

Bank of Canada Participation in the 2007 FSAP Macro Stress-Testing Exercise

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In 2007, Canada's financial system was the subject of an FSAP (Financial Sector Assessment Program) update (Box 1). A key component of this exercise was the stress testing of the Canadian financial system with a macroeconomic scenario. The Bank of Canada took the lead in developing, implementing, and assessing the results. This report describes the role played by the Bank and the main results of, and lessons derived from, this exercise.¹

General Framework

The purpose of stress testing is to assess the resilience of a segment of the financial system in the face of "rare but plausible" events that have either resulted in vulnerabilities in the past or could do so in the future. In macro stress testing, the events considered are macroeconomic shocks assembled (typically by means of a macroeconomic model) to form a macroeconomic scenario. The objective is to assess the impact of the scenario on a set of financial institutions.

There are two basic approaches to conducting macro stress-testing exercises:

- i) Bottom-up, in which the participating institutions assess the impact of a given scenario on their portfolio, and the authorities then aggregate and interpret the results.
- ii) Top-down, in which the authorities assess the impact of the scenario on financial institutions at a more aggregate level and use the results as a basis for discussion with individual participants.

In the Canadian FSAP update, it was agreed that macro stress testing would be conducted using the bottom-up approach, and that the subject of the stress test would be the loans portfolio of the participating Canadian banks. The Bank of Canada played several roles in the exercise:

- designing the macroeconomic scenario using an in-house model;
- modelling the relationship between macro variables and default rates in the business and household sectors (the individual institutions used these default rates to simulate the losses in their loans portfolio);
- conducting an independent assessment of losses that would arise under the scenario, to cross-check the results of individual banks.²

In the rest of this report, we elaborate on these points by describing the general features of the chosen scenario, the method used to relate default rates to macroeconomic variables, and the results that were obtained. The last section contains a summary of the results, some thoughts on the lessons learned, and an outline of the areas where further work is needed.

The Macroeconomic Scenario

In 2006, during the preparation stage of the exercise, it was agreed that the scenario to be considered would be based on a disorderly adjustment of global imbalances brought about by a downward revision to expectations for productivity growth in the United States. The impact of such a scenario would be traced over a 2-year horizon, starting in 2007Q1.

Our scenario has its origins in the historically high level of trend labour productivity growth experienced in the latter half of the 1990s and the early 2000s in the United States.³ As

1. For a more detailed analysis, see Coletti et al. (forthcoming).

2. The IMF has conducted its own independent assessment, the results of which are in their FSAP report at <<http://www.imf.org/external/pubs/cat/longres.cfm?sk=21710.0>>.

3. The macroeconomic scenario was developed using the Bank of Canada's version of the Global Economy Model (BoC-GEM) (Lalonde and Muir 2007). BoC-GEM is a variant of the GEM developed at the IMF (Faruqee et al. 2007).

Box 1**FSAP Update: Highlights of the IMF Conclusions**

The Financial Sector Assessment Program (FSAP), established by the International Monetary Fund (IMF) and the World Bank in 1999, provides countries with comprehensive assessments of the stability of their national financial systems. Canada undertook an FSAP assessment during the program's pilot phase in 1999–2000. In September 2006, Canadian authorities formally requested that the IMF undertake an FSAP update for Canada.

This update included an assessment of Canada's compliance with internationally accepted standards and codes for financial sector regulation, as well as a focused review of Canada's compliance with revised Basel Core Principles for Effective Banking Supervision. It also included a stress-testing exercise designed to assess the capacity of the Canadian financial system to absorb various adverse economic and financial shocks.

The full FSAP report can be found at <www.imf.org/external/pubs/ft/scr/2008/cr0860.pdf>. The IMF's overall conclusion is that Canada's financial system is mature, sophisticated, and well managed. The report states that financial stability is underpinned by sound macroeconomic policies and strong prudential regulation and supervision, while deposit insurance and arrangements for crisis management and failure resolution are well designed.

