of Shocks

To isolate the role of bank capital in the transmission of shocks we conduct a hypothetical policy experiment, comparing the economic responses following adverse economic shocks under two scenarios. The first scenario features an active bank-capital channel, where endogenous movements in bank capital affect the amount of loans made.[9] The second scenario is similar to the first, except that the bank-capital channel is turned off by removing the asymmetric-information problem between bankers and their creditors. In this experiment, the capital requirement is market determined (Meh and Moran 2010). The results of this policy experiment are illustrated in **Chart 1**, which presents the effects of a one-standard-deviation adverse shock to productivity.[10]

Based on a reasonable calibration, the key result is that the bank-capital channel amplifies and propagates the effect of shocks on output, investment, bank lending and inflation. Indeed, when the bank-capital channel is active, the peak decline in bank lending is twice as large, and the decline in output is much more pronounced. Further, the adverse productivity shock has longer-lasting effects on the economy: under an active bank-capital channel, it takes about 13 quarters for the impact of the shock on bank lending and output to bottom out, as opposed to 8 quarters otherwise. Moreover, the upward pressure on inflation that typically results from an adverse productivity shock is markedly higher when the bank-capital channel is present than when it is not. This is because the decrease in bank lending is greater in the presence of the bank-capital channel, and this in turn compounds the effects on output and inflation. These results are broadly consistent with empirical evidence.[11]

The bank-capital channel amplifies and propagates the effect of shocks on output, investment, bank lending and inflation

The amplification of shocks through the bank-capital channel results primarily from the emergence of feedback effects. After a disturbance that causes a decrease in economic performance, such as a productivity shock, an adverse feedback loop emerges, where falling profitability and asset values lead to increased loan losses in the banking sector. The loan losses cause a decline in bank capital, leading the banking sector to face more-stringent conditions in its own funding markets. This disruption in financial intermediation leads to a further drop in output, investment and asset prices.

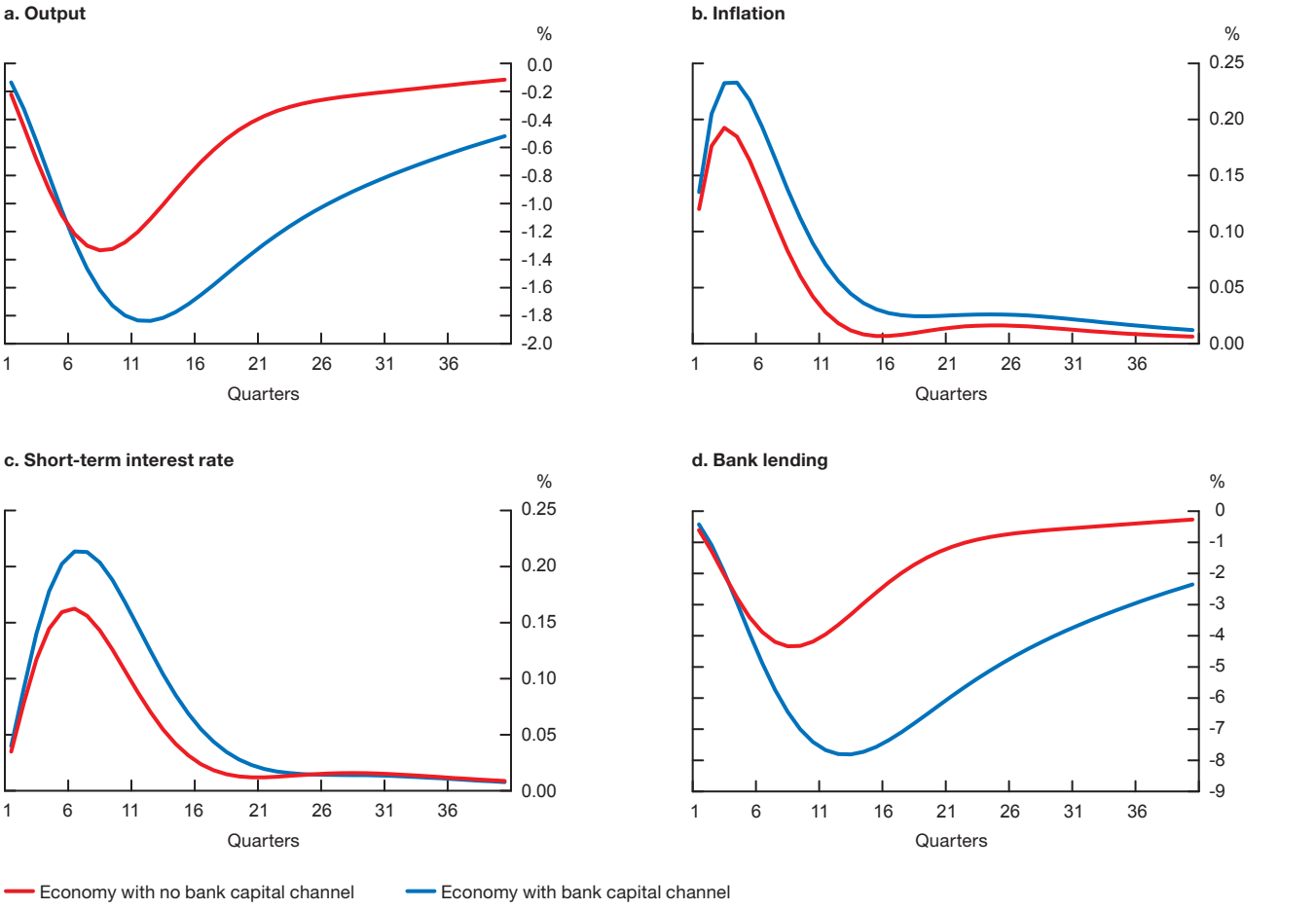
8 For simplicity, the countercyclical capital buffers in the model depend only on the credit gap. In practice, they may depend on other variables, such as asset prices and credit spreads, and be activated only occasionally (Chen and Christensen 2010).

9 This is the baseline economy in Meh and Moran (2010). The monitoring cost, which dictates the degree of asymmetric information between bankers and their creditors, is calibrated to be in the range of the estimate of the ratio of bank operating costs to bank assets for developed economies (Erosa 2001). For further details on the calibration, see Meh and Moran (2010).

10 The size of the shock measured in percentage points is the same under the two scenarios. The monetary policy rule is assumed to remain the same under the two scenarios.

11 Peek and Rosengren (1997, 2000) show that decreases in the capitalization of Japanese banks in the late 1980s adversely affected economic activity in regions where these banks had a major presence. Moreover, bank-level data (Kishan and Opiela 2000; Van den Heuvel 2007b) indicate that poorly capitalized banks reduce lending more significantly following monetary policy contractions. Finally, Van den Heuvel (2002) shows that U.S. states with banking systems that are less capitalized are more sensitive to monetary policy shocks.

Chart 1: Economic response to an adverse productivity shock in the presence of the bank-capital channel
Deviation from steady state



Source: Adapted from Meh and Moran (2010)

The Impact of a Shock to Bank Capital on Economic Activity

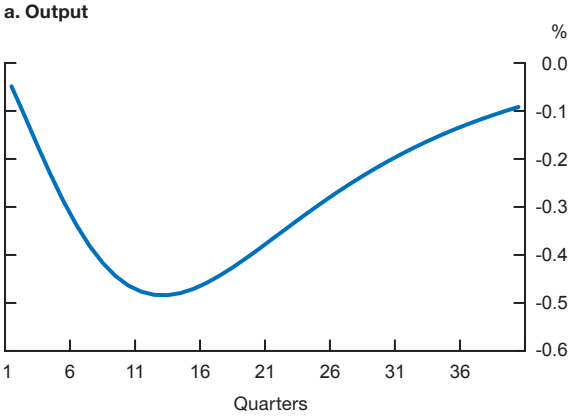
We now consider the effects of a financial shock that decreases the net worth of banks. Such a shock could result from a fall in the perceived quality of their assets (Gertler and Karadi 2011). In the following experiment, the size of the shock is a 5 per cent decline in asset quality to roughly match the broad dynamics of the U.S. subprime-mortgage shock. The results are displayed in **Chart 2**.

The key finding from this policy experiment is that shocks originating in the banking sector can have significant and long-lasting macroeconomic effects. As illustrated in **Chart 2**, the sudden deterioration of bank capital causes a decline in banks' capital-asset ratios. To restore these ratios to their targeted levels, banks endogenously deleverage by tightening loan standards, which leads to a decrease in lending.

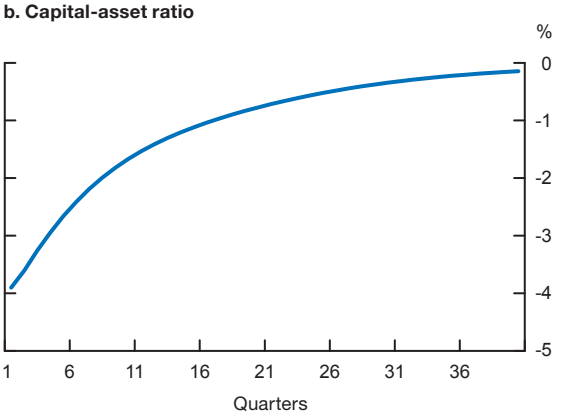
The resulting "credit crunch" directly affects investment expenditure within the economy, and asset prices come under pressure. The reduction in investment spending and asset prices leads to a reduction in incomes (household income, aggregate output and business profits) through standard economic multiplier effects and wealth effects. These negative impacts then affect loan values and bank capital, sparking a further round of deleveraging. Thus, because of this adverse feedback loop, the final effect of a negative shock to banks' balance sheets on aggregate economic activity can be significantly and persistently larger than the initial direct effect.

Chart 2: Economic response to a negative shock to bank capital
Deviation from steady state

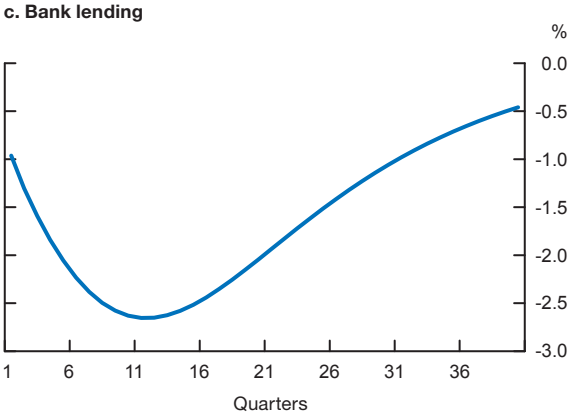
a. Output



b. Capital-asset ratio



c. Bank lending



Source: Adapted from Meh and Moran (2010)

Economic Response to Shocks and the Capitalization of the Banking System

The previous sections show that endogenous movements in bank capital amplify and prolong the adverse effects of shocks on the economy. The following question then emerges: Can a high level of bank capital mitigate this amplification mechanism when the bank-capital channel is active?

