BANK OF CANADA
BANQUE DU CANADA

Bank of Canada Review

Autumn 2013

Articles

Monetary Policy Decision Making at the Bank of Canada 1
John Murray

Assessing Financial System Vulnerabilities:
An Early Warning Approach 10
Gurnain Pasricha, Tom Roberts, Ian Christensen and Brad Howell

Fragmentation in Canadian Equity Markets 20
Corey Garriott, Anna Pomeranets, Joshua Slive and Thomas Thorn

Members of the Editorial Board

Chair: Allan Crawford

David Beers
Paul Chilcott
Don Coletti
Agathe Côté
Donna Howard
Grahame Johnson
Sharon Kozicki
Timothy Lane
Tiff Macklem
Ron Morrow
Stephen Murchison
John Murray
Sheila Niven
Lynn Patterson
Eric Santor
Lawrence Schembri
Ianthi Vayid
Richard Wall
Carolyn Wilkins

Editor: Alison Arnot

The Autumn 2013 issue is the last quarterly publication of the *Bank of Canada Review*. Starting in 2014, the *Review* will be published biannually, in May and November. Articles undergo a thorough review process. The views expressed in the articles are those of the authors and do not necessarily reflect the views of the Bank. The contents of the *Review* may be reproduced or quoted, provided that the publication, with its date, is specifically cited as the source.

For further information, contact:

Public Information
Communications Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9

Telephone: **613 782-8111**; **1 800 303-1282** (toll free in North America)
Email: **info@bankofcanada.ca**
Website: **bankofcanada.ca**

ISSN 1483-8303
© Bank of Canada 2013

Monetary Policy Decision Making at the Bank of Canada

John Murray, Deputy Governor

- Canada's monetary policy framework and the process that the Bank of Canada follows to make its decisions have evolved over time.
- The decision-making process is very information-intensive and collaborative, drawing on the expertise, judgment and analysis of many people.
- This article discusses monetary policy decision making at the Bank, focusing on how the process is organized; the key information that is collected, shared and interpreted as part of the process; and some common misconceptions about monetary policy and the factors affecting the decision-making process.

Canada weathered the financial crisis that erupted in 2007–08 better than most of its peers, thanks in part to the healthy condition of its banks, prudent regulation of the financial industry and the country's strong fiscal position, which allowed the government to implement aggressive countercyclical measures.

The Bank of Canada's monetary policy, guided by the inflation-targeting framework put in place over 20 years ago, also played a critical role in Canada's performance throughout the crisis and the recovery that followed. The Bank provided significant and timely monetary policy stimulus and, through its hard-earned credibility, helped to anchor household and business confidence during a turbulent time. The decision-making process underlying its monetary policy actions, in normal as well as exceptional periods such as the crisis, involves a great deal of consultation, research and analysis by Bank staff.

This article discusses monetary policy decision making at the Bank,[1] and touches on three related topics: (i) how the monetary policy decision-making process is organized; (ii) the information that is collected and interpreted as an important part of this process; and (iii) common misconceptions about both monetary policy and the factors affecting the decision-making process.

1 This article updates and extends a May 2012 speech of the same title (Murray 2012). It also draws extensively from Macklem (2002).

Bank of Canada Review articles undergo a thorough review process. The views expressed in the articles are those of the authors and do not necessarily reflect the views of the Bank. The contents of the *Review* may be reproduced or quoted, provided that the publication, with its date, is specifically cited as the source.

A Brief Primer on Monetary Policy

Before describing the decision-making process, it will be helpful to provide some background information on monetary policy itself.

Monetary policy in Canada has one objective—achieving and maintaining a low, stable and predictable level of inflation. This objective was formalized in 1991 in an inflation-control agreement between the federal government and the Bank of Canada. The agreement identifies a specific target for the rate of inflation—the midpoint of an inflation-control range—as well as the price index that is to be used to measure inflation. Since 1995, the target level for the inflation rate has been 2 per cent (within a control range of 1 to 3 per cent), as measured by the 12-month rate of change in the total consumer price index.

Achieving a targeted inflation rate is the best contribution monetary policy can make to the economic well-being of Canadians

Achieving a targeted inflation rate may seem like a rather narrow objective—a notion that will be revisited later—but experience has shown that this is the best contribution monetary policy can make to the economic well-being of Canadians. The greater certainty that low and stable inflation provides regarding the future path of prices allows households and businesses to make more-informed spending and investment decisions, and minimizes the inequitable impact of unexpected movements in the overall level of prices. Keeping inflation low, stable and predictable is a means to an end, not an end in itself.