The IMF's conclusion concerning the stress-testing exercise is that Canada's major banks can withstand sizable shocks. Although capital drops below the regulatory minimum in the stress scenario, it remains adequate. The banking system thus appears sound, but it faces some challenges. In particular, the IMF notes that global financial turmoil since mid-2007 has highlighted the information and liquidity risks in the structured financial products that Canadian banks have embraced in recent years.

The report also concludes that CDSX, the securities-settlement system operated by Clearing and Depository Services Inc., is sound, efficient, and reliable and that it complies with almost all recommendations for securities-settlement systems. As well, Canada is found to be compliant with the four revised Basel Core Principles for Effective Banking Supervision. Finally, concerning securities regulation, the IMF concludes that the regulatory framework for the securities market in Canada implements the objectives and principles of the International Organization of Securities Commissions (IOSCO) in most respects, but that there would be advantages in moving towards a single securities regulator.

expectations of long-term growth in U.S. labour productivity were gradually revised upwards to 2 per cent and higher, perceived rates of return on U.S. investments were boosted, leading to increased investment demand, as well as increased capital inflows and a stronger U.S. dollar. In addition, expectations of higher permanent income led to an increase in consumption and a drop in the savings rate. In turn, these factors led to a rise in imports and an expansion of the U.S. current account deficit (Ferguson 2005).

In the scenario, it is assumed that expectations of a permanent rise in the growth of U.S. labour productivity are revised sharply downwards to 1.1 per cent per annum for the next 10 years from 2 per cent. The resulting downward revision to permanent income growth and to expected rates of return on investment lead to a retrenchment in demand that offsets the decline in the growth of the economy's productive capacity. It is also assumed that increased economic uncertainty causes declines in the confidence of consumers and firms, leading to a reduction in consumption and investment expenditures. Heightened uncertainty is also assumed to motivate foreigners to sell off U.S.-dollar assets, resulting in a rapid depreciation of the U.S. dollar. The resulting deterioration in the balance sheets of consumers and firms leads to a significant rise in financial risk premiums, further magnifying the economic slowdown.⁴

Furthermore, it is assumed that Canadian trend labour productivity growth slows to about 0.8 per cent per annum over the next 10 years from 1.5 per cent. As in the United States, we assume similar but smaller declines in consumer and business confidence. Premiums on Canadian commercial interest rates also rise as a result of the economic downturn, exacerbating the weakness in Canadian GDP growth.⁵

4. We assume that the risky spread (the difference between the rate on medium-term business loans and the rate on 5-year U.S. government bonds) widens to reach historic highs in early 2007 (the starting point of the shock scenario). Our analysis assumes similar increases in the spreads on consumer interest rates.
5. We assume that the risky spread between the rate on medium-term business loans and the rate on 5-year Government of Canada bonds widens to historically high levels. Risky spreads of this magnitude have occurred only about 2 per cent of the time in Canada over the period 1980 to 2006. The rate on medium-term Canadian business loans is based on the yield on bonds of A-rated firms, which represents the median rating of Canadian corporate bond issuers. We assume similar increases in spreads on consumer interest rates.

Table 1
Macro Stress-Testing Scenario (2007Q1–2009Q1)^a

	2007Q1	2008Q1	2009Q1
United States			
Trend labour productivity growth	1.9	0.9	1.1
GDP growth	2.2	-6.2	3.2
Unemployment rate (level)	4.5	7.7	8.0
Core CPI inflation	2.3	-2.0	-0.7
Real commodity price index (US\$, 1997=100)	194	180	177
Real effective exchange rate (+=depreciation)	1.06	1.19	1.18
Federal funds rate	5.3	0.7	2.1
Rate on 5-year government bonds	5.1	3.2	4.1
Rate on medium-term business loans	7.6	8.4	7.7
Canada			
Trend labour productivity growth	1.1	0.5	0.8
GDP growth	1.9	-4.3	2.0
Unemployment rate (level)	6.2	8.0	9.4
Core CPI inflation	2.2	-0.6	0.3
Real bilateral U.S. exchange rate (+=depreciation)	1.15	1.05	1.08
Target overnight rate	4.2	0.2	1.0
Rate on 5-year government bonds	4.4	1.9	2.6
Rate on medium-term business loans	5.0	4.0	3.8

a. The values are year-over-year (Q1 over Q1).