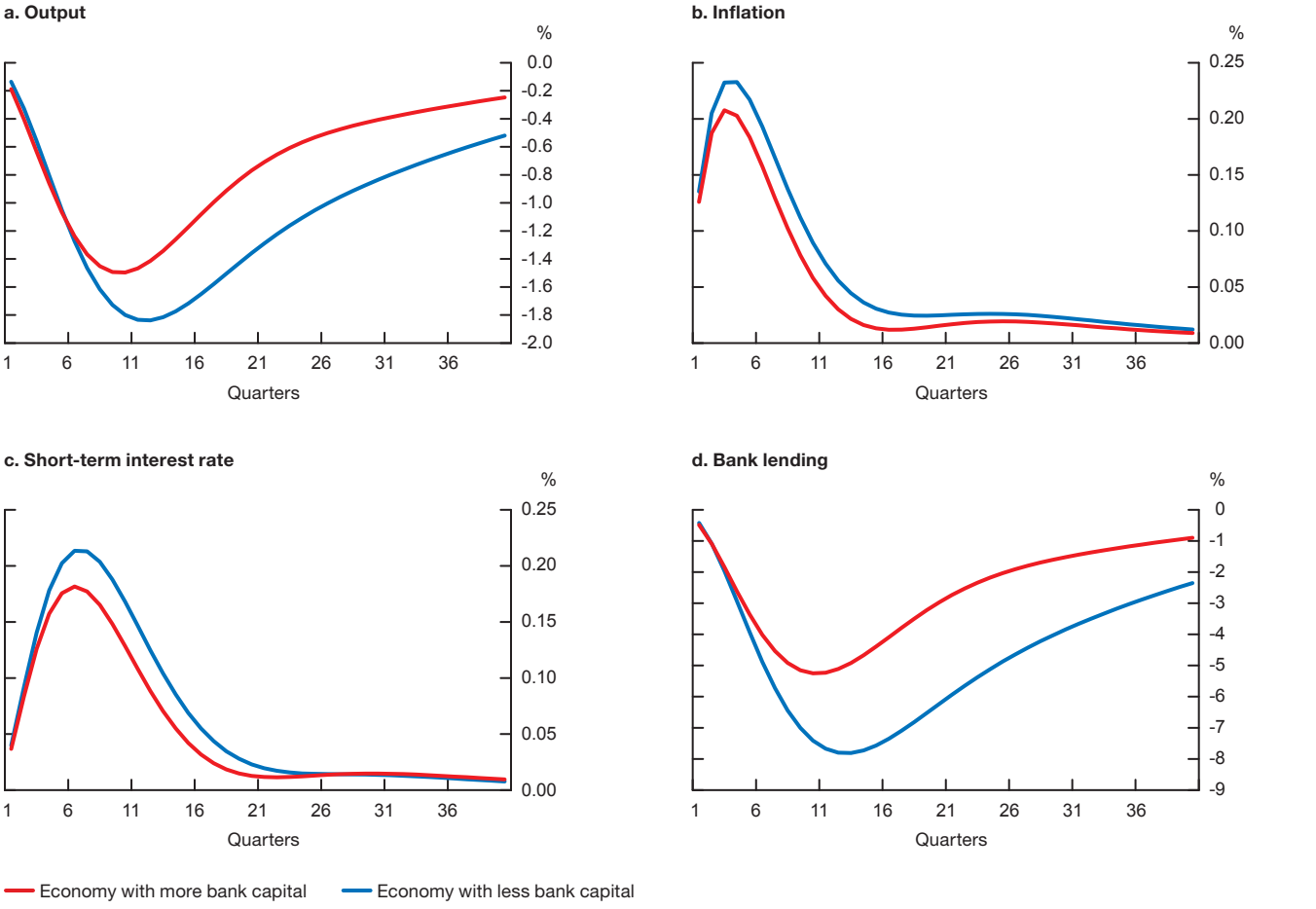
To examine this question, we conduct a third policy experiment, contrasting the responses to shocks when the banking sector has more capital with those when the banking sector has less capital (baseline in the previous sections). The capital-asset ratio in the banking sector with more capital is set exogenously to be twice as large as that in the banking sector with lower capital.[12] The monetary policy rule is still assumed to be the same for both scenarios. From the results reported in **Chart 3**, the outcome is clear: an economy with a banking system that has more capital is better able to absorb the adverse effects of shocks on bank lending, output and inflation. As illustrated in **Chart 3**, this is because the drop in bank lending after the shock is much smaller in the economy with abundant bank capital. When the banking system has more capital, bank lending and output tend to fall by about 5.2 per cent and 1.5 per cent, respectively, while the fall in bank lending is about one and a half times greater and the decline in output increases to about 1.8 per cent when the banking system is less capitalized.

An economy with a banking system that has more capital is better able to absorb the adverse effects of shocks on bank lending, output and inflation

This finding suggests that higher capital makes the banking sector more resilient to stress and helps dampen the inherent procyclicality of the banking system and broader economic cycles.

12 In this hypothetical case, the banking system is exogenously given capital for a given degree of asymmetric information between banks and their creditors. See Meh and Moran (2010) for a description of this experiment.

Chart 3: Effects of bank capital on the economic response to an adverse productivity shock
Deviation from steady state



Source: Adapted from Meh and Moran (2010)

Countercyclical Capital Buffers and the Transmission Mechanism of Monetary Policy and Other Shocks

The experiments discussed above illustrate that the amplification and propagation effects of the bank-capital channel can be mitigated when the banking system is better capitalized. These results are interesting, since the countercyclical capital buffers approved under Basel III are intended to reduce the procyclicality of the banking system. In doing so, however, countercyclical capital buffers will undoubtedly affect the behaviour of the financial system and, hence, alter the monetary transmission mechanism as well.[13] This section analyzes how countercyclical capital buffers are likely to affect the transmission mechanism of shocks.[14]

In principle, countercyclical capital buffers can have two benefits. First and foremost, they can make financial crises less frequent and less severe if they do occur (BCBS 2010a; Bank of Canada 2010). Second, they can help dampen economic cycles.[15] Since Christensen, Meh and Moran (2010) abstract from modelling the endogenous occurrence of crises, this article focuses only on the second benefit. In the experiments that follow, we

13 Caruana (2011) discusses the conduct of monetary policy in a world with macroprudential policy.
14 Boivin, Lane and Meh (2010) use the same model to examine whether monetary policy should be used to lean against the buildup of imbalances.
15 Carney (2011) reviews the benefits of countercyclical capital buffers and Basel III.

assume that countercyclical capital requirements can range within plus or minus 2 percentage points around a steady-state capital-asset ratio equal to 10 per cent.[16] Then, holding the monetary policy rule unchanged, we compare outcomes in an economy with and without countercyclical capital buffers.

Results suggest that the extent to which countercyclical capital buffers affect the transmission mechanism depends on the nature of the shocks hitting the economy

Results from our model-based simulations suggest that the extent to which countercyclical capital buffers affect the transmission mechanism depends on the nature of the shocks hitting the economy. Consider, for instance, (demand-type) financial shocks that generate simultaneous downward pressures on inflation and credit contractions. An example of such a shock is the exogenous negative shock to bank capital discussed earlier. In this case, countercyclical capital buffers and monetary policy reinforce each other to simultaneously achieve macroeconomic and banking stability. This is illustrated in **Chart 4**. Countercyclical capital buffers help to dampen the decline in bank lending; therefore, a smaller decrease in the interest rate is needed to stabilize inflation and output than in the case with no countercyclical capital buffers. This arises since bank lending, output and inflation all move in the same direction in response to the financial shock. As a result, the policy actions required to stabilize the economy are associated with a loosening of both the countercyclical capital buffer and monetary policy. There is thus no inherent trade-off between countercyclical capital buffers and monetary policy when the underlying financial shocks act like demand-type shocks.

However, when the underlying shocks affecting the economy are (supply-type) financial shocks that cause credit contractions and upward inflation pressures, the effort to stabilize the banking system through countercyclical capital buffers may pose some challenges to the price-stability objective. For instance, excessive pessimism about future productivity could lead to credit contractions while, at the same time, putting upward pressures on inflation (Lorenzoni 2008). This is illustrated in **Chart 5**. Stabilizing credit growth after an adverse productivity shock therefore calls for a looser countercyclical capital buffer. But loosening the countercyclical buffer puts additional upward pressure on inflation, making it even harder for monetary policy to control inflation.[17] Indeed, in this case, **Chart 5** shows that, in the presence of countercyclical buffers, the interest rate must be increased more aggressively to combat inflation than in a world without countercyclical capital buffers.

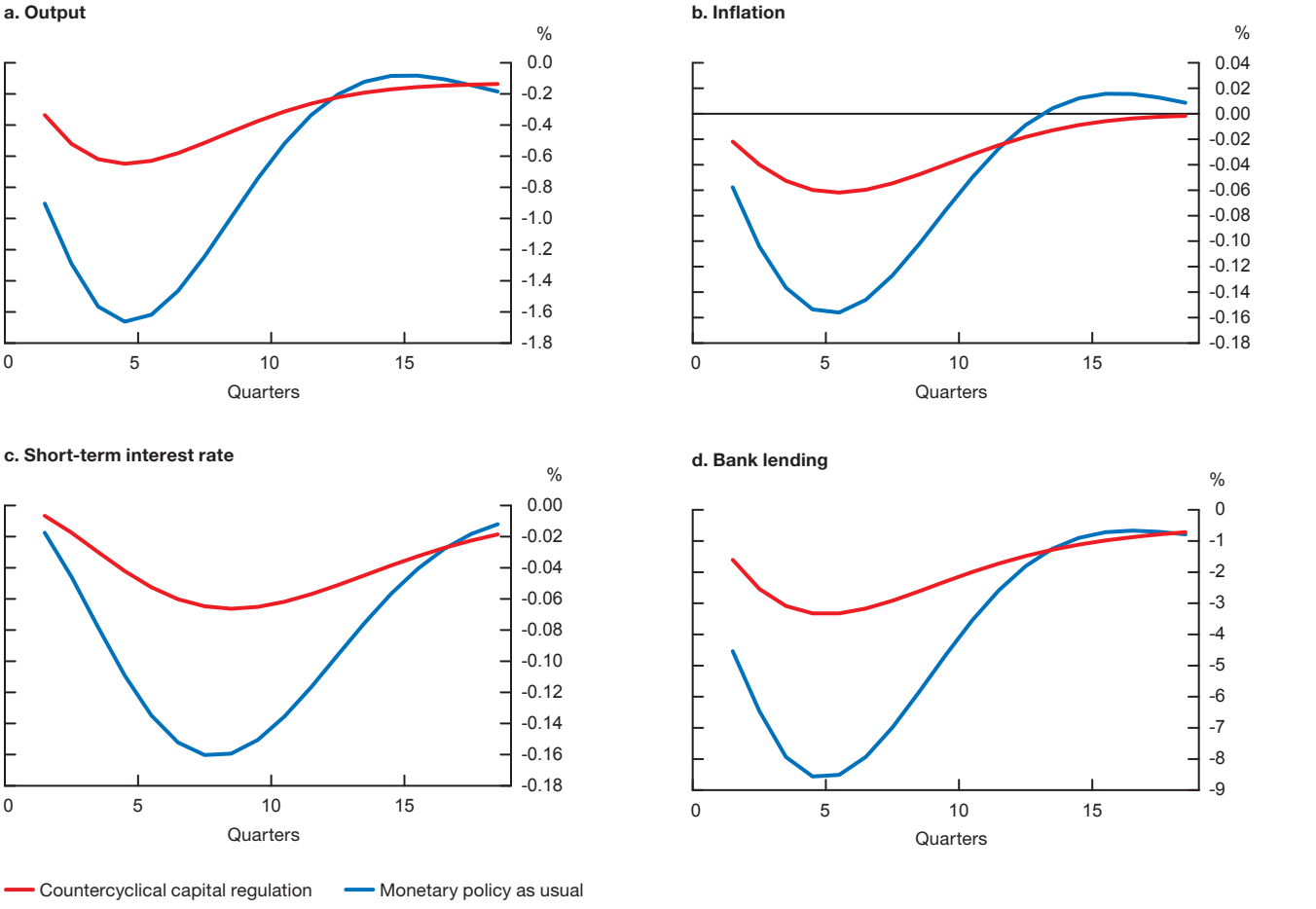
Overall, these results suggest that the impact of countercyclical capital buffers on the transmission mechanism of monetary policy and, consequently, the nature of the coordination between these two tools, depend on the nature of the shocks experienced by the economy. Demand-type financial shocks pose no inherent trade-offs between stabilizing credit and achieving price stability. In this case, the use of countercyclical capital buffers eases the pressure on monetary policy, and less-aggressive movements in the interest rate would be required to achieve economic stability. Supply-type financial shocks, however, can generate a tension between stabilizing credit and price stability. In this case, activating countercyclical capital buffers could make it harder to stabilize inflation, and more-aggressive movements in the interest rate would be required. Under such circumstances, proper coordination between the two policy instruments will lead to a better policy outcome.[18]

16 This range is broadly in line with the range of 0 to 2.5 per cent for the countercyclical capital buffer recently announced by the regulators (BCBS 2010b).

