Agathe Côté: Modelling risks to the financial system

Remarks by Ms Agathe Côté, Deputy Governor of the Bank of Canada, to the Canadian Association for Business Economics, Kingston, Ontario, 21 August 2012.

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Introduction

It has become a summer tradition for the Bank of Canada to address the Canadian Association for Business Economics. This year it is my pleasure and I thank you for the kind invitation.

An audience of colleagues and fellow economists offers me an opportunity to delve into a complex subject, and one that is particularly timely: financial system risk.

We continue to see today the enormous costs to the global economy of the financial crisis that started five years ago. Of the many lessons we have learned from the crisis, a key one is this: we need to pay more attention to the stability of the financial system as a whole.

This means understanding better how risks get transmitted across financial institutions and markets, and understanding better the feedback loop between the financial system and the real economy. From a policy perspective, this means taking a system-wide approach to financial regulation and supervision. Major reforms of the global financial system now under way address this need.

System-wide risk has been a focus of attention at the Bank of Canada, and at other central banks, for some time. Ten years ago, the Bank issued the first edition of its semi-annual *Financial System Review* in which it identifies key sources of risks to the Canadian financial system and highlights the policies needed to address them. A year later, in 2003, we organized our annual conference on the theme of financial stability.[1]

In the wake of the global financial crisis, the Bank has intensified its research efforts in this area. In particular, a priority is to improve the theoretical and empirical models we use to analyze elements of the financial system that can lead to the emergence of risks and vulnerabilities. With more finely tuned quantitative models and tools, the Bank will be better able to identify risks on a timely basis so that the private sector and policy-makers can take corrective action to support financial stability.

Let me acknowledge upfront that this task is complex. While macroeconomic models have long been used to guide monetary policy decisions by central banks, models of financial stability and systemic risk are much less advanced.

In my remarks today, I want to talk about the progress that we have made at the Bank in modelling risks to the financial system. I will start by briefly describing the notion of systemic risk and various approaches used to identify and measure it. I will then discuss two state-of-the-art quantitative models that we have developed to improve our assessment of risks to the Canadian financial system.

The multiple dimensions of systemic risk

Systemic, or system-wide, risk goes beyond individual institutions and markets. It is the risk that the financial system as a whole becomes impaired and that the provision of key financial services breaks down, with potentially serious consequences for the real economy.

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[1] Bank of Canada annual conference on "The Evolving Financial System and Public Policy" held in December 2003 in Ottawa.

Systemic risk manifests itself in different ways. There is a time dimension, which refers to the accumulation of imbalances over time, and a cross-sectional dimension, which refers to how risk is distributed throughout the financial system at a given point in time.

Procyclicality is the key issue in the time dimension. It reflects the tendency to take on excessive risk during economic upswings – too much punch from the punchbowl, if you will – and to become overly risk averse during the downturns. Procyclicality makes the financial system and the economy more vulnerable to shocks, and increases the likelihood of financial distress.

Risk concentrations and interconnections are the key issues in the cross-sectional dimension. Financial institutions can have similar exposures to shocks or be linked through balance sheets. As a result, losses in one institution can lead to fears of contagion that amplify the adverse effects of the initial shock. For instance, uncertainty about the viability of counterparties can lead to hoarding of liquidity, which may seem like an appropriate action for the individual institution but can have disastrous consequences for the financial system as a whole.

System-wide surveillance requires that we regularly assess the importance of various types of systemic risk. How we judge a particular risk will be based on the probability that it will lead to financial system distress, and on the extent of its impact should that distress materialize.

Early-warning indicators

A fundamental challenge is to detect the risks arising from both global and domestic sources in an environment with a vast number of potential indicators. Therefore, one direction of research at the Bank has been to isolate the key signals from this broad information set by identifying a smaller group of variables that can serve as early-warning indicators of emerging imbalances.

Since financial crises in Canada have been rare, international data are used to help establish numerical thresholds for each domestic indicator. For example, if international evidence suggests that credit growth above a certain rate tends to be associated with increased risk, then a period with credit growth above the threshold would suggest an elevated probability of financial stress. Selecting the level of thresholds involves a difficult trade-off between false alarms and failure to signal an event, so in practice the early-warning indicators are used mainly to identify areas where more detailed investigation may be warranted. They provide an objective, practical starting point to detect the buildup of imbalances in the financial system.