Taken together, the shocks in our scenario are extremely large by historical standards. As shown in Table 1, the scenario results in high real interest rates for consumer and business loans and an extremely severe economic contraction in the United States. The recession embodied in the scenario is even more severe than that experienced in 1981–82, with year-over-year real GDP growth in the United States troughing at -6.2 per cent in 2008Q1. As a result of the weakness in aggregate demand, U.S. labour market conditions deteriorate and the unemployment rate rises to a peak of about 8.5 per cent in mid-2008.

The recession in the United States, a higher Canada/U.S. real exchange rate, falling world commodity prices, the downward revision to expectations for the growth of domestic trend labour productivity, losses in domestic consumer and business confidence, and the rise in domestic financial risk premiums lead to a significant recession in Canada in 2007 (Table 1). In terms of cumulative output loss, the domestic recession embodied in the scenario is about one-third larger than that experienced in 1990–91, despite a significant easing in monetary policy.

As a result, core consumer prices fall throughout 2008. Inflation picks up gradually in 2009 and returns to the 2 per cent inflation target by the end of 2010. Canadian policy interest rates fall quickly to 0.25 per cent in early 2008 and remain very low for several years. The aggressive decline in policy rates, consistent with Canada's inflation-targeting framework, plays a very important role in mitigating the impact of the adverse shocks on the Canadian economy. Consequently, the rate on 5-year Canadian medium-term business loans actually declines in early 2007, despite the large rise in the financial risk premium. The relatively low level of domestic interest rates at a time when GDP growth is quite weak distinguishes the macroeconomic outlook from the events in the early 1990s.

Relating Default Rates to Macro Variables⁶

In modelling sectoral default rates, the objective was to identify systemic factors that affect default rates in all sectors. We assume that these factors are related to the overall performance of the economy. The initial set of explanatory variables includes the Canadian GDP growth rate, unemployment rate, interest rate (medium-term business loan rate), and the credit/GDP ratio. The paths of these variables under stress are obtained from the macro scenario.

The dependent variables are sectoral default rates. Because long time series of historical sectoral default rates with broad coverage are not available for Canada, proxies are constructed based on sectoral bankruptcy rates, supplemented by additional information. The adjusted data span the period from 1988Q1 to 2005Q4, at a quarterly frequency.

The specification of the sectoral regressions includes non-linear terms. We find that non-linearities are the key to capturing the behaviour of default rates around the historical extremes (Misina and Tessier 2007). Without non-linearities, even the extreme macroeconomic shocks have a very limited impact on default rates.

Simulation results are presented in Table 2, which contains information on historic peaks, as well as fitted values from the non-linear specification.⁷ Fitted values are, on average, close to historical peaks. The values used in the stress-testing exercise contain an ad hoc upward adjustment (equivalent to 0.25 standard deviation) reflecting the IMF's opinion that the magnitudes of responses should be larger than those generated by the default-rate models.⁸

Table 2

Peak Default Rates (Scenario and Historic Peaks)