17 Loosening the countercyclical capital buffer can cause additional inflation because such loosening increases credit, which, in turn, leads to a rise in aggregate demand, causing a further rise in inflation.

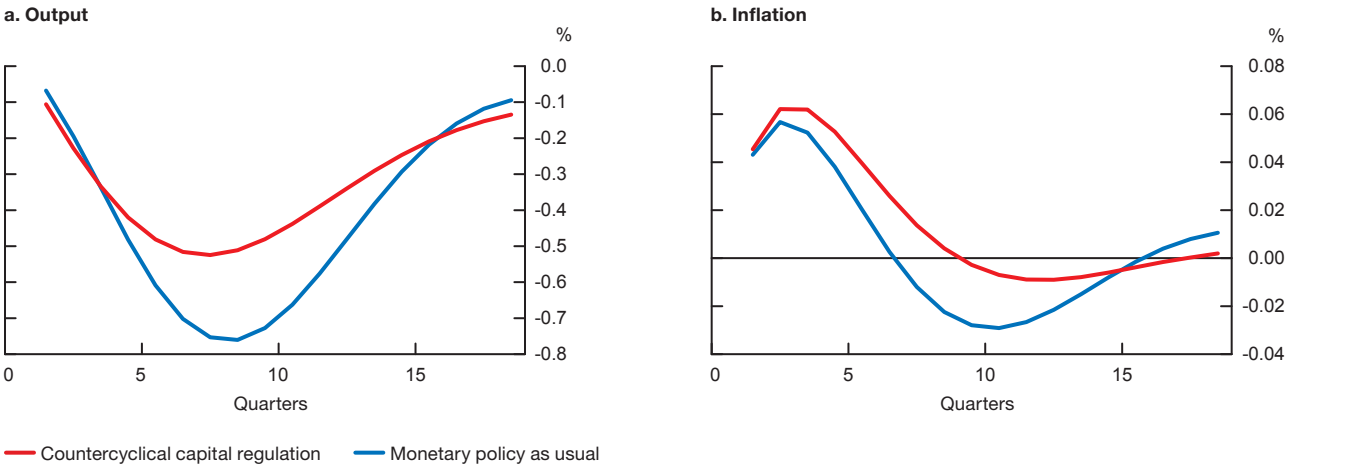
18 Countercyclical capital buffers should be considered neither a substitute for monetary policy nor an all-purpose stabilization instrument. Rather, they should be viewed as a useful complement to monetary policy in a world in which financial shocks have become an important source of economic fluctuations.

Chart 4: Effects of countercyclical capital requirements following a negative shock to bank capital
Deviation from steady state



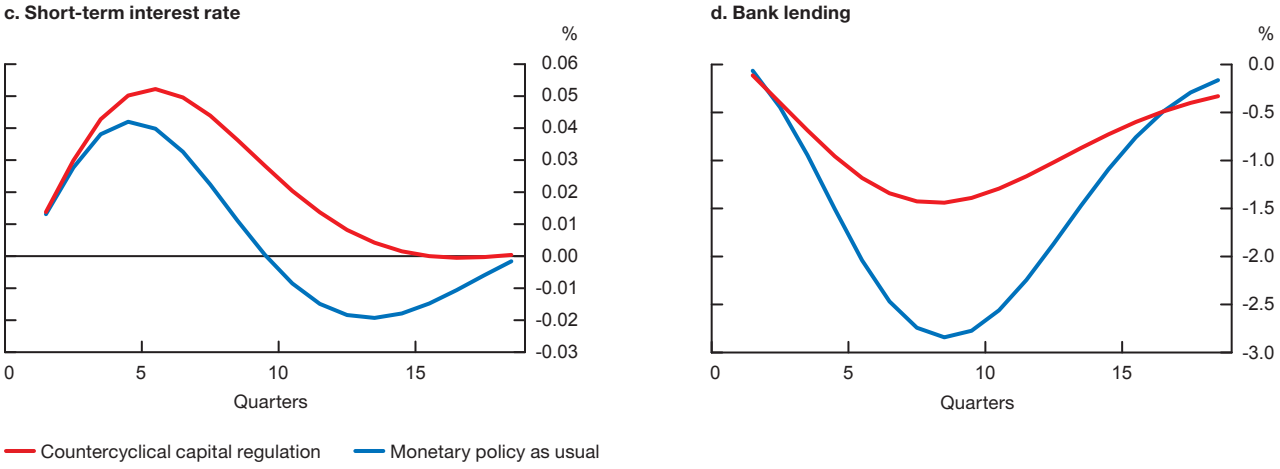
Source: Adapted from Christensen, Meh and Moran (2010)

Chart 5: Effects of countercyclical capital requirements following an adverse productivity shock
Deviation from steady state



Source: Adapted from Christensen, Meh and Moran (2010)

Chart 5: Effects of countercyclical capital requirements following an adverse productivity shock (cont'd)
Deviation from steady state



Source: Adapted from Christensen, Meh and Moran (2010)

Conclusion

The depletion of bank capital and the subsequent deleveraging by banks played an important role in the severity of the recent global financial crisis. To understand the mechanism behind these phenomena, this article presents a simple macroeconomic framework in which bank capital emerges as the solution to an asymmetric-information problem between banks and their creditors. One finding is that a more-capitalized banking system is better able to absorb the effects of shocks on bank lending and the economy. Furthermore, countercyclical capital buffers can increase the resilience of the banking system to adverse shocks, but, in doing so, they also alter the transmission mechanism of shocks and monetary policy to the broader economy.

Although the research discussed in the article provides important policy insights, it also abstracts from elements that can be important in understanding the role of bank capital in the transmission mechanism, as well as the implications of countercyclical capital buffers for monetary policy. Further research will be needed to improve our understanding of these issues. For example, more work is required on introducing crisis dynamics and the resulting non-linearities in macroeconomic models.[19] Another area that needs further work is the interaction between various macroprudential tools and their implications for monetary policy and the transmission mechanism. For instance, what are the interactions between countercyclical capital buffers and more-targeted macroprudential instruments, such as the loan-to-value ratio for mortgages? And what are the implications of such interactions for monetary policy? Finally, another important area of future research will be to improve our understanding of the determinants of liquidity and of the interaction between liquidity and the capital positions of financial intermediaries.

19 Woodford (2010) took an interesting first step by introducing an endogenous probability of crisis in standard macroeconomic models. This reduced-form probability of crisis depends on leverage. See also Brunnermeier and Sannikov (2011) who examine endogenous risk taking in a macroeconomic model with banking.

Literature Cited

Aikman, D. and G. Vlieghe. 2004. "How Much Does Bank Capital Matter?" *Bank of England Quarterly Bulletin* (Spring): 48–58.

Angelini, P., S. Neri and F. Panetta. 2011. "Monetary and Macroprudential Policies." Bank of Italy Working Paper No. 801.

Bank for International Settlements (BIS). 2010. "Assessing the Macroeconomic Impact of the Transition to Stronger Capital and Liquidity Requirements." Macroeconomic Assessment Group Interim Report (August).

Bank of Canada. 2010. "Strengthening International Capital and Liquidity Standards: A Macroeconomic Impact Assessment for Canada." Bank of Canada Report (August).

Basel Committee on Banking Supervision (BCBS). 2010a. "An Assessment of the Long-Term Economic Impact of Stronger Capital and Liquidity Requirements." LEI Report (August).

——— 2010b. "Guidance for National Authorities Operating the Countercyclical Capital Buffer." (December).

Bayoumi, T. and O. Melander. 2008. "Credit Matters: Empirical Evidence on U.S. Macro-Financial Linkages." IMF Working Paper No. WP/08/169.

Bernanke, B., M. Gertler and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." In *Handbook of Macroeconomics*, edited by J. Taylor and M. Woodford. Amsterdam: North-Holland.

Boivin, J., M. Kiley and F. Mishkin. 2010. "How Has the Monetary Transmission Mechanism Evolved Over Time?" NBER Working Paper No. 15879.

Boivin, J., T. Lane and C. Meh. 2010. "Should Monetary Policy Be Used to Counteract Financial Imbalances?" *Bank of Canada Review* (Summer): 23–36.

Brunnermeier, M. and Y. Sannikov. 2011. "A Macroeconomic Model with a Financial Sector." Princeton University. Manuscript.

Carney, M. 2011. "Countercyclical Capital Buffers and Basel III." In "Regulatory Reforms and Remaining Challenges." Group of Thirty Occasional Paper No. 81: 7–14.

Caruana, J. 2011. "Monetary Policy in a World with Macroprudential Policy." Speech at the SAARCFINANCE Governors' Symposium 2011, Kerala, India, 11 June.

Chen, D. and I. Christensen. 2010. "The Countercyclical Bank Capital Buffer: Insights for Canada." Bank of Canada *Financial System Review* (December): 29–34.

Christensen, I. 2011. "Mortgage Debt and Procyclicality in the Housing Market." *Bank of Canada Review* (this issue): 35–42.

Christensen, I., C. Meh and K. Moran. 2010. "Bank Leverage Regulation and Macroeconomic Dynamics." Bank of Canada and Université Laval. Manuscript.

Christiano, L., M. Eichenbaum and C. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113 (1): 1–45.

de Resende, C. and R. Lalonde. 2011. "The BoC-GEM-Fin: Banking in the Global Economy." *Bank of Canada Review* (this issue): 11–21.

Dib, A. 2010. "Banks, Credit Market Frictions, and Business Cycles." Bank of Canada Working Paper No. 2010–24.

Erosa, A. 2001. "Financial Intermediation and Occupational Choice in Development." *Review of Economic Dynamics* 4 (2): 303–34.

Gertler, M. and P. Karadi. 2011. "A Model of Unconventional Monetary Policy." *Journal of Monetary Economics* 58 (1): 17–34.

Holmstrom, B. and J. Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics* 112 (3): 663–92.

Iacoviello, M. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review* 95 (3): 739–64.

Jermann, U. and V. Quadrini. Forthcoming. "Macroeconomic Effects of Financial Shocks." *American Economic Review*.

Kishan, R. and T. Opiela. 2000. "Bank Size, Bank Capital, and the Bank Lending Channel." *Journal of Money, Credit and Banking* 32 (1): 121–41.

Literature Cited (cont'd)

Kiyotaki, N. and J. Moore. 1997. "Credit Cycles." *Journal of Political Economy* 105 (2): 211–48.

Lorenzoni, G. 2008. "Inefficient Credit Booms." *Review of Economic Studies* 75 (3): 809–33.

Meh, C. and K. Moran. 2010. "The Role of Bank Capital in the Propagation of Shocks." *Journal of Economic Dynamics and Control* 34 (3): 555–76.

Peek, J. and E. Rosengren. 1997. "The International Transmission of Financial Shocks: The Case of Japan." *American Economic Review* 87 (4): 495–505.

———. 2000. "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States." *American Economic Review* 90 (1): 30–45.

Van den Heuvel, S. 2002. "Banking Conditions and the Effects of Monetary Policy: Evidence from U.S. States." Wharton School. Manuscript (January).

———. 2007a. "The Bank Capital Channel of Monetary Policy." Wharton School. Manuscript (June).

