Developing a Framework to Assess Financial Stability: Conference Highlights and Lessons

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The Bank of Canada hosted its sixteenth annual economic conference in Ottawa on 7 and 8 November 2007. Papers and discussions presented by an international group of economists focused on such topics as stress testing financial systems, models for assessing risks to financial stability, and the effects of linkages among payment, clearing, and settlement systems.

Developing a framework to assess financial stability is an important subject for central banks, both because of their involvement in various aspects of the work on financial system stability and because the framework currently in place is still rather rudimentary. On the monetary policy side, clear policy strategies have been identified and are supported by well-developed macroeconomic models; central banks are still defining their approach to questions of financial stability, however, and are at an early stage in the development of useful models. The objective of the conference was to stimulate progress in further developing the financial-stability framework.

In this article, we report on conference highlights and propose directions for future research on financial-stability issues. We begin by reporting on the experiences of central banks with stress-testing exercises performed in the context of the International Monetary Fund's (IMF) Financial Sector Assessment Program (FSAP), which is designed to help countries identify vulnerabilities in their financial system and to determine necessary reforms. Recent FSAP work on stress testing provides a good illustration of the progress that has been made in financial-stability analysis and clearly points to various areas where progress is needed. This is followed by a discussion of each of the three frameworks proposed by conference participants as having good potential to generate such progress: the contingent-claims-analysis (CCA) framework, the semi-structural framework, and structural financial-stability models. We then report on discussions about the implications for financial stability of linkages among payment, clearing, and settlement systems.[1] We conclude with some suggestions for future research priorities.

Experiences with FSAP Macro Stress Testing

In 2006, Canada invited the IMF to examine the country's financial system under its FSAP. An important component of FSAP was a stress-testing exercise to assess the ability of Canada's financial system to resist various adverse shocks and to respond to a scenario representing a disorderly resolution of global imbalances. As a key participant in the stress-testing exercise, the Bank of Canada organized a panel session at the conference on central banks' experiences with FSAP

1. The full text of selected conference papers and some of the discussants' presentations are available on the Bank's website at <http://www.bankofcanada.ca/en/conference_papers/econ_conf07/papers.html>. A partial list of the conference papers and presentations is provided at the end of this article.

stress testing, with the objective of sharing experiences and identifying strengths and areas for improvement. In a session open to all conference participants, central bankers from Australia, France, Denmark, and Canada made short presentations that were intended to stimulate discussion among participants.

Stress testing will be an important component of the framework, since it can be used to assess the financial system's robustness to negative shocks and scenarios.

The four countries have shared similar FSAP experiences, which included using single-factor shocks and macroeconomic scenarios to assess the stability of financial systems. While single-factor shocks have focused on liquidity and market risks, macroeconomic scenarios have focused on credit risk. The choice of shocks and scenarios to be simulated emerged from discussions between the IMF and the various national authorities. Among the single-factor shocks were sudden interest rate changes and abrupt illiquidity in certain markets. As for the macroeconomic scenarios, central banks have often taken the lead in designing the details of scenarios that have been agreed upon with the IMF. For instance, the Bank of Canada used its version of the Global Economy Model (BoC-GEM) to design a coherent scenario of a disorderly resolution of global current account imbalances (Coletti et al. 2007).[2] This macro scenario was supplemented with single equations linking sectoral default probabilities with macroeconomic variables (Misina and Tessier 2007).[3] In some cases, developing the macroeconomic scenario(s) has been a joint effort by various authorities. In Australia, for example, developing the macroeconomic scenarios (sharp decline in house prices, difficulties experienced by banks in obtaining foreign funding) was a joint effort by the Treasury, the prudential regulator, and the central bank (Aylmer 2007).

Bottom-up and top-down approaches have been used to simulate the impact of shocks and scenarios on financial institutions. In a bottom-up approach, simulations are performed by financial institutions with their own internal models. In a top-down approach, the IMF and / or the national authorities use their models and the information they have about financial institutions' exposures to measure the impact of shocks and scenarios. In most cases, top-down and bottom-up approaches have produced similar results. An exception was Denmark where, because of differences in assumptions concerning loss-given default, top-down results showed more severe outcomes for financial institutions (IMF 2007; Lund 2007).