	History (peak date)	BoC model (peak date)	Scenario	Scenario +0.25 standard deviation
Accommodation	7.58 (1992Q1)	6.26 (1992Q1)	12.3	13.75
Agriculture	0.83 (1992Q4)	0.78 (1992Q1)	1.37	1.61
Construction	3.27 (1992Q4)	3.61 (1991Q2)	5.63	6.38
Manufacturing	8.28 (1992Q1)	8.36 (1992Q2)	11.1	12.22
Retail	5.31 (1992Q1)	5.17 (1992Q2)	3.76	4.31
Wholesale	4.63 (1992Q1)	4.73 (1992Q2)	6.58	7.42
Mortgage	0.63 (1996Q4)	0.59 (1996Q3)	0.55	0.57

6. Technical details related to this section can be found in Misina and Tessier (2007).
7. The sectors included were accommodation, agriculture, construction, manufacturing, retail, wholesale, and default rates on mortgages in the household sector. Sectors for which default rates were not provided could either be merged with the above or classified in a separate category, and an average of defaults in the above sectors used. Both approaches were used by individual banks in implementing the scenario.
8. The performance of sectoral regressions under stress will depend on the precise configuration of the macroeconomic variables in a particular sectoral regression. During the recession in the early 1990s, interest rates were much higher than under the scenario. Thus, for interest-sensitive sectors, such as retail and mortgages, the situation under the stress scenario is more favourable than in the early 1990s, resulting in responses that are below historic peaks.

To compute losses under the stress scenario, we need information on exposures and on loss-given-default, in addition to default rates. Data on loan exposures are taken at 2006Q4, the last available point at the time of the exercise.

There is very little information on loss-given-default in Canada. A rough proxy can be obtained by looking at the ratio of estimated assets to estimated liabilities at the time of bankruptcy. This information is available from the Office of the Superintendent of Bankruptcy. For the corporate sector, the average for the period 1988–2006 is 0.35, which would suggest an expected recovery rate of 35 per cent, or losses given bankruptcy of 65 per cent. Since bankruptcy is the last stage of distress, and since most losses occur because of missed interest payments, we believe that this recovery rate might be somewhat low and, for the purpose of the FSAP exercise, have agreed with the IMF to set the recovery rate at 50 per cent.

Loss Assessment

Expected and unexpected losses

Each participating bank⁹ was asked to provide an estimate of expected and unexpected losses (the mean of the loss distribution, and the 99.9 per cent value-at-risk) arising from the macroeconomic scenario, for each quarter over a 2-year horizon. Individual results depend on how the banks used the inputs provided to them. While approaches vary across banks, some key commonalities had to be taken into account in arriving at the estimates of losses using our internal model. In particular:

- The banks' estimates of losses are based on their estimates of exposures at default (EAD), and these data were not publicly available at the time of the exercise.¹⁰ These estimates are larger than the publicly available balance sheet loan values, since the latter are based on the drawn amounts, whereas the former take into account undrawn commitments. Consequently, the

use of the balance sheet exposures will result in systematically lower estimates of losses.

- The banks' results indicate that the loss distribution has fat tails.

To deal with the first set of issues, the banks were asked to provide the values of EAD that they used in their stress tests. This information was used to adjust the results of the Bank of Canada's internal model by the difference between the exposures they used and those in their balance sheets. The difference between the two varied from bank to bank, with the lowest being 4 per cent, and the largest being 45 per cent.¹¹ To deal with the second set of issues, the simulations are performed using a *t*-distribution (with four degrees of freedom), rather than the normal distribution.

Chart 1 is a summary of the impact of the scenario on the participating banks. It contains estimates of expected and unexpected losses based on the individual results provided by the banks, Bank of Canada's estimates based on our internal stress-testing model (labelled BoC), and the IMF's estimates, which are based on the results contained in the IMF's FSAP report.¹²

The banks' estimates of their expected losses are higher than ours in the first year and lower in the second year. Estimates of the unexpected losses are similar in terms of overall magnitude.

An examination of the results reveals that increases in losses are driven largely by developments in the retail, manufacturing, and services sectors. (In this stress test, the retail sector includes consumer loans.)

The IMF's estimates are somewhat different, being either below (expected losses) or above (unexpected losses) the other two sets of estimates.