———. 2007b. "Do Monetary Policy Effects on Bank Lending Depend on Bank Capitalization?" Wharton School. Manuscript (September).

———. 2008. "The Welfare Cost of Bank Capital Requirements." *Journal of Monetary Economics* 55 (2): 298–320.

Woodford, M. 2010. "Inflation Targeting and Financial Stability." Columbia University. Manuscript.

Mortgage Debt and Procyclicality in the Housing Market

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- *Housing market booms and busts have occurred in a number of advanced economies and were frequently associated with rising leverage. These boom-busts misallocate resources and lead to large losses on the balance sheets of households and financial institutions. Policy-makers and regulators are keenly interested in understanding how these booms and busts emerge and how public policy might dampen or prevent them.*
- *Rising house prices increase the value of the main form of household collateral. Some households subsequently increase their borrowing and spending on housing and non-housing consumption. The higher demand for housing leads to further increases in house prices since the supply of housing is slow to adjust. This mechanism amplifies developments in housing markets (procyclicality) and is an important ingredient in the emergence of booms and busts.*
- *Research from a number of countries suggests that the setting of the maximum limit on the loan-to-value (LTV) ratio on a residential mortgage could help to moderate procyclical movements in house prices and housing market activity.*
- *Models developed at the Bank of Canada and elsewhere allow researchers to examine the link between the level of the LTV ratio and the degree of procyclicality in the housing market. They demonstrate that an LTV ratio set at a lower level would dampen procyclicality. Varying the LTV ratio for mortgages countercyclically could mitigate procyclicality even further.*

In the aftermath of the financial crisis, much attention has been focused on the role of mortgage finance in house-price dynamics.[1] The subprime-mortgage crisis that began in 2007 in the United States is an extreme example of how easing financing conditions can amplify a housing market boom and leave the financial system highly vulnerable to a bust in house prices.[2] Boom-bust cycles in real estate markets are a common precursor to banking crises in advanced and emerging economies (Reinhart and Rogoff 2009); the most severe and costly busts, in terms of lost gross domestic product (GDP), arise when the real estate boom is associated with the increased leverage of households and financial institutions (Crowe et al. 2011). Claessens, Kose and Terrones (2008) show that recessions that coincide with housing busts tend to last longer and be deeper than recessions where no housing bust has occurred. They find that, on average, the cumulative loss to GDP is roughly three times as large when a housing bust coincides with a recession. The high macroeconomic costs of a bust are due to the relatively high direct exposure of the financial system to real estate and to the resulting knock-on effects of financial system losses to the rest of the economy.

A rising supply of credit, often caused by some form of financial liberalization or technological innovation, is a characteristic feature of a real estate boom. A key mechanism for the boom is feedback between rising house prices and household debt that is created because homeowners are able to use their houses as collateral. Rising house prices increase the value of a household's collateral and expand the capacity of households to accumulate debt. If new debt leads to further spending on real estate,

1 Similar concerns exist for commercial real estate.
2 Other notable examples are the boom-bust cycles in the Nordic countries and the United Kingdom between the mid-1980s and early 1990s and, more recently, in the United Kingdom and Spain.

house prices rise, completing the feedback loop. The presence of this effect is associated with greater procyclicality in the housing market. In addition, some portion of this increased debt capacity may also finance non-housing consumption. In this case, higher household indebtedness increases the risk of default when income falls during the bust phase of the cycle. Other factors that are likely to reinforce the procyclical movements of house prices are positive views on the outlook for the economy and the presence of capital inflows from abroad that amplify the boom (Tomura 2010).

In an effort to reduce procyclicality in real estate markets and the magnitude of booms and busts, a number of countries have altered key elements in their regulation of housing finance (CGFS 2010; Wong et al. 2011). Many more are considering such measures (FSB 2011). One area of focus is the appropriate setting of the upper cap or maximum loan-to-value (LTV) ratio, which defines the minimum down payment required to obtain a mortgage for a house purchase. A high LTV ratio allows the borrower to tap into more debt for a $1 rise in collateral value. This article examines a maximum LTV ratio on mortgages through the lens of a model developed in Christensen et al. (2009) and Christensen and Meh (forthcoming). This model provides an environment in which to examine mortgage market regulation, because it features a housing market and borrowing-constrained households that can borrow up to a specified fraction of the value of their real estate wealth.

In an effort to reduce procyclicality in real estate markets, a number of countries have altered key elements in their regulation of housing finance

The article begins with a description of the evidence linking housing booms and procyclicality to rising household credit and leverage. It then reviews some of the policies being considered to dampen boom-bust cycles in real estate, notably the LTV ratio on mortgages. The model is then described and used to consider how permanent changes in the LTV ratio alter the feedback effects associated with procyclicality and the effect of reducing the maximum LTV ratio in the face of a rising credit supply.

Housing Booms and the LTV Ratio in Canada

Canada has not been a stranger to real estate booms and busts in the past: one occurred in the mid-1970s and another in the late 1980s (Ahearne et al. 2005). Both had long-lasting impacts on the balance sheets of Canadian financial intermediaries. In fact, the large losses on mortgage loans that trust companies experienced during the 1980s were one of the factors that led to their ultimate demise. The impact on the financial system reflects its exposure to real estate. Since the late 1960s, mortgages and other debt secured by real estate have averaged more than 35 per cent of total private sector credit outstanding, and this share has risen over time to its current level of more than 57 per cent.[3]

Over the past three years, the Government of Canada has adopted a number of changes to the rules for government-backed insured mortgages,[4] with the objective of supporting "the long-term stability of Canada's housing market"[5] and "to help prevent Canadian households from getting overextended, and acting to prevent some lenders from facilitating [this]."[6] These changes have resulted in lower maximum LTV ratios of 95 per cent for new government-backed insured mortgages, 85 per cent for mortgage refinancing, and 80 per cent for non-owner-occupied properties. These changes follow a relaxation of the first two rules between 2004 and 2007.

Allen (2010–11) shows that from 1999 to 2004 most households with insured mortgages borrowed up to, or near, the maximum LTV ratio available at the time they purchased a home. Thus, in that period, the typical LTV ratio for a newly issued insured mortgage was in the range of 90 to 95 per cent. This suggests that changes to the maximum LTV ratio could have significant effects on housing markets.

3 This includes residential and non-residential mortgages and lines of credit secured by real estate. The share is a proportion of credit outstanding and excludes equity, warrants and trust units. All data are from the *Bank of Canada Banking and Financial Statistics*. If we exclude insured mortgages, for which the banks do not bear the losses from default, this number is about 48 per cent in the first quarter of 2011. This measure does not include direct exposures to construction and building-sector loans.

4 In Canada, the Bank Act states that federally regulated financial institutions cannot offer mortgages with an LTV ratio higher than 80 per cent, unless that mortgage is insured by a government agency (Canada Mortgage and Housing Corporation) or private insurer. Mortgage insurance backed by the federal government is available for mortgages with LTV ratios up to 95 per cent.

5 Government of Canada, press release, 17 January 2011.

6 Government of Canada, press release, 16 February 2010.

Mortgage Finance and Procyclicality: Selected Evidence

Research from a number of countries finds an important relationship between mortgage finance and developments in the housing market—a critical link in the U.S. subprime-mortgage crisis, as well as the boom and bust in the United Kingdom (FSB 2011).

Empirical evidence confirms the importance of mortgage market rules for macroeconomic fluctuations. Almeida, Campello and Liu (2006) show that countries with high maximum LTV ratios are those in which house prices and the demand for new mortgage borrowing are most sensitive to income shocks (i.e., procyclicality is the strongest). Lamont and Stein (1999) have similar findings for U.S. cities with a large proportion of highly leveraged (high LTV ratio) households.

Studies based on microdata have also investigated the link between housing finance and household behaviour. Using U.S. credit bureau data and zip-code-level data on house prices, Mian and Sufi (2009a) find evidence that U.S. banks increased the availability of credit to first-time home buyers and that this was a key driver of rising household leverage between 2002 and 2005. In addition, rising house prices allowed existing homeowners to increase their debt levels dramatically (Mian and Sufi 2009b). The authors document that homeowners extracting equity from their homes during the period of rising house prices experienced a jump in default rates as house prices reversed (Mian and Sufi 2009b). This research shows that the feedback effect between house prices and household debt is clearly linked to the degree of vulnerability of the financial system.

Studies suggest that the maximum limit on the LTV ratio could play a role in moderating procyclical movements in house prices and housing market activity

Finally, Ortalo-Magné and Rady (1999) develop a model with young and old households, as well as a property ladder, whereby people seek to move from apartments to houses as they age. A key finding is that the rise in owner occupancy and house prices during the U.K.'s housing boom in the 1980s can be at least partly explained by credit market liberalization, as captured by an increase in the LTV ratio. An alternative hypothesis, that the boom resulted from rising household incomes, cannot explain these facts.

Together, these studies suggest that the maximum limit on the LTV ratio on a residential mortgage could play a useful role in moderating procyclical movements in house prices and housing market activity.

A Model to Capture Links Between Housing Finance and the Real Economy

Christensen et al. (2009) develop and estimate a dynamic stochastic general-equilibrium (DSGE) model for Canada (referred to as CCMN, after the authors' names—Christensen, Corrigan, Mendicino and Nishiyama), featuring borrower and lender households and a housing market. As in Iacoviello (2005), borrowers and lenders are distinguished by their impatience: impatient households seek to consume more today and borrow from patient households. Differing degrees of impatience across household types is a common modelling device to allow borrowing and lending to occur. It captures some of the differences in household behaviour over the life cycle, where impatient households resemble the young, and patient households the old who have accumulated more wealth. Loan contracts in this model specify that borrowers can borrow up to a fraction of the value of their real estate holdings (the LTV ratio). This type of contract often arises in models where the financial friction takes the form of an enforcement problem: lenders require borrowers to post collateral in view of the risk that they may not repay the loan. Importantly, when this collateral constraint is present, rising house prices lead to a higher value of collateral, giving households greater access to credit and allowing them to increase their expenditures on consumption and housing. Christensen et al. (2009) find that this mechanism helps the model to better capture the empirical relationship between the time series data for house prices and consumption.