One early-warning indicator that we regularly track is the deviation of the aggregate private sector credit-to-GDP ratio from its trend (the credit-to-GDP gap), which serves as a rough measure of excessive leverage across the financial system (***Chart 1***). This indicator has been shown to provide some leading information as a predictor of banking crises, and has been proposed by the Basel Committee on Banking Supervision (BCBS) as a useful guide for decisions about when to activate the countercyclical capital buffer – an important macroprudential policy instrument in the Basel III agreement.[2]

Given the complexity of systemic risk, it is unrealistic to expect a single measure or indicator to serve all purposes. Combining indicators can produce better signals with fewer false alarms and undetected crises. For example, research shows that combining the

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

credit-to-GDP gap with a measure of real estate prices produces an indicator that performs better than either variable on its own.[3]

Our own work at the Bank reinforces findings elsewhere that aggregate private sector credit and real estate prices are among the most reliable indicators of financial stress.

Identifying sources of risk is essential, but so is determining the likelihood that these risks will materialize. Therefore, another important aspect of ongoing research is the development of statistical models to help us forecast the probability that a crisis will occur based on a group of indicators.[4]

Macro stress tests

Early-warning indicators are useful to gauge the probability of financial stress, but a thorough assessment also requires an analysis of what could happen if the risk materializes. This is the goal of macro stress testing.

A good part of the Bank's efforts in recent years has been devoted to developing and refining stress-testing models. This class of models takes a large but plausible macroeconomic shock as a starting point and analyzes its impact on the balance sheets of banks or other sectors of the economy.

The Bank now has two main stress-testing models to help monitor risks to the financial system. These models can also be used to assess the potential impact of policy tools or regulatory actions in mitigating financial system risks.

Assessing risks from elevated household debt

The first, the Household Risk Assessment Model, or HRAM, is a microsimulation model that assesses how the debt burden of Canadian households can affect financial stability. Using microdata from household balance sheets, the model allows us to estimate how various shocks would affect the distribution of debt within the household sector. The simulations take into account changes over time in individual debt levels, as well as changes in household wealth from savings and fluctuations in the value of financial assets. Tracking the asset side of household balance sheets gives us a more accurate picture of systemic risk since changes in wealth affect households' ability to pay their debt.

Household vulnerabilities depend not only on the average level of debt, but also on how debt is distributed across individuals. One strength of the model is precisely its ability to account for this distribution. For instance, while record-low interest rates in recent years have contributed to a relatively low aggregate household debt-service ratio, the share of Canadian households that are considered most vulnerable – those with a debt-service ratio equal to or higher than 40 per cent – has climbed to above-average levels, as has the proportion of debt held by these vulnerable households (***Chart 2***).

Using HRAM, we estimate that if interest rates were to rise to 4.25 per cent by mid-2015, the share of highly indebted households would rise from slightly above 6 per cent in 2011 to roughly 10 per cent by 2016, while the proportion of debt held by these households would rise from 11.5 per cent to about 20 per cent over the same period.

So while the aggregate household debt-service ratio paints a somewhat rosy picture, taking into account distributions gives us a clearer and more cautionary indication of how vulnerable our financial system actually is to household debt.

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[3] See C. Borio and M. Drehmann, "Assessing the Risk of Banking Crises – Revisited," BIS Quarterly Review (March 2009): 29–46. The Bank of Canada is also conducting research on approaches to combine indicators.

[4] For example, logit and probit models are used widely to calculate the probability of a crisis.

Another strength of the model is that it provides a flexible tool for simulating the impact on household solvency of a wide range of potential shocks, such as an increase in unemployment. HRAM indicates that household loans in arrears would more than double under a severe labour market shock similar to that observed in the recession of the early 1990s.

Despite the model's strengths, we continue to enhance our analysis by improving HRAM. Expanding the behavioural aspects of the model is one way to do this. For instance, the model currently allows distressed households to pay their debts by selling their liquid assets, but not their homes. Work is also under way to improve the design of the shock scenarios.

Results of stress tests using HRAM are regularly reported in the Bank's *Financial System Review* and constitute an important element of our overall assessment of the risks associated with household finances.

Assessing contagion effects in the banking system

HRAM provides invaluable information on vulnerabilities in the household sector, but the Bank is also interested in assessing risks more broadly within the Canadian financial system. To this end, we have been working for several years on developing a MacroFinancial Risk Assessment Framework (or MFRAF).[5]

Drawing on detailed data from bank balance sheets, MFRAF is a quantitative model that tracks the contribution of individual banks to systemic risk. Traditional stress-testing models focus exclusively on solvency risk, and estimate the overall risk to the financial system by simply aggregating credit (or other asset) losses that would materialize at individual banks in the event of a severe shock. MFRAF goes beyond this traditional approach by taking into account linkages among banks arising from counterparty exposures – or network spillover effects – as well as funding liquidity risk, that is, the risk of market-based runs on banks.