9. These are the "Big 5" banks: CIBC, RBC Financial Group, Bank of Montreal, TD Bank Financial Group, and Scotia-bank.

10. Under Basel II reporting rules, banks will be required to provide this information.

11. Scaling up the results by the difference between exposures is implicitly based on the assumption that the sectoral distribution of exposures used by the banks corresponds, in relative terms, to their balance sheet exposure. This assumption is difficult to verify, since the banks provided only total exposures.

12. The IMF reports losses as a percentage of risk-weighted assets. These were converted into dollar amounts by using publicly available information on the values of risk-weighted assets.

Impact on the capital-adequacy ratio

The ability of the banks to absorb the losses that arise under the scenario can be assessed based on the impact on their capital-adequacy ratio (CAR). That assessment is based on the fact that total capital (Tier 1 + Tier 2) should be sufficient to cover the unexpected losses (at the 99.9 per cent value-at-risk).

The results are presented in Chart 2, which shows the average of the results reported by banks, our estimates, and the IMF estimates. The horizontal line represents Basel II requirement for total capital (8 per cent). The results suggest that if the unexpected losses materialized at any point over the stress-testing horizon, the CAR would fall below the 10 per cent threshold for total CAR set by the Office of the Superintendent of Financial Institutions. If the unexpected losses materialized after the fourth quarter of the scenario, the results indicate that the CAR would fall below the Basel II requirements.¹³ The results do vary across banks, and in the best case the CAR remains above 8 per cent throughout the exercise.

The above analysis is based on the assumption of zero growth in regulatory capital over the stress-testing horizon (no mitigating action by the management to reduce the impact of the scenario). This assumption results in very conservative (worst-case) estimates. Some banks also assessed the impact of the shock on their CAR allowing for management action. These assessments were based on a variety of assumptions, but in all cases, the estimated CAR under stress remained above the regulatory requirements.

There is no doubt that the banks would use a variety of measures to maintain their CAR above the stipulated threshold (e.g., reduce/halt dividend payments or change lending practices to include fewer risky borrowers). Nonetheless, banks' estimates may be overly optimistic, since simultaneous actions by all banks to manage their capital (e.g., tightening credit) may have a negative impact on the real economy and exacerbate the problem.

Chart 1 Losses under the Scenario

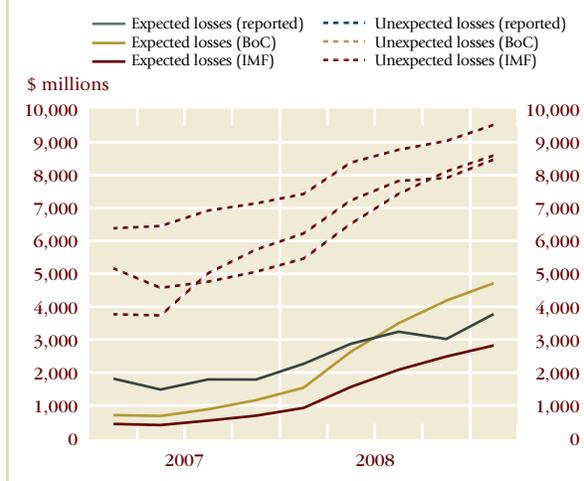
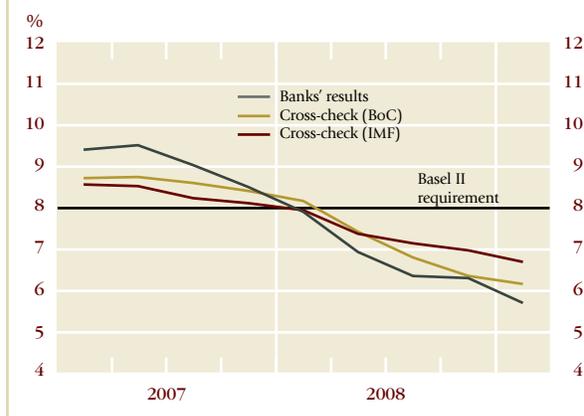


Chart 2 Impact of the Scenario on the Capital-Adequacy Ratio



13. Since the default rates reach their peaks around 2009Q1, we expect the biggest impact on the banks' CAR to occur around that time, with a possible improvement later on.