Like many models of its type, CCMN does not capture the decision of households to default, which is a key element of financial system vulnerability. In contrast to Meh (2011) and de Resende and Lalonde (2011), there is no explicit role in the model for banks to act as intermediaries for credit, since loans are contracts between lender households and

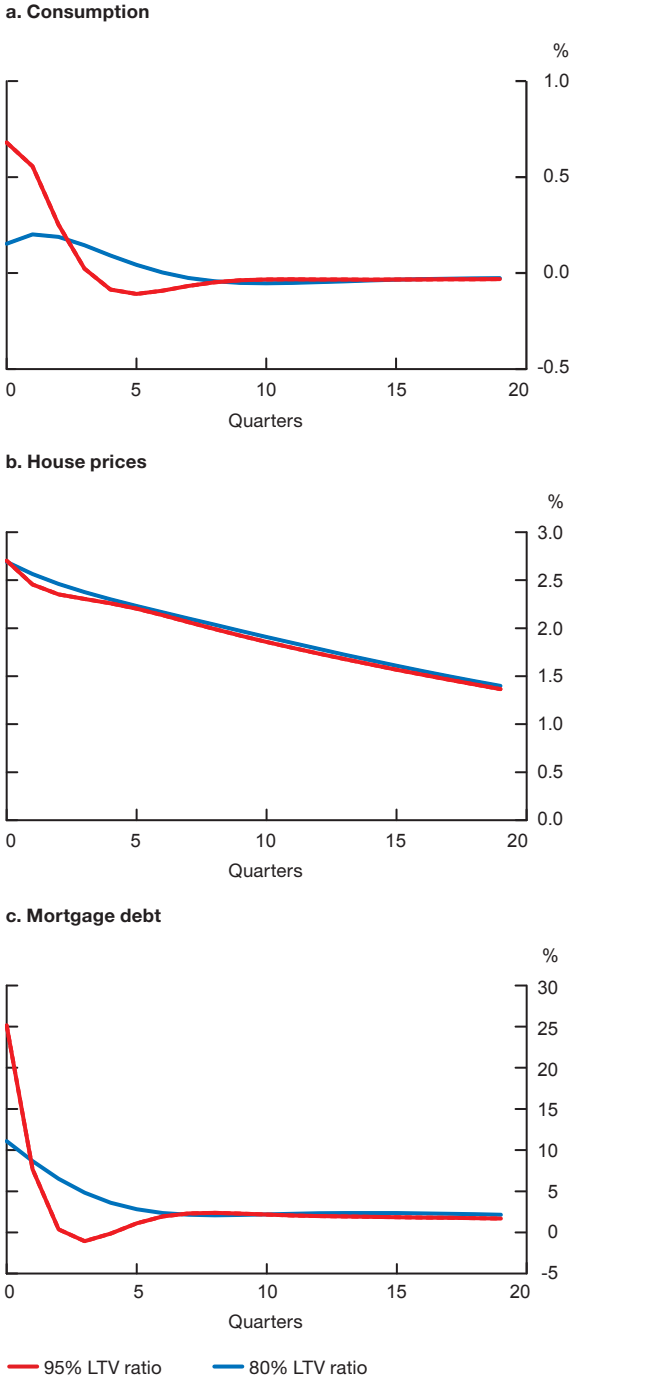
borrowers. Thus, the model does not capture how loan losses can lead to banking sector stresses, tighter lending standards and further amplification during the bust phase of the cycle. Though stylized in these respects, the model does capture the feedback between house prices and household debt accumulation that drives the procyclicality of the housing market and, as noted above, is the motivation for some of the recent changes to housing-finance policy in Canada. The following sections focus on the role that this mechanism plays in the boom phase.

The LTV Ratio and Spillovers from the Housing Market

Given the presence of collateral-constrained households, the level of the LTV ratio on mortgage lending is one factor that determines the extent of procyclicality in the housing market. In this case, it is useful to consider economic shocks that may arise in the housing market itself and lead to changes in the price of housing. For example, a number of researchers have studied the impact of shocks to housing demand on the housing sector and on the overall economy.[7] Iacoviello and Neri (2010) find that housing-demand shocks play an important role in capturing the swings in U.S. house prices in a two-sector monetary DSGE model. Jarociński and Smets (2008) find that this type of shock can account for a significant fraction of the U.S. boom in construction and house prices, but its effect on overall GDP growth and inflation is relatively small.

Chart 1 illustrates the economy's response to a positive shock to housing demand in the CCMN model. This shock is captured as a sudden shift in the desire of households to consume housing services relative to other consumption goods or leisure. It can also be thought of as a rise in the return to residential investment. The higher demand for housing services increases housing investment. However, the stock of housing is slow to adjust, so there is a rise in house prices[8] and, thus, the value of housing that can be posted as collateral.[9] Rising collateral values allow households to borrow more against the equity in their home to finance higher (non-housing) consumption in the short run.

Chart 1: Economic impact of a lower LTV ratio on the volatility of mortgage debt after an increase in the demand for housing
Deviation from steady state



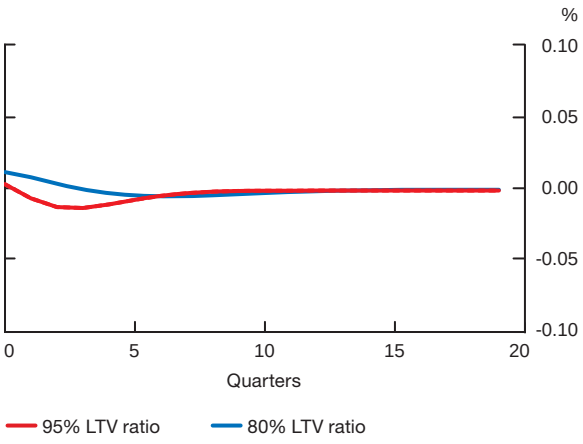
7 Housing-demand shocks are sometimes described as a shift in preferences toward housing services. Iacoviello and Neri (2010) discuss alternative interpretations.

8 Charts 1 and 2 show the price of housing relative to consumer prices.

9 In this example, the persistence of the house-price response is driven primarily by the high estimated persistence of the shock rather than by the intrinsic dynamics of house prices.

Chart 1: (cont'd)
Deviation from steady state

d. Inflation



Borrowing households subsequently reduce their consumption and repay this debt over time.

In the case where the maximum LTV ratio is set to 80 per cent, the model responses suggest that a 1 per cent rise in house prices is associated with an increase of 0.1 per cent in consumption, which is close to the estimates of Iacoviello and Neri (2010) for the United States.[10] In the case where the maximum LTV ratio is 95 per cent, the initial response of consumption is three times larger. **Chart 1** shows that a lower LTV ratio substantially reduces the magnitude of the rise in consumption and household debt in response to a rise in house prices.[11]

A Countercyclical Policy for the LTV Ratio

Recent international discussions have begun to examine the merits of adjusting mortgage market rules over time. For example, country authorities could change the maximum LTV ratio in a countercyclical fashion, lowering it during housing booms and raising it when house prices are depressed.[12] One outcome of this type of policy is an increase in the resilience of the financial system since it requires borrowers to have a larger equity stake in their property during booms, thus reducing the potential losses to financial intermediaries during the bust phase when income and house prices fall. In addition, the lower LTV ratio (higher down payment) would act against the boom in the first place by reducing the extent to which borrowers could extract equity from their homes or take on more leverage to buy a bigger home.

Christensen and Meh (forthcoming) investigate the role of a time-varying maximum LTV ratio in a model based on Christensen et al. (2009).[13] They consider the impact when the public authorities respond to a credit boom by lowering the regulatory maximum LTV ratio below its long-run setting of 80 per cent. The extent of the countercyclical response of the LTV ratio is determined by a regulatory rule that links the change in the LTV ratio to the level of mortgage credit relative to its long-run value.

Housing booms and busts are often attributed, at least in part, to an easing of mortgage-underwriting conditions. We now turn to the case in which lenders themselves supply more credit and consider how the outcome might differ if the LTV ratio was lowered in response.

Christensen and Meh (forthcoming) capture an increase in the availability of credit as an exogenous shift in the lender's perception of the quality of housing collateral. **Chart 2** illustrates the impact of a large shock, which raises the collateral value of a unit of housing by 5 per cent, when the LTV ratio is held constant at 80 per cent. With the increase in availability of debt, borrowers immediately increase their mortgage borrowing and use these funds to increase both consumption and housing expenditures. The shock produces a growth rate of mortgage debt over the first year that is roughly in line with the average annual growth of mortgage debt seen during the housing boom in the United States in 2003–06. House prices rise in response to the increased demand for housing, raising the value of housing collateral and household debt capacity.

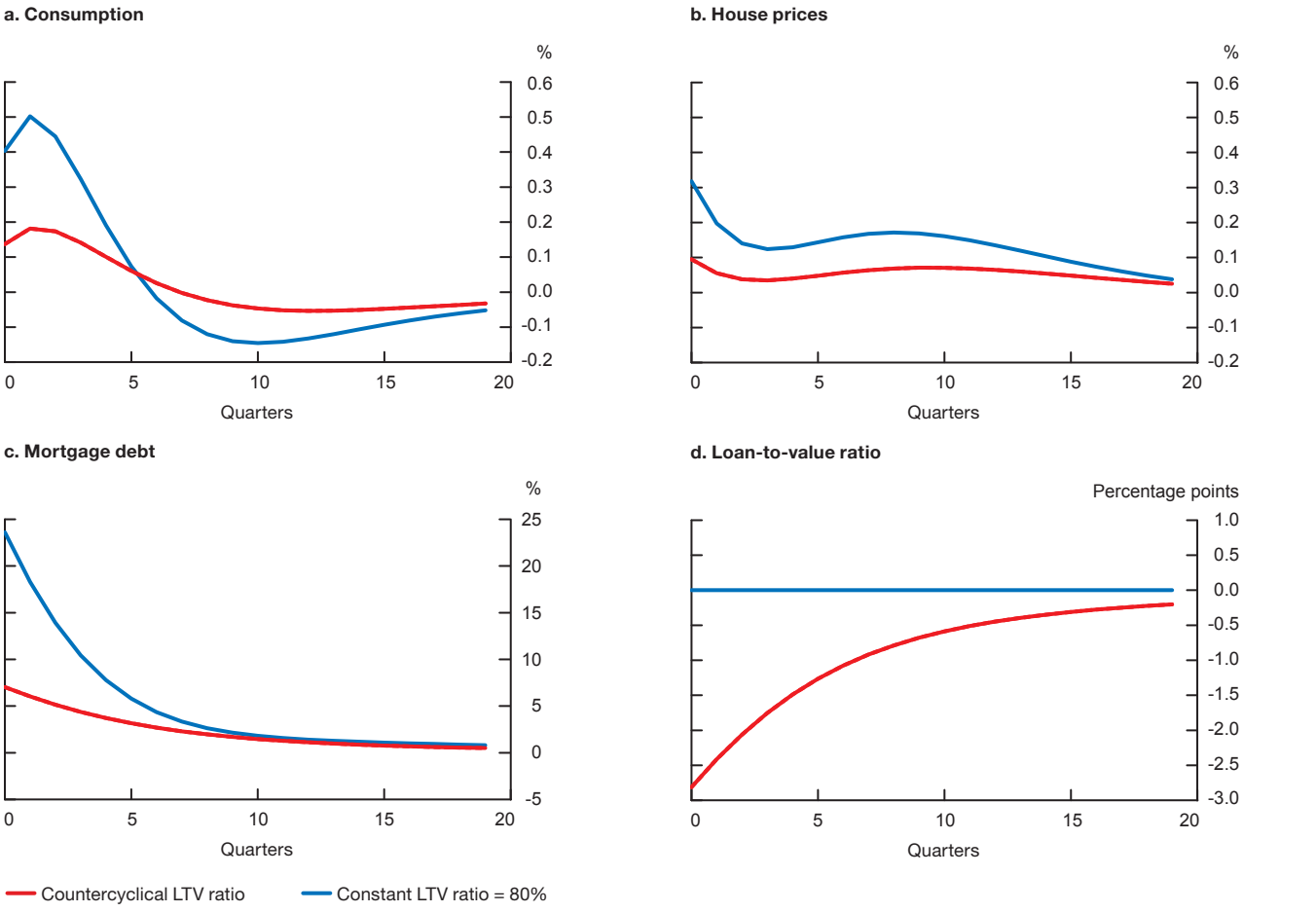
10 In the model of Iacoviello and Neri (2010), the LTV ratio is 85 per cent. Our results are somewhat higher than the marginal propensity to consume from housing wealth for Canada of 5.7 per cent reported in Pichette (2004) and are in the upper range of estimates reported in Flood, Morin and Kolet (2008).

11 The response of house prices to a housing-demand shock is not very sensitive to the level of the LTV ratio in this class of models. Nevertheless, the model captures important effects on quantities of changes in the LTV ratio, as can be seen from the boost to the consumption response of constrained households. Life-cycle effects and different dwelling types, both absent from this model, may be important in capturing larger effects on house prices. For example, if the LTV ratio rises, young households with increased access to credit may bid up the price of starter homes, and this could increase the wealth of others and allow them to move up the property ladder.

12 Changing the capital-adequacy risk weights for residential mortgages is an alternative approach that has been suggested elsewhere (Borio, Furfine and Lowe 2001; Bank of England 2009).