The financial crisis illustrated the significant risks associated with a deterioration of funding liquidity. The collective reactions of market participants led to mutually reinforcing solvency and liquidity problems at banks around the world. As funding liquidity evaporated, many well-capitalized institutions had to take writedowns on illiquid assets, or sell them at a loss, creating uncertainty in the market about their solvency and adding to the downward pressure on asset prices.

MFRAF has been built to integrate funding liquidity risk as an endogenous outcome of the interactions between solvency concerns and the liquidity profiles of banks. This strong microeconomic foundation constitutes a major innovation in macro stress-testing models. MFRAF also incorporates network externalities caused by the defaults of counterparties, with the size of a counterparty's interbank exposures increasing the likelihood of spillover effects.

A key lesson from the model is that failure to account for either funding liquidity risk or interbank exposures could lead to significant underestimation of the risks to the financial system as a whole if the banking system is undercapitalized and relies extensively on the short-term funding market.[6] Importantly, the loss distributions generated by the model exhibit fat tails, a key feature of the actual distribution of financial system risks (***Chart 3***).[7]

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[5] Work on MFRAF started in 2006, ahead of the 2007 IMF-FSAP exercise for Canada which involved the assessment of the Canadian banking sector using a credit-risk model only. The analytical foundation of MFRAF is based on the work by S. Morris and H. S. Shin, "Illiquidity Component of Credit Risk," Princeton University, 2009, which provides a theoretical framework for roll-over risk, and by F. Allen and D. Gale, "Financial Contagion," Journal of Political Economy 108, 1 (2000):1–33, which explores the spread of contagion in a banking network.

[6] This hypothetical banking system consists of six major banks whose main balance-sheet parameters (capital ratio level, reliance on short-term funding and holdings of liquid assets) are in line with those observed in 2007

The fact that the model is able to replicate this important stylized fact demonstrates that it has significant potential as a tool for assessing systemic risk. Nevertheless, while MFRAF is already somewhat complex, the layers of interaction will need to be further augmented. For instance, the model misses any negative feedback that could occur between heightened risks to the banking system and the real economy. The model could also be expanded over time to include other types of financial institutions and markets.

Compared with other approaches that use market-based data, such as the asset-pricing approach, the transmission channel in models like MFRAF is transparent, and this improves our interpretation of results. Because of this "story-telling" ability, many central banks have begun to use this type of framework in their financial stability analysis.[8]

In addition to assessing risks, MFRAF can be used to examine the merits of policy or regulatory initiatives such as capital and liquidity rules. As the model becomes more refined, the objective is to use it more to complement other existing macro stress-testing exercises and to sharpen our analysis and communication of risks in the Bank's *Financial System Review*.

Conclusion

Let me conclude.

The Bank of Canada is conducting extensive research into finding methodologies and tools to identify and measure systemic risk.

While work in this area is extremely complex, the Bank has made substantial progress in recent years. We now have two state-of-the art models. And with HRAM, the Bank of Canada is one of the few central banks at the leading edge of using microsimulation models to assess vulnerabilities in the household sector.

Our efforts to build these models have provided us with important lessons.

First, distributions matter – we cannot rely solely on aggregate data: distributional features and complex interactions are very important for assessing risks. This means developing models that capture these effects. Our household simulation model is aimed directly at understanding how the distribution of debts, assets and income affects financial stability. MFRAF uses information about the interconnections of individual financial institutions because these can lead to non-linear network effects that are also important for assessing systemic risks.

Second, predicting behaviour under stress conditions is very difficult. Models need to be able to handle a variety of "what-if" scenarios corresponding to different assumptions about behaviours under stress.

Finally, we need to consider the many different sources of risk to the financial sector and take into account their cumulative effects and interactions; otherwise we may underestimate risks.

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for international banks that were bailed out during the crisis. See C. Gauthier and M. Souissi, "Understanding Systemic Risk in the Banking Sector: A MacroFinancial Risk Assessment Framework," Bank of Canada Review (Spring 2012): 29–38.

[7] See A. Haldane, "Tails of the Unexpected," speech to the University of Edinburgh Business School, 8 June 2012).

[8] See C. Borio and M. Drehmann, "Assessing the Risk of Banking Crises - Revisited," BIS Quarterly Review (March 2009): 29–46. Also see A. Foglia, "Stress Testing Credit Risk: A Survey of Authorities' Approaches," International Journal of Central Banking 5, no. 3 (2009): 9–45.