Conclusion

With a recession that is one-third larger than that experienced in the early 1990s, and increases in defaults exceeding predictions made by econometric models, the stress-test scenario analyzed in the FSAP update is extreme. Nonetheless, in terms of severity, the Canadian scenario is broadly in line with the scenarios used in other developed countries.

In the event of the materialization of the unexpected losses implied by the scenario, the banks' capital is, on average, sufficient to absorb these losses, although the average CAR falls below the regulatory requirements. In such circumstances, banks would need to take action either to raise new capital, which could be difficult given the high financial stress assumed in the scenario, or to cut risk-weighted assets, which could be costly for the economy. Authorities, particularly monetary policy authorities, would need to factor in these impacts on banks in determining the appropriate policy response.

While modelling and data differences make it difficult to compare the outcomes of stress tests across countries, generally speaking, the results indicate that the losses, while not negligible, did not pose a systemic threat to the financial systems of the countries tested. The results for Canada are in line with these general findings.

From the perspective of the Bank of Canada's ongoing work to develop tools to assess the resilience of the financial sector and its impact on financial stability, the exercise was valuable, leading to:

- a deeper understanding of the complexities of the relationship between the micro and macro aspects of the analysis of financial stability;
- improvements in the Bank's internal stress-testing models and methodologies;
- increased awareness of data limitations and data requirements;
- improved information sharing between the banks and Canadian government agencies; and
- increased knowledge of risk-management practices at individual financial institutions.

The exercise has also revealed the limitations of the existing stress-testing tools and methodologies, as well as the need for continued improvement, including:

- developing macro models that would be better suited to the analysis of extreme events;
- further work on models that relate default rates to macroeconomic variables (better integration with the main macro model and explicit modelling of economic behaviours); and
- gathering data on defaults beyond those of large publicly traded companies and getting more comprehensive data on the exposures of financial institutions.

Difficult issues at the frontier of current research efforts reflect broader problems: lack of the second-round/feedback effects that relate the actions of financial institutions back to financial markets and the real economy; the interlinkages among financial institutions; and channels of contagion. Nonetheless, we think that, even at the present stage, properly designed stress tests, based on scenarios that reflect rare but plausible sources of stress, can be useful in identifying vulnerabilities in the system. This information can help to guide official institutions in looking more deeply, in a risk-focused way, at possible channels through which vulnerabilities in one bank could be transmitted to others in the system. It can also form the basis for supervisory/macroprudential guidance to individual institutions or to the market as a whole.¹⁴

The FSAP has stimulated the Bank of Canada's stress-testing work. We are planning to maintain this accelerated momentum by investing in two priorities: (i) research efforts to address some of the shortcomings identified in the previous paragraph, and (ii) regular updating, using various scenarios of interest, of the top-down approach (Box 2). We are also considering, together with financial institutions and other government agencies, the possibility of

14. We thank Karl Habermeier and Mark Swinburne of the IMF for insightful comments and for providing a broader perspective regarding the nature of these exercises.

Box 2

Macro Stress Testing: An Update of the FSAP Results

The FSAP exercise discussed in this report was based on data for 2006Q4. Here we present an updated top-down assessment of credit losses in the loans portfolio based on data for 2008Q1.

Highlights of the changes in the data since 2006Q4

In the aggregate, there has been little change in the composition of banks' loans portfolios. Exposure to mortgage and retail sectors (the latter includes consumer loans) continues to account for approximately 75 per cent of total lending.