There was general agreement at the conference that there are significant net benefits from participating in FSAP stress testing. It can promote co-operation among the various government authorities involved and improve communication between these authorities and financial institutions. It can also reveal useful information about the exposure of financial institutions to various types of risk and stimulate the development of stress-testing tools.

Of particular interest will be stress-testing methods that can be used to assess potential contagion risks and feedback effects between the financial system and the real economy.

The FSAP stress-testing exercises discussed at the conference show that much progress has been made in developing macro stress-testing tools. Only a few years ago, macro stress testing could not have been performed in most countries; now, useful tools are available to assess credit risk in banks' loan portfolios. Nevertheless, current tools have important limitations. In particular, existing bottom-up and top-down approaches do not allow for an integrated analysis of the types of risk affecting financial institutions (market, credit, liquidity, etc.). In practice, these risks are likely to be correlated, which could accentuate the impact of severe negative shocks. As well, existing tools do not factor in contagion effects between various components of the financial system and feedback effects between this system and the real economy. Since the models used by financial institutions are not likely to include feedback and

2. The approach to monitoring and analyzing international risks that is presented in Maier, Paulin, and Santor (2007) shares common characteristics with the approach used for Canada's FSAP stress testing: risk identification, development of a macroeconomic scenario with a structural model, and analysis of the potential implications of the scenario.

3. An alternative approach to modelling default probabilities was presented at the conference by Jiménez and Mencía (2007).

contagion effects, factoring in these effects could be a significant contribution of top-down approaches. Finally, the links between the macro models used to design the scenarios and the tools used to assess their impact on financial institutions tend to be ad hoc.[4]

The Contingent-Claims-Analysis Framework

A contingent claim is a financial asset whose future payoff depends on the value of another asset. The best-known contingent claim is an option—the right to buy or sell a specified asset at a pre-specified exercise price, by a certain expiration date. When applied to the analysis and measurement of credit risk at the firm level, the CCA is commonly called the Merton model. Gray, Merton, and Bodie (2002) proposed an extension of the CCA to generate a risk-adjusted balance sheet at the national level where the sectors of the economy are viewed as interconnected portfolios of assets, liabilities, and guarantees.[5]

Gray, Merton, and Bodie (2007) presented applications of such a framework to Chile and proposed different ways of doing stress testing through the estimation of reduced-form equations or factor models linking the risk indicators identified by the CCA to macro variables. The last section of their paper discusses ways of integrating indicators of financial risk (such as those generated by the CCA) with monetary policy models. The discussant, Jack Selody, was of the view that the CCA approach is promising, in particular because it allows for a clear quantification of default risks and can be a good monitoring tool. He noted important limitations of this approach, however, including that it does not explicitly model the behaviour of economic agents and is not able to factor in the role of policy instruments. Pierre Duguay commented that, while instructive, the sectoral aggregation proposed by Gray, Merton, and Bodie could not be used to identify important sources of financial stress, such as loss of confidence in counterparties.

Souissi (2007) uses the CCA to evaluate the risks in the Canadian mortgage portfolio. He calculates the probability of default for different loan-to-value (LTV) ratios and combines them with the distribution of Canadian mortgages by LTV to obtain an estimation of the overall rate of default in the mortgage portfolio. Souissi also analyzes the impact of changes in housing prices on the decision to default. The model could be used to assess the impact of changes in the LTV distribution on the level of risk in the mortgage portfolio.

Tools based on the contingent-claims analysis are worth developing further because they provide a useful framework to monitor and quantify default risks.