13 Research at other institutions has begun to consider related questions. See Kannan, Rabanal and Scott (2009); Angelini, Neri and Panetta (2011); and Lambertini, Mendicino and Punzi (2011).

Chart 2: Economic impact of a countercyclical maximum LTV ratio after an increase in the availability of credit
Deviation from steady state



A noteworthy feature of this shock and of the housing-demand shock is that there is little impact on consumer price inflation.[14] This is similar to the U.S. situation in the 2003–06 period, when a housing boom took hold but inflation remained subdued.[15] There is only a small impact on inflation because the largest effects are mainly on borrowing-constrained households (a smaller group than lenders) and the housing market (a small sector), and because households supply more labour, which offsets some of the upward pressure on the cost of production.[16] The mild inflationary impact results in little response from policy interest rates. The lack of a rise in interest rates allows mortgage borrowing and house prices to expand more strongly.

Rather than holding the maximum LTV ratios on mortgage loans constant, there is the possibility of varying the maximum LTV ratio to stem the buildup of household debt. **Chart 2** illustrates the responses to the credit-supply shock when the authorities lower the regulatory LTV ratio in response to the observed increase in mortgage credit that accompanies the shock. In this case, the drop in the maximum regulatory LTV ratio, which lasts for about 20 quarters, reduces the surge in mortgage debt by about two-thirds. The rises in house prices and consumption are reduced to about one-third of their peak response. Again, policy interest rates hardly move. In this model, the LTV ratio does not have to adjust by a large magnitude to achieve this dampening of the boom: it is lowered by about 2.8 percentage points

14 The impact would be somewhat higher if the measure of inflation in the model included the direct impact of increases in house prices, as is the case for the Canadian consumer price index.
15 In the United States, offsetting shocks—for example, from lower import prices—also played a role.
16 Households supply more labour because the extra costs of working more hours are outweighed by the benefits from the extra income that can now purchase more housing services than before.

from 80 per cent to just above 77 per cent.[17] In this model, changes to the maximum LTV ratio are a more effective tool to mitigate boom-bust cycles in real estate than monetary policy because they are better targeted at the source of the volatility.

One potentially important limitation to this work is that the mortgages in these models have short maturities and are rolled over more frequently than is the case in practice. The implication is that changes in the regulatory maximum LTV ratio in the model have an impact on the entire stock of mortgages outstanding in every period. Since, in practice, those changes apply only to newly issued or refinanced mortgages, the model will overstate the impact of changes in the LTV ratio on the stock of mortgage debt, consumption and real economic activity.

Concluding Remarks

This article has focused on the role of household leverage and housing collateral in generating procyclicality in the housing market and on the potential use of the LTV ratio—both the level and countercyclical variations—to dampen this cycle. The models discussed take some important steps toward understanding the links between housing finance, financial system vulnerability and real economic activity.

To improve our understanding of the impact of housing-finance policy on the vulnerability of the financial system, future work should seek to explicitly model the link between the mechanisms driving procyclicality and the buildup of vulnerabilities in the financial system. In addition, more explicit account should be taken of how losses at financial intermediaries result in tighter lending standards and amplify the bust phase of the cycle. Ultimately, the evaluation of macroprudential policies must consider the benefits associated with less-frequent crises or busts, as well as any detriments to long-run economic growth from higher costs of financial intermediation.

Future work should seek to explicitly model the link between the mechanisms driving procyclicality and the buildup of vulnerabilities in the financial system

In addition, many practical issues related to the implementation of countercyclical regulatory policies remain to be addressed; for example, under what circumstances should public authorities activate countercyclical policies, and how are they held accountable for achieving the objectives of these policies; which policy tools are most appropriate in a given situation; and what information should form the basis for that decision. These questions are of keen interest to policy-makers and offer fertile ground for future research.

17 In this model, the response of debt and house prices to the shock will rise if the long-run LTV ratio is set higher (e.g., to 95 per cent, as is the case in Chart 1). Nonetheless, a decline in the LTV ratio of 2.8 percentage points produces a similar proportional dampening of house prices and mortgage debt.

Literature Cited

Ahearne, A., J. Ammer, B. Doyle, L. Kole and R. Martin. 2005. "House Prices and Monetary Policy: A Cross-Country Study." Board of Governors of the Federal Reserve System International Finance Discussion Papers No. 841.

Allen, J. 2010–11. "Competition in the Canadian Mortgage Market." *Bank of Canada Review* (Winter): 1–9.

Almeida, H., M. Campello and C. Liu. 2006. "The Financial Accelerator: Evidence from International Housing Markets." *Review of Finance* 10: 321–52.

Angelini, P., S. Neri and F. Panetta. 2011. "Monetary and Macroprudential Policies." Bank of Italy Working Paper No. 801.

Literature Cited (cont'd)

Bank of England. 2009. "The Role of Macroprudential Policy." Bank of England Discussion Paper, 21 November.

Borio, C., C. Furfine and P. Lowe. 2001. "Procyclicality of the Financial System and Financial Stability: Issues and Policy Options." In *Marrying the Macro- and Microprudential Dimensions of Financial Stability*. BIS Papers No. 1.

Christensen, I., P. Corrigan, C. Mendicino and S. Nishiyama. 2009. "Consumption, Housing Collateral, and the Canadian Business Cycle." Bank of Canada Working Paper No. 2009-26.

Christensen, I. and C. Meh. Forthcoming. "Countercyclical Loan-to-Value Ratios and Monetary Policy." Bank of Canada Working Paper.

Claessens, S., M. Kose and M. Terrones. 2008. "What Happens During Recessions, Crunches and Busts?" IMF Working Paper No. WP/08/274.

Committee on the Global Financial System (CGFS). 2010. "Macroprudential Instruments and Frameworks: A Stocktaking of Issues and Experiences." CGFS Papers No. 38.

Crowe, C., G. Dell'Ariccia, D. Igan and P. Rabanal. 2011. "Policies for Macrofinancial Stability: Options to Deal with Real Estate Booms." IMF Staff Discussion Note No. SDN/11/02.

de Resende, C. and R. Lalonde. 2011. "The BoC-GEM-Fin: Banking in the Global Economy." *Bank of Canada Review* (this issue): 11–21.

Financial Stability Board (FSB). 2011. "Thematic Review on Mortgage Underwriting and Origination Practices." Available at <http://www.financialstabilityboard.org/publications/r_110318a.pdf>.

Flood, K., S. Morin and I. Kolet. 2008. "House Prices and Consumer Spending." *Bank of Canada Review* (Summer): 31–44.

Iacoviello, M. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review* 95 (3): 739–64.

Iacoviello, M. and S. Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics* 2 (2): 125–64.

Jarociński, M. and F. Smets. 2008. "House Prices and the Stance of Monetary Policy." European Central Bank Working Paper No. 891.

Kannan, P., P. Rabanal and A. Scott. 2009. "Monetary Policy and Macroprudential Policy Rules in a Model with House Price Booms." IMF Working Paper No. WP/09/251.

Lambertini, L., C. Mendicino and M. Punzi. 2011. "Leaning Against Boom-Bust Cycles in Credit and Housing Prices." Bank of Portugal Working Paper No. 8-2011.

Lamont, O. and J. Stein. 1999. "Leverage and House-Price Dynamics in U.S. Cities." *RAND Journal of Economics* 30 (3): 498–514.

Meh, C. 2011. "Bank Balance Sheets, Deleveraging and the Transmission Mechanism." *Bank of Canada Review* (this issue): 23–34.

Mian, A. and A. Sufi. 2009a. "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis." *Quarterly Journal of Economics* 124 (4): 1449–96.

———. 2009b. "House Prices, Home-Equity-Based Borrowing, and the U.S. Household Leverage Crisis." NBER Working Paper No. 15283.

Ortalo-Magné, F. and S. Rady. 1999. "Boom In, Bust Out: Young Households and the Housing Price Cycle." *European Economic Review* 43 (4-6): 755–66.

Pichette, L. 2004. "Are Wealth Effects Important for Canada?" *Bank of Canada Review* (Spring): 29–35.

Reinhart, C. and K. Rogoff. 2009. *This Time is Different: Eight Centuries of Financial Folly*. Princeton, New Jersey: Princeton University Press.

Tomura, H. 2010. "International Capital Flows and Expectation-Driven Boom-Bust Cycles in the Housing Market." *Journal of Economic Dynamics and Control* 34 (10): 1993–2009.

Wong, E., T. Fong, K.-F. Li and H. Choi. 2011. "Loan-to-Value Ratio as a Macroprudential Tool—Hong Kong's Experience and Cross Country Evidence." Hong Kong Monetary Authority Working Paper No. 01/2011.

Developing a Medium-Term Debt-Management Strategy for the Government of Canada

Marc Larson and Etienne Lessard, Funds Management and Banking Department

- *The development of a sound medium-term debt-management strategy is a complex task that requires a thoughtful balance between cost and risk. Moreover, any change to the government's debt structure has to be considered from a long-term, forward-looking perspective.*
- *Federal debt managers have various analytic tools to assess the cost-risk trade-offs of different borrowing strategies. These tools, combined with debt managers' judgment and experience, are used to develop Canada's medium-term debt strategy.*
- *An important element of the decision-making process is to engage market participants in regular and open dialogue.*

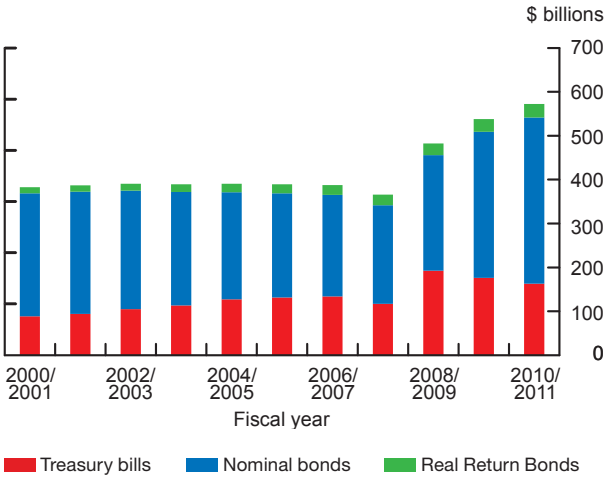
The recent international focus on levels of sovereign debt and the sustainability of countries' borrowing programs has reinforced the importance of developing a sound strategy for structuring and managing government debt.[1] There are, however, a number of other policies that work in conjunction with the debt strategy to keep debt costs low and stable, such as a sustainable fiscal policy; a monetary policy that keeps inflation low, stable and predictable; and an efficient financial system.

While the Government of Canada's federal debt-to-GDP ratio of about 34 per cent is the lowest in the G-7 countries, considerable effort and planning is still required to develop a debt-management strategy[2] that thoughtfully balances many different cost and risk considerations.[3] Moreover, a well-developed debt strategy can have considerable financial benefits. With over $575 billion of Government of Canada market debt outstanding (**Chart 1**), annual interest payments on that debt are about $17 billion, and about 8 cents of every tax dollar collected by the government goes toward paying these interest charges.[4]

As the fiscal agent for the Government of Canada, the Bank of Canada provides strategic policy advice on the management of the government's debt in addition to being responsible for conducting

1 The article focuses on the Canadian-dollar-denominated debt issued by the Government of Canada, and so excludes debt issued by federal Crown corporations and global bonds issued by the Government of Canada to fund the Exchange Fund Account.
2 The debt-management strategy sets out the Government of Canada's objectives, strategy and plans for managing its domestic and foreign debt, other financial liabilities and related assets.
3 See the Government of Canada's Budget 2011 at <http://www.budget.gc.ca/2011/home-accueil-eng.html>.
4 See the Public Accounts of Canada 2010 at <http://www.tpsgc-pwgsc.gc.ca/recgen/txt/72-eng.html>.