- The banks' loans portfolios have increased by 12 per cent on average.
- On average, the capital-adequacy ratio (CAR) of total (Tier 1 + Tier 2) capital to risk-weighted assets has declined slightly.
- New data on exposures at default (EAD), which the banks started reporting in 2008Q1, obviates the need to rely on adjustments to balance sheet exposures, as was done in the FSAP exercise.

Results

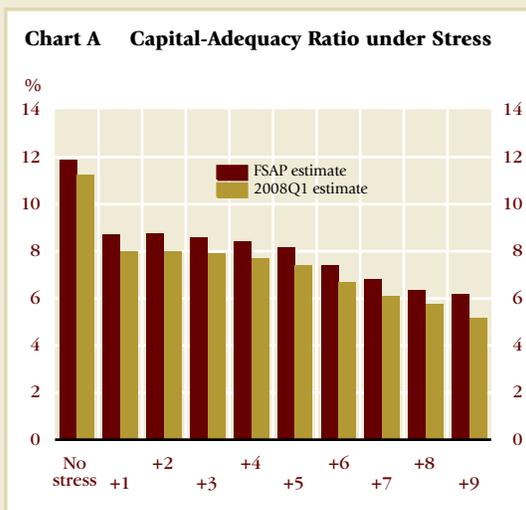
Chart A summarizes the results of the stress-testing exercise that takes the above points into account. Losses under the scenario are estimated using our internal model and are converted into an impact on the CAR using the same methodology as in the FSAP exercise. The first bar represents the median values of CAR for the five banks prior to stress. The subsequent bars represent the level of the CAR in each quarter if the unexpected losses (i.e., 99.9 per cent value at risk) associated with the scenario were to materialize.¹ For example, if the scenario-induced unexpected losses were to materialize in the fourth quarter after the initial shock, the median value of the CAR would change from

1. Recall that the actual CAR is determined on the basis of the estimates of the unexpected losses.

11.26 prior to stress to 7.69 in that quarter. If, instead, the unexpected losses materialized in the sixth quarter after the shock, the median value of the CAR would change from 11.26 prior to stress to 6.68 in that quarter.²

Higher exposures and a lower CAR starting point for values produce somewhat lower values for CAR under the scenario than in the 2006Q4 exercise. The levels of capital at these banks in 2008Q1 would still, in the aggregate, be sufficient to absorb the losses. Nonetheless, to continue to meet the regulatory requirements (total CAR of 8 per cent under Basel II; OSFI threshold of 10 per cent), the banks would have to take appropriate action: raising their levels of capital, reducing their risk-weighted assets, or a combination of the two. The feasibility and broader implications of these adjustments would depend on the nature and timing of these actions, as well as the horizon over which the banks' CAR values would return to their target levels.

2. The methodology used here does not allow us to infer the CAR values in the quarters following that in which the unexpected loss first materializes.



conducting periodic bottom-up exercises, as well as developing a more comprehensive approach to stress testing.

References

- Coletti, D., R. Lalonde, M. Misina, D. Muir, and P. St-Amant. "Bank of Canada's Participation in the 2007 FSAP Macro Stress-Testing Exercise." Bank of Canada Discussion Paper. Forthcoming.
- Faruqee, H., D. Laxton, D. Muir, and P. Pesenti. 2007. "Smooth Landing or Crash? Model-Based Scenarios of Global Current Account Rebalancing." In *G7 Current Account Imbalances: Sustainability and Adjustment*, 377–451, edited by R. Clarida. National Bureau of Economic Research Conference Report. Chicago: The University of Chicago Press.
- Ferguson, R. W. Jr. 2005. "U.S. Current Account Deficit: Causes and Consequences." Remarks to the Economics Club of the University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, 20 April.
- 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.
- Misina, M. and D. Tessier. 2007. "Sectoral Default Rates Under Stress: The Importance of Non-Linearities." Bank of Canada *Financial System Review* (June): 49–54.