Allenspach and Monnin (2007) use the CCA to shed light on two questions: What is the impact of international integration on banks' exposure to shocks between 1993 and 2006? And what is its impact on systemic risk in the international banking sector? To answer the first question, they analyze the evolution of the correlations between banks' asset-to-debt (AD) ratios using a new method to estimate the joint dynamics of the AD ratios of all banks. To answer the second question, they analyze the evolution of an index of systemic risk proposed by Lehar (2005). Lehar's index measures the probability of observing a systemic crisis (defined as a given number of simultaneous bank defaults) at a given time. Both the AD ratio and Lehar's index are based on the market value of banks' assets assigned by the Merton model. As well, the authors try to determine whether there is a link between banks' common exposures and systemic risk. Their findings are that: (i) common exposures have decreased in the first part of the sample and increased in later parts; (ii) there is no significant trend in their measure of systemic risk; and (iii) common exposures as measured by correlations between banks are not a reliable measure of systemic risk. Discussant Ramdane Djoudad emphasized the difficulty of translating linear correlations into non-linear measures of systemic risks.

In summary, the CCA approach appears particularly useful for measuring and monitoring default risk, at least as perceived by the market. It is likely, however, to be of limited use in the study of stress scenarios.

The Semi-Structural Framework

The potential for contagion between financial institutions may have increased with the size and complexity

4. de Bandt (2007) presented work to better link developments in the corporate debt market to implied stress-testing scenarios and their impact on French banks.

5. For an application to the Canadian business sector, see Kozak, Aaron, and Gauthier (2006).

of their interconnections. One goal of the semi-structural framework is to integrate some of the potential contagion channels that exist between financial institutions. A first channel comes from direct balance-sheet interlinkages between financial institutions, i.e., distress at one bank may cause distress at another because of mutual exposures. A second channel for contagion is the impact of fire sales of the assets of a distressed institution on both its own marked-to-market balance sheet and on those of other institutions holding the same class of assets.

Cifuentes, Ferrucci, and Shin (2005) discuss the case where a bank that fails to meet its regulatory capital ratio may feel the need to sell some of its liquid assets in order to reduce the size of its balance sheet. If this is not sufficient, illiquid assets may have to be sold. Because of their illiquidity, their price goes down in a non-linear way with the amount sold.[6] This could affect the balance sheet of other institutions so that they would also fail to meet their minimum capital requirement and, in turn, would need to take measures to reduce the size of their balance sheets.

Pier Allessandri (Bank of England) presented work that explicitly integrates these two channels into a quantitative framework for gauging systemic risk. He also suggested ways to quantify the impact on banks' balance sheets of macro credit risk, interest income risk, and market risk.[7]

Frisell et al. (2007) adopt a method proposed by Elsinger, Lehar, and Summer (2006) to analyze the stability of the Swedish banking system, relying mostly on market data. Their approach captures both correlated exposures of banks and mutual credit exposures that can cause domino-effect insolvencies. The main contribution of the paper by Frisell et al. is on the data side. The four largest banks, representing 80 per cent of total bank assets in Sweden, have reported their 15 largest counterparty exposures since 1999. Data include both on- and off-balance-sheet items, such as credit commitments, guarantees, derivatives, etc. Exposures between banks are found to be very asymmetric and to vary considerably over time. Frisell et al. find that although the use of entropy maximization to estimate bilateral exposures on the basis of aggregate exposures may be the best possible approach when bilateral exposures are not disclosed, it may underestimate the largest exposures and contagion risks.

Céline Gauthier expressed reservations about the approach used by Frisell et al. First, some double counting may occur, since publicly known interbank exposures should already be integrated in market prices. This would lead to some overestimation of risk. Second, stress testing based on Monte Carlo simulations of the multivariate distribution of asset correlations does not allow for explicit linkages between the real economy and the banking system, whereas a balance-sheet approach, such as the one followed by Allessandri, does.

The semi-structural framework offers some promising developments for the analysis of various types of contagion effects.

The semi-structural framework seems to have good potential for addressing some of the present weaknesses of the models and approaches used to analyze financial-stability risk. In particular, it offers some promising developments for the analysis of various types of contagion effects. Nevertheless, its main limitations are that it is not always based on well-specified microfoundations, and it may not account for feedback effects between the real economy and the financial sector. An objective of structural financial-stability models is to address these limitations.

Structural Modelling

Dimitrios Tsomocos presented results based on a calibrated version of the Goodhart, Sunirand, and Tsomocos (2006) model. This is a microfounded general-equilibrium model with endogenous default and heterogeneous agents, which treats banks' defaults as an equilibrium phenomenon. Policy instruments are factored in, notably through capital-adequacy requirements.