Chart 1: Outstanding amount of treasury bills and bonds



Source: Bank of Canada Last observation: 31 March 2011

debt-management operations, such as auctions of Government of Canada securities. The Minister of Finance is responsible for making final decisions that pertain to the Government of Canada's debt-management strategy. To this end, the Bank of Canada and Department of Finance collaborate through a number of committees created to ensure the effectiveness of the decision-making process.[5]

A new medium-term debt strategy was announced in the "Debt Management Strategy for 2011–12," which was released as part of the federal Budget on 22 March 2011.[6] The new strategy has an increased focus on issuing short- and medium-term bonds (with maturities of 2, 3 and 5 years). It also includes specific actions, such as a reduction in the stock of treasury bills and changes to maturity dates in certain bond sectors, to reduce the amount of debt maturing over near-term horizons. This article provides further insight and more details on the decision-making process that led to the formulation of this new strategy. This includes the debt-management objectives, the modelling approach, the long-term perspective of the decision made, the communication strategy and the use of debt-management metrics to monitor and assess the evolution of the debt structure over time.

Objectives

The fundamental objective of debt management is to raise stable, low-cost funding to meet the financial needs of the Government of Canada. This objective reflects the fundamental cost-risk trade-off that the government faces as a borrower: shorter-term debt instruments are generally less costly but also more risky (i.e., annual borrowing costs are more variable) than longer-term debt instruments. An associated objective is to maintain a well-functioning market (i.e., liquid and efficient) in Government of Canada securities. Well-functioning markets for government securities attract broad investor interest and increase competitive demand for those securities, which helps to keep debt costs low and stable and provides broader benefits to domestic capital markets.[7]

The fundamental objective of debt management is to raise stable, low-cost funding

In pursuing these objectives, the government adheres to key principles for debt management that include prudence, transparency, liquidity and regularity. These principles ensure that debt-strategy decisions are taken with a long-term perspective, balance cost and risk, are communicated in a timely and transparent manner to market participants, and support the liquidity in the Government of Canada securities market.

Adherence to these objectives and principles helps to ensure that the operational framework is consistent with the best practices of comparable sovereign borrowers.

The Road Toward Establishing a New Medium-Term Debt-Management Strategy

The complex task of developing a medium-term debt strategy requires a thoughtful balance between the many considerations that flow from the debt-management objectives and principles (see **Box**). Factors that must be taken into account include

5 A detailed description of the Treasury Management Governance Framework can be found at <http://www.fin.gc.ca/treas/goveev/tmgf03_1-eng.asp>.

6 The "Debt Management Strategy for 2011–12" can be found at <http://www.fin.gc.ca/pub/dms-sgd/index-eng.asp>.

7 A well-functioning Government of Canada securities market also supports other Canadian financial markets (e.g., markets for provincial and corporate bonds and derivatives markets) in addition to supporting the implementation of monetary policy.

A Brief History of the Debt Strategy

As the underlying budgetary and economic environments have changed and evolved over the past 20 years, so has Canada's debt strategy, which can be broadly grouped into four periods:

1991–94

To improve Canada's financial position, considering the prevailing environment of volatile interest rates and high debt levels, the government focused on extending the average term of its debt maturities. The main metric used to track progress on this objective was the fixed-rate share of the debt (the share of the debt stock that will not mature or be repriced in the next 12 months), which increased from a level of 50 per cent to 55 per cent over the period.

1995–2002

In 1995, the government announced that it would increase the fixed-rate share of the debt to 65 per cent by no later than the end of 2004–05. This initiative was undertaken to achieve a more prudent debt structure in an increasingly volatile market environment and to moderate refinancing risk. The fixed-rate target of 65 per cent was achieved in 1997, much sooner than expected. Thereafter, the debt structure was reviewed annually and was managed so as to maintain a target for the fixed-rate share of about two-thirds.

2003–07

In 2003, the target for the fixed-rate share of the debt was reduced from two-thirds to 60 per cent, to be achieved within a five-year period. This decision reflected an environment in which the ratio of debt to gross domestic product (GDP) was declining, as well as the desire to reduce the expected costs of the debt by lowering the share of fixed-rate debt. The 60 per cent target was achieved in 2006–07, before the onset of the financial crisis in late 2007.

2008–11

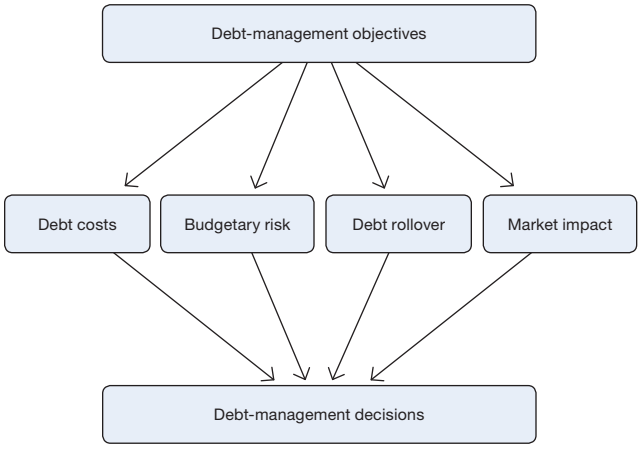
The increased borrowing requirements necessitated by the financial crisis served to reinforce the importance of the government's ongoing practice to regularly review its debt-management strategy.

projected debt costs, the projected annual variability of debt costs and their potential impact on the budgetary balance (budgetary risk), the amount of debt maturing or rolling over in a specific period (debt rollover), and the maintenance of a well-functioning market in Government of Canada securities (market impact) (**Figure 1**).

To balance these competing considerations, Canada's debt managers have developed various approaches to assessing the cost-risk trade-offs of different borrowing strategies. These include analytic tools that complement debt managers' judgment and experience, such as the modelling of uncertainty about the future evolution of the economy and interest rates and the corresponding effect on the budgetary balance, as well as developing metrics to monitor the evolving cost-risk characteristics of the debt structure. They also include consultations with market participants.

The balance of the article provides a broad description of these tools and approaches.

Figure 1: Factors considered in debt-management decisions



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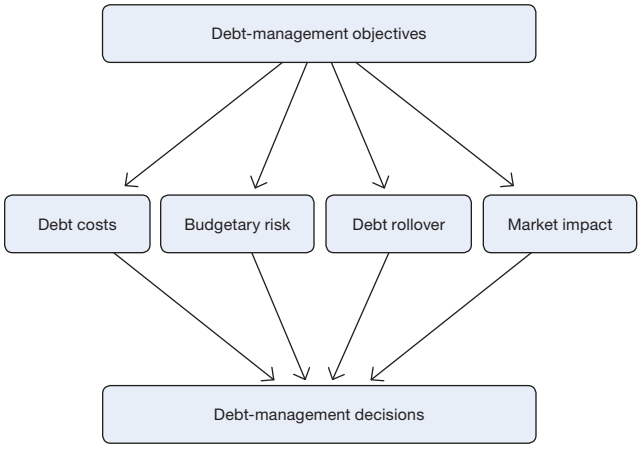


The Modelling Approach

The ability to model Canada's debt has evolved gradually. Canada's core debt model was developed about 10 years ago to assess and quantify the expected variability of debt costs. Since then, the model has been enhanced to include the addition of macroeconomic variables (e.g., inflation and the output gap), to examine the relationship between these variables and the government's borrowing requirements, and to improve the simulation engine that generates the future paths of interest rates. The current version of the Canadian Debt-Strategy Model (CDSM) reflects a considerable amount of research undertaken over the past five years.[8] Based on feedback received from other countries, the CDSM is one of the most sophisticated models developed by sovereign debt managers.

The objective of any model is to help to develop intuition and to facilitate the understanding of complex (i.e., densely interconnected) and/or complicated (i.e., many moving parts) real-world phenomena. The CDSM is no exception. The future evolution of the economy, interest rates and financial requirements are all uncertain and interrelated in a complex way. The CDSM can provide information on the trade-offs between the government's debt costs and the risks associated with different financing strategies. The model also allows debt managers to examine how these trade-offs change across a wide variety of different economic and interest rate environments, thereby providing a comprehensive evaluation of different funding choices. The main objective of the analysis is to find a funding mix consisting of treasury bills, nominal bonds and inflation-linked bonds that ensures a prudent risk profile while simultaneously minimizing debt-service charges and maintaining a well-functioning market in Government of Canada securities.

By examining hundreds of different financing strategies, each with different proportions of short-, medium- and long-term bonds and treasury bills, the CDSM can provide broad directional guidance for the debt-management strategy. For example, modelling analysis conducted in 2010 demonstrated that over a wide range of interest rate scenarios, debt portfolios weighted toward more short- and medium-term bonds would improve the efficiency of the debt structure in the long run, while reducing exposure to debt-rollover risk. In this context, improving the efficiency of a portfolio means either reducing cost for a given level of risk or reducing risk for a given level of cost.

By examining hundreds of different financing strategies, the CDSM can provide broad directional guidance for the debt strategy

The modelling process used to support the medium-term debt-management strategy consists of five steps (each of which is explained below):

1. generation of random (stochastic) economic and interest rate scenarios
2. calculation of debt cost and risks
3. determination and composition of optimal strategies
4. imposition of minimum issuance constraints to meet the objective of maintaining well-functioning markets
5. sensitivity, scenario and stress-testing analysis

Step 1 – Generating economic and interest rate scenarios

This step employs a stochastic macroeconomic term-structure model that generates various economic and interest rate scenarios over a long-term period (e.g., 10,000 scenarios over a 10-year horizon).[9] The scenarios contain paths for the output gap, inflation, the overnight interest rate, the term structure of interest rates and the government's borrowing requirements.

Step 2 – Calculating costs and risks

The second step computes the government's debt costs and the associated risk measures for a specific financing strategy.[10] Computing debt costs is relatively straightforward, since they can be calculated

8 Working papers that cover the technical aspects of the model are available on the Bank of Canada's website. For example, Bolder and Rubin (2007) provide a thorough description and evaluation of several optimization techniques. A full description of the CDSM can be found in Bolder (2008) and Bolder and Deeley (2011).

9 Several Bank of Canada working papers provide a detailed description of the macroeconomic term-structure models used. See, for example, Bolder (2001, 2006), Bolder and Gusba (2002) and Bolder and Liu (2007).

10 In this context, a financing strategy is composed of a relative mix of 3-, 6- and 12-month treasury bills; 2-, 3-, 5-, 10- and 30-year nominal bonds; and 30-year inflation-linked bonds (Real Return Bonds). Global bonds issued by the Government of Canada to fund the Exchange Fund Account are excluded from the analysis since they are managed within an asset-liability-matching framework.

as the average annual debt-service charges in dollars or as a percentage of the total debt stock over a specific simulation horizon (e.g., 10 years).

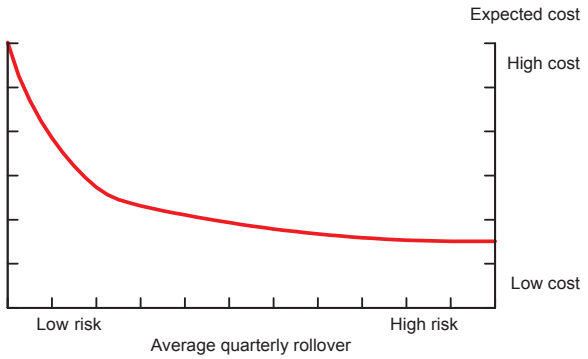
Measuring risk is more complex, however, since it can be defined many different ways, depending on the policy objectives of the government. In the context of debt modelling, risk is characterized as the amount of debt maturing or rolling over in a specific period (single-day, quarter or year), the variability of interest costs over time (i.e., the extent to which interest costs could change significantly from one year to the next), and the variability of the government's budgetary balance resulting from the correlation between debt costs and the government's revenues and expenditures. Moreover, although risk can be mitigated by modifying the issuance structure of the debt, other tools are also available to debt managers to mitigate some types of risks. For example, a bond-buyback program, as well as a liquidity plan,[11] can help mitigate debt-rollover risk.