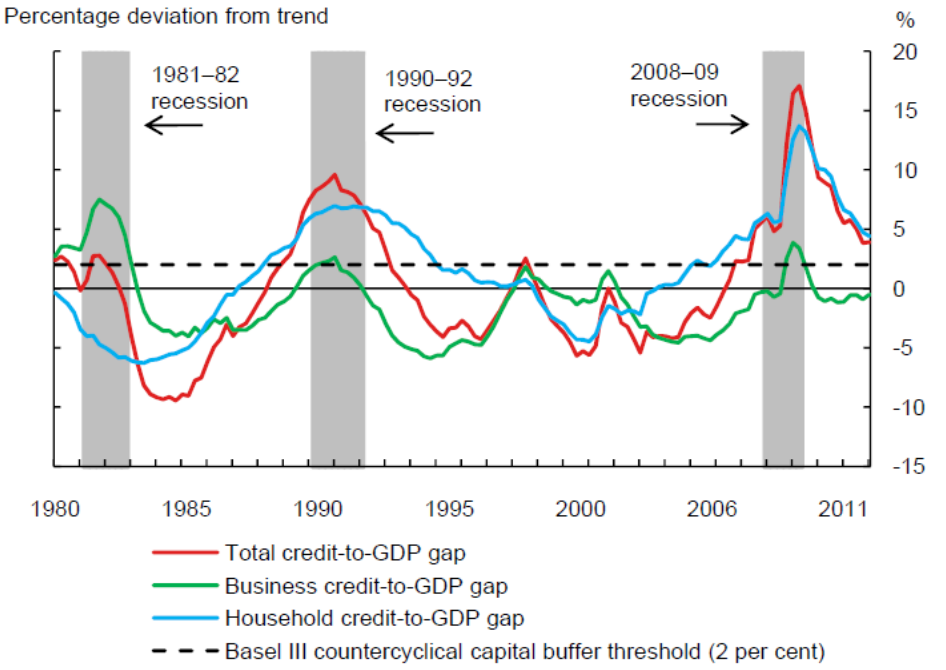
Obviously, quantitative measures alone will never be enough to get a complete picture, especially since the financial system evolves rapidly. Intelligence gathered from discussions with the financial sector, as well as information shared with other policy-makers and supervisors here in Canada and in the international community, will always be critical to the overall assessment of the risks.

While we are making progress, it is important to remember that financial system modelling is still in its infancy. The goal – understanding, preventing, and reducing systemic |risk – deserves our attention, diligent research and hard work.

It has been my pleasure to share some of the Bank's efforts with you today.

Thank you very much.

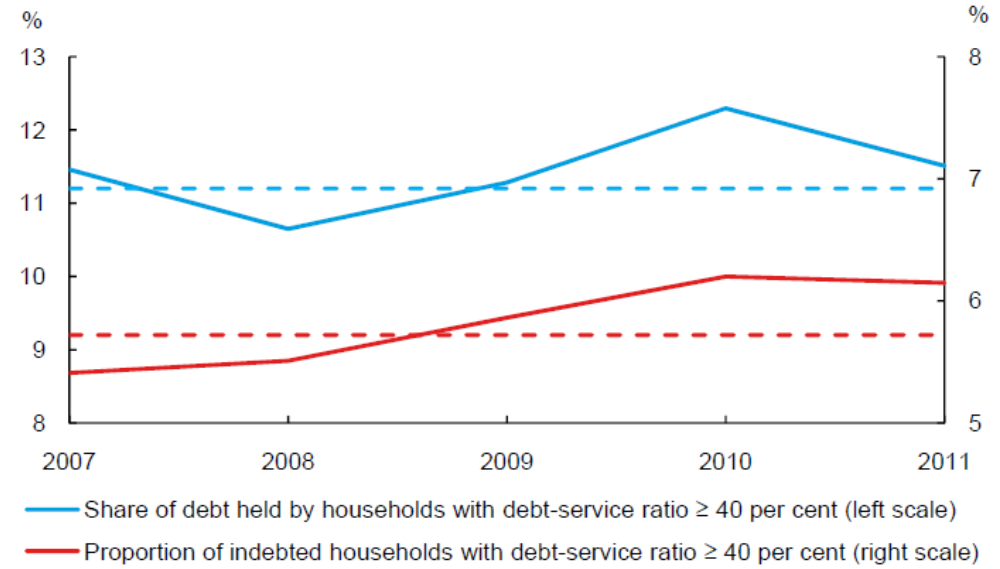
Chart 1: The Aggregate Credit-to-GDP Gap Has Declined but Remains High



Sources: Statistics Canada and Bank of Canada calculations

Last observation: 2012Q1

Chart 2: Vulnerability Measures Based On Household Microdata Are Elevated



Note: Broken lines indicate historical average from 2002 to 2011.
Sources: Ipsos Reid and Bank of Canada calculations

Last observation: 2011

Chart 3: Loss Distributions of a Hypothetical Banking System for Various Groups of Risks