Aspachs et al. (2007) suggest ways to assess the stability of the overall banking system using a two-factor model that includes banks' default rates and profitability. At this stage, both indicators are based on market data: The probability of default is estimated from CCA-based distance-to-default data calculated by the IMF,

6. In its current applications, an ad hoc non-linear inverse demand curve is assumed for the illiquid assets.

7. The paper is currently not available.

and profitability is represented by equity values. The authors use a reduced-form vector-autoregression approach to evaluate the impact of the two financial-fragility "factors" on output. In his discussion of the paper, Césaire Meh stressed that the model included a large number of free parameters and that the exclusive focus on banking intermediation was at variance with increasingly market-based financial systems. He expressed concern that the empirical reduced-form applications of the model might have only weak links with the theoretical model. He also indicated that capital ratios could be determined endogenously by banks and were not entirely determined by regulators. During the final panel discussion, Charles Goodhart and Pierre Duguay agreed that the focus on banks was fully warranted, given their role in providing the means of payment.

The existence of coordination failures and the "special" role for money in the business cycle and in macroeconomics were highlighted by David Laidler as arguments in favour of a role for the central bank as lender of last resort (LLR) and, therefore, for the development of models with a non-trivial monetary / financial sector. In his John Kuszczak Memorial Lecture, Laidler reviewed economic history back to the early nineteenth century. A general theme was that, historically, the business cycle was actually considered a credit cycle. Nowadays, the success of central banks in maintaining price stability should pave the way for them to take a more active role in the area of financial stability. Indeed, both the monetarist tradition, which stresses the possible discrepancy between the supply of and demand for money, and the Wicksellian tradition, which highlights discrepancies between savings and investment (a form of coordination failure), indicate that stabilizing the inflation rate is not sufficient to stabilize the real economy and eliminate the risk of financial instability.

Several contributors picked up on the observation made by both David Laidler and Charles Goodhart that, in the absence of default risk (i.e., if borrowers would repay their debt with certainty), there would not be any need for money. This calls for augmenting the dynamic-stochastic general-equilibrium model currently used with success in the analysis of price stability by incorporating the risk of default. The analysis of financial stability would require investigating additional transmission channels (such as the financial accelerator), constructing richer models than representative-agent models, and considering the difference in behaviour between "tranquil" and "crisis" periods. The need to capture the amplifying effect triggered by fluctuations in financial prices was also a joint conclusion of the three final panellists.

Payment, Clearing, and Settlement Systems

Conference participants also investigated a third theme: how systemic risk may arise from the transmission of shocks in payment, clearing, and settlement systems. Different papers addressed these issues through the lens of liquidity management, which appeared to have been crucial during the subprime crisis and is characterized, among other things, by a reduced willingness of financial institutions to transact with other participants. Liquidity is a broad concept, however. Payment and settlement systems are usually not the primary sources of liquidity shock, even if they might transmit shocks across banks or market participants, particularly in cases where, by delaying payments, participants create system gridlock. From that point of view, payments-system experts observed no unusual behaviour in the subprime crisis, although caution is still warranted.

Given their significant role in linking the components of the financial system, it is important that further progress be made in the research on payment, clearing, and settlement systems.

Several perspectives on these systems were reflected at the conference. First, Larry Radecki presented the provisional conclusions of the "Report of the Working Group on System Interdependencies,"[8] one of which is that, given the complexity of current payment and security settlement systems, participants often have little information on the other participants and on the degree of interdependencies among them (CPSS 2007). Its most surprising result is that large global banks do not pose a high degree of risk, since most of them operate through correspondents in foreign countries and have limited direct linkages with payment and security systems. Discussant Charles Freedman commended the report for providing a useful taxonomy,

8. The paper is currently not available.

including a three-by-three matrix distinguishing these interdependencies along two dimensions: the form of interdependence (system, institution, and environment) and the type of relationship (clearing and settlement, risk management, and operational relationships). He pointed out, however, that the report focused on benign conditions, but said little about crisis periods.