Step 3 – Selecting optimal strategies

In this step, a wide range of different financing strategies are reviewed, some of which may involve issuing debt in only some maturity sectors but not others. An optimization algorithm is then used to select those strategies with the best cost-risk trade-offs, or the lowest cost for a specific level of risk. The output of this work is a curve that represents the most efficient financing strategies, similar to an efficient portfolio frontier, as well as the composition of the most efficient financing strategies.

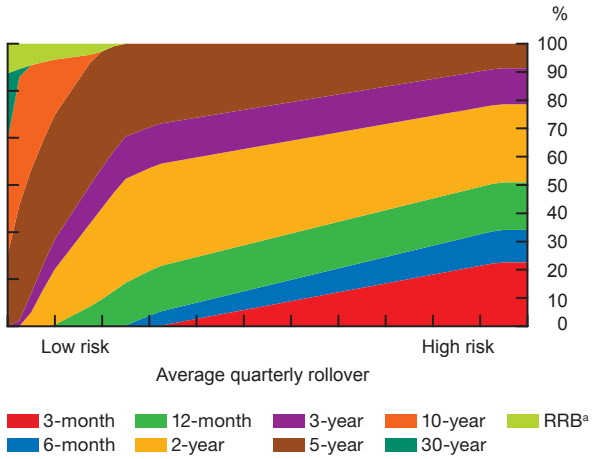
Chart 2 and **Chart 3** illustrate the results of the optimization exercise based on debt rollover as a risk measure. Note that the same exercise can also be performed using other risk measures. **Chart 2** shows the efficient frontier of the optimal debt structures (lowest cost for a specific level of risk). Moving along this frontier from left to right shows how expected borrowing costs decrease—and rollover risk increases—as the government shifts the proportion of its borrowing program from long-term debt to short-term debt. **Chart 3** illustrates how the proportion of short-term debt in the optimal portfolio changes as one moves along the efficient frontier. Each colour represents a different debt instrument issued by the Government of Canada. As shown in this chart, low-risk debt structures contain mainly long-term maturity instruments (10-year and 30-year nominal bonds and

Chart 2: Expected cost frontier



Source: Bank of Canada — Last observation: 24 May 2011

Chart 3: Optimal portfolio weights



a. Real Return Bonds
Source: Bank of Canada — Last observation: 24 May 2011

Real Return Bonds), while high-risk debt structures contain mostly short-term debt instruments (3-, 6- and 12-month treasury bills and 2-year bonds).

Step 4 – Imposing constraints

The issuance strategies considered in step 3 do not necessarily involve issuing debt in all maturity sectors, and these strategies may therefore be inconsistent with the government's objective of maintaining a well-functioning securities market. Accordingly, the fourth step imposes constraints on the financing strategies whereby they all maintain at least a minimum amount of issuance in all the selected maturity sectors.[12] These levels of minimum issuance differ

11 A liquidity plan consists of having liquid financial assets available to support meeting payment obligations in situations where normal access to markets may be disrupted or delayed.

12 The bond-buyback program can also be used to help maintain a minimum amount of issuance in some maturity sectors by repurchasing less-liquid bonds in exchange for building benchmark bonds.

for each sector and are generally based on past issuance, comments obtained during consultations with market participants and the judgment of debt managers.

Step 5 – Analyzing results

To assess the robustness of the modelling results, the assumptions underlying the model, as well as the idiosyncratic characteristics built into the model itself, the results are stress tested and analyzed under various scenarios. Tests are conducted to assess the impact of changing assumptions regarding long-term GDP growth, inflation, the government's borrowing requirements and the level of interest rates, as well as the spread between long-term and short-term interest rates. In addition, different interest rate models are used to test the sensitivity of the overall results to the idiosyncratic characteristics of the various models.

A Long-Term Perspective

The transition toward a more efficient debt structure can take many years to be fully realized because of the modest size of the annual bond issuance relative to the size of the outstanding debt portfolio and the fact that some bonds take up to 30 years to mature. In addition, Government of Canada securities play an important role in the Canadian fixed-income market, as a key reference for the pricing of other securities. Debt managers therefore try to avoid potentially disruptive or abrupt changes to the government's annual patterns of debt issuance. Thus, any change to the government's issuance structure has to be based on a long-term, forward-looking perspective.

While the long-term objectives of a given debt strategy may be clear, some degree of flexibility also needs to be built into the strategy

Moreover, while the long-term objectives of a given debt strategy may be clear, some degree of flexibility also needs to be built into the strategy. Annual issuance plans need to remain flexible enough to adapt to evolving fiscal and economic conditions to ensure that the government's financing requirements can always be met.

A Communication Strategy

An important element of the decision-making process when considering the debt strategy is to engage market participants in regular and open dialogue (e.g., annual debt-management-strategy consultations, consultations ahead of each auction call for tender, ad hoc consultations with investors and government securities distributors).

As the largest issuer of Canadian-dollar-denominated fixed-income securities, the government considers consultations with market participants to be an essential component of its ongoing commitment to maintaining a well-functioning government securities market, as well as an integral part of the debt-management process.

Thus, every year, officials from the Bank of Canada and the Department of Finance seek the views of government securities distributors, institutional investors and other interested parties on issues related to the design and operation of the Government of Canada's domestic debt program for the coming year and beyond.

These consultations typically cover general market conditions, the effectiveness of the bond and treasury bill programs, bond-buyback operations, and various operational details. They can thus help to validate many modelling assumptions being used, particularly those related to the minimum level of issuance required to maintain well-functioning markets. Consultations also provide an opportunity to discuss operational considerations (e.g., the size and frequency of auctions) that the government needs to consider when implementing its debt-management strategy. As part of the ongoing effort to promote transparency, a summary of the views expressed during these consultations is provided on the Bank of Canada website and released in conjunction with the government's "Debt Management Strategy."[13]

The release of the "Debt Management Strategy" and the "Debt Management Report," which provides a detailed account of the government's borrowing and debt-management activities for the previous fiscal year, ensures that the current debt strategy is broadly communicated and understood by market participants, investors or any interested parties. These documents describe the expected long-term debt structure using a variety of different

13 The consultation document and the summary of consultations can be found at <http://www.bankofcanada.ca/publications-research/market-notices/>.

debt-management metrics (see below). The "Debt Management Strategy" also announces any required adjustments to bond-maturity dates and to the bond-buyback program to smooth the daily debt-maturity profile and to reduce debt-rollover risk.

Debt-Management Metrics

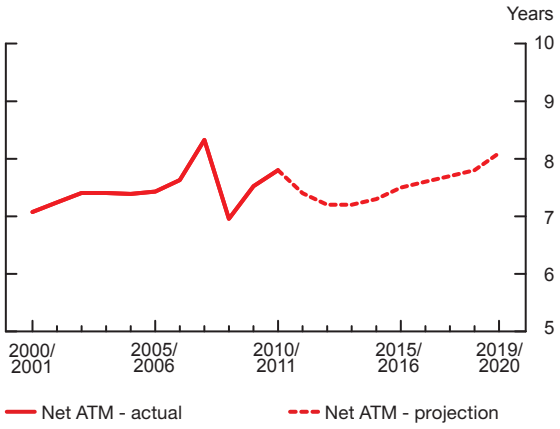
A range of key debt-management metrics (the set of measurements used to describe the structure of the debt portfolio) are used to monitor and assess the evolution of the debt structure. They also consider the objectives of debt management. As a result, they help debt managers to evaluate and monitor the impact of decisions regarding the debt strategy with respect to the four factors discussed earlier: debt costs, budgetary risk, debt rollover and market impact. Different metrics can be attributed to each factor.

The "Debt Management Strategy for 2011–12" contains metrics showing the expected evolution of the debt structure over the next 10 years. For example, **Chart 4** shows the historical and expected trend of the average-term-to-maturity (ATM), which is generally used to assess debt costs, given that longer-term debt maturities are generally more costly. **Chart 5**, which highlights the amount of debt to be refixed (i.e., refinanced or repriced) over a specific period, helps to illustrate interest rate and budgetary risk.

The "Debt Management Report 2009–10" also contains metrics on debt rollover (quarterly maturities of domestic market debt and single-day bond maturities plus coupon payments) and on the well-functioning of markets (size of bond benchmark issues).[14]

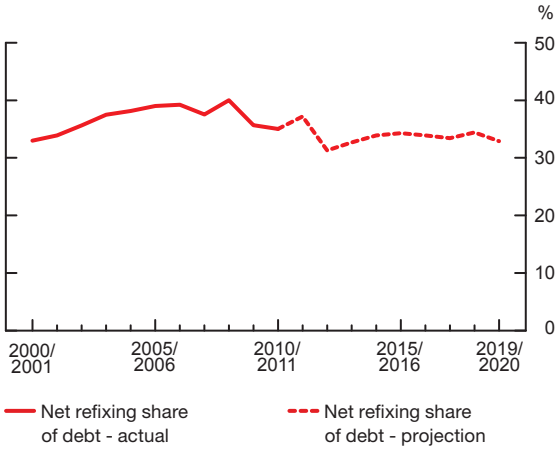
In addition to providing information on the evolution of the debt portfolio over time, these metrics allow cross-country comparisons of debt structures.

Chart 4: Projected evolution of the ATM of the debt portfolio



Source: Department of Finance Last observation: 22 March 2011

Chart 5: Projected evolution of the refixing share of debt as a percentage of debt stock



Source: Department of Finance Last observation: 22 March 2011

Concluding Remarks

The Government of Canada's new medium-term debt strategy marks an exciting new chapter in the management of Canada's sovereign debt. The design and implementation of the medium-term debt-management strategy is a long-term process, resulting from an extensive and sophisticated modelling approach that balances costs and risks and that is supplemented by market input, as well as the judgment and experience of debt managers. Its evolution and direction are also closely monitored on a regular basis to adjust to changing fiscal and economic environments.

Moreover, evolving risk-management practices in debt management and among other sovereign borrowers will continue to be monitored. Combined with ongoing input from market participants, these steps will ensure that the decisions taken will strive to create a debt-management strategy that is efficient, sound and consistent with the government's objectives.

14 The most recent "Debt Management Report" can be found at <http://www.fin.gc.ca/dtman/2009-2010/DMR2010_ENG.pdf>.

Literature Cited

Bolder, D. 2001. "Affine Term-Structure Models: Theory and Implementation." Bank of Canada Working Paper No. 2001-15.

———. 2006. "Modelling Term-Structure Dynamics for Risk Management: A Practitioner's Perspective." Bank of Canada Working Paper No. 2006-48.

———. 2008. "The Canadian Debt-Strategy Model." *Bank of Canada Review* (Summer): 3–16.

Bolder, D. and S. Deeley. 2011. "The Canadian Debt-Strategy Model: An Overview of the Principal Elements." Bank of Canada Discussion Paper No. 2011-3.

Bolder, D. and S. Gusba. 2002. "Exponentials, Polynomials, and Fourier Series: More Yield Curve Modelling at the Bank of Canada." Bank of Canada Working Paper No. 2002-29.

Bolder, D. and S. Liu. 2007. "Examining Simple Joint Macroeconomic and Term-Structure Models: A Practitioner's Perspective." Bank of Canada Working Paper No. 2007-49.

Bolder, D. and T. Rubin. 2007. "Optimization in a Simulation Setting: Use of Function Approximation in Debt Strategy Analysis." Bank of Canada Working Paper No. 2007-13.

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