Second, Bech, Chapman, and Garratt (2007) addressed the issue of the liquidity in payment systems, with reference to the Canadian Large Value Transfer System. The two main innovations of the paper are that it formally models the network of relations among banks in the payment system, and it estimates the main parameters of this model. Liquidity is determined by bilateral credit limits and by self-generated credit created by the bank's ability to delay payments. Using the special mathematical properties of the payment network (i.e., the structure of flows among banks), the authors manage to estimate the stationary structure of the network, as well as the degree of delay in processing the payment orders.

Commentator Thorsten Koeppl congratulated the authors for the originality of their approach and the focus on the delay parameter, which is indeed crucial. This stands in contrast to traditional methods, where the resilience of the network is generally assessed through its response to simulated shocks. Indeed, the ability of banks to slow outgoing flows has often been acknowledged as creating gridlock in payment systems and, hence, systemic risk. Nevertheless, beyond its mathematical complexity, the model is only descriptive and does not explain the behaviour behind the delay parameters. Banks may delay in response to either shocks or heterogeneous characteristics, which may depend on size or competition. From a policy perspective, this limits the conclusions that can be drawn from the model.

The issue of liquidity was also the central question investigated by Schanz (2007), although with particular emphasis on foreign exchange (FX) transactions. Schanz considered how the coordination of liquidity management within financial institutions affects the transmission of liquidity shocks, using a model that compares local banks to a global bank with subsidiaries. He addressed the very topical issue of possible market failure in the domestic interbank market (resulting from adverse selection), which might prevent liquidity-rich banks from lending to liquidity-strapped banks. His main conclusion is that, for financial institutions, going global implies an increased risk of technical defaults, because banks with high solvency risk would not be able to refinance themselves, either domestically or via FX transactions, in response to liquidity outflows. This is partly offset, however, by a lower transmission of losses within and across systems. In her comments, Alexandra Lai notably stressed the need to take into account market structure, which can affect how funding decisions are made during a crisis, and the need to look at various types of shocks (in particular, global liquidity shocks).

Conclusion

This sixteenth annual Bank of Canada economic conference provided an opportunity for researchers to exchange information on the various strands of research that are contributing to the development of a framework to assess financial stability.

There is no doubt that stress testing will be an important component of the framework, since it can be used to assess the financial system's robustness to negative shocks and scenarios. Significant progress has been made in the development of stress-testing methods, including some that have been used in FSAP exercises. Various areas for further improvement remain, however. Of particular interest will be methods that could be used to assess potential contagion risks and feedback effects between the financial system and the real economy. As well, the various types of risk need to be better integrated into the analysis. Some of the conference papers, in particular those using a semi-structural, network-based approach, demonstrate the significant progress being made in both the analysis of contagion channels and in integrating the analysis of different types of risk.

Structural general-equilibrium models could also be used to perform macro stress testing. The general-equilibrium model presented at the conference by Goodhart, Sunirand, and Tsomocos (2006) incorporates many of the desirable features of a stress-testing model. The model is very complex, however, and seems difficult to calibrate or estimate with actual data. As well, there may be considerable distance between the more theoretical general models and the versions to be used with actual data. More work is needed in evaluating and developing this type of model.

The contingent-claims analysis suffers from some limitations. In particular, it does not explicitly model the behaviour of economic agents and is of limited usefulness in performing stress-testing, or counterfactual, exercises. Nevertheless, it provides a useful framework to monitor and quantify default risks. For

this reason, we believe it is worth developing further, although it should not be a main focus of our research efforts.

Finally, given their significant role in linking the components of the financial system, it is important that further progress be made in the research on payment, clearing, and settlement systems. The functioning of these systems is conditioned by the behaviour of economic agents, indicating that these behaviours need to be modelled explicitly. As well, given that there can be feedback effects between these systems and the rest of the financial system, we believe that these effects should be factored into future research.

While significant progress has been made in recent years towards the development of a framework to assess financial stability, much remains to be done, and this field of research should remain an exciting one.

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Conference papers, as well as commentary provided by the discussants, are available at <http://www.bankofcanada.ca/en/conference_papers/econ_conf07/papers.html>.

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