Under normal circumstances, this objective is pursued using a single policy instrument or tool—changes to the overnight rate of interest.[2] The Bank sets the overnight rate, which determines the rates at which banks and other selected agents are able to borrow and lend at the shortest end of the yield curve. Movements in the overnight rate also set in motion a number of other changes throughout the economy that ultimately affect the rate of inflation.

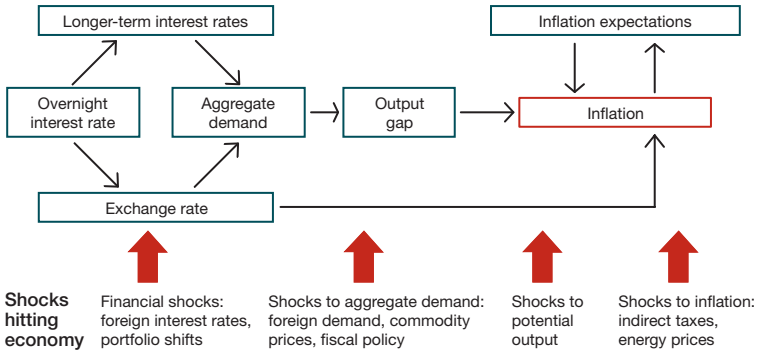
The transmission mechanism

Through the monetary policy transmission mechanism (**Figure 1**), changes in the overnight interest rate influence the interest rates that the market sets on securities further out the yield curve, as well as rates on securities with different risk and liquidity characteristics (for example, bonds, equities and mortgages). These changes also influence the exchange rate—the external value of the Canadian dollar. The resulting movements in asset prices, in turn, affect aggregate demand in the Canadian economy by influencing the spending and investment decisions of both Canadians and foreigners.

If strong aggregate demand pressures appeared likely to push output above the economy's capacity limits and lift inflation above the 2 per cent target, the Bank would respond by raising the overnight rate. This would put upward pressure on other interest rates and the exchange rate, all other things being equal, dampening aggregate demand and stabilizing inflation at the 2 per cent target. The process would be reversed if demand were too weak and inflation seemed likely to fall below 2 per cent. The overnight rate would be lowered, boosting aggregate demand and increasing inflation. It is important to note that the Bank takes a symmetric approach to the pursuit of its monetary policy objective; it is as concerned about undershooting

2 In exceptional circumstances, central banks have several other, unconventional monetary policy tools at their disposal, including quantitative easing, credit easing and conditional commitments concerning the path of future interest rates (sometimes referred to as "guidance"). These tools have been used by a number of central banks in the past five years as a means of providing additional monetary policy stimulus once the overnight interest rate approached zero and hit its effective lower bound. For more information, see Bank of Canada (2009) and Santor and Suchanek (2013).

Figure 1: The monetary policy transmission mechanism



the 2 per cent target as overshooting it. Keeping actual output at or near potential is the only way that inflation can be maintained at a low, stable and predictable level.

Establishing an explicit inflation target and consistently achieving it helps to build credibility, anchor the inflation expectations of businesses and households, and make monetary policy more effective. An explicit inflation target improves the transparency and effectiveness of the Bank's communications and also provides a direct means by which the Bank's performance can be judged, thereby improving accountability.

The Bank's job would be easy if, having achieved the target rate of inflation, it could simply leave the overnight rate of interest where it was and allow the economy to run. In reality, this is impossible. The economy is constantly being buffeted by shocks of varying size and duration from both internal and external sources. By their very nature, these shocks are difficult to anticipate. Indeed, it is often difficult to identify the nature and potential intensity of a shock until well after it has occurred. Moreover, monetary policy affects the economy with long and variable lags. Adjustments to the policy rate made now would typically take four to six quarters to have their full effect on economic activity, and six to eight quarters to have their full effect on inflation (essentially, two years). Policy therefore has to be forward looking, and policy-makers must make their decisions in conditions of considerable uncertainty.

Policy has to be forward looking, and policy-makers must make their decisions in conditions of considerable uncertainty

Fixed announcement dates

Before December 2000, the Bank had no fixed or pre-announced schedule for its interest rate decisions. Instead, it stood ready to move whenever action was deemed appropriate. While this approach may appear sensible, and certainly allowed for a great deal of flexibility, experience in Canada and elsewhere showed that it also added uncertainty to what was already a very unpredictable operating environment. Businesses, households and market participants never knew when the Bank was going to move rates. The unscheduled approach also made coordinating the Bank's forecasting and policy decision-making activities difficult.

To avoid these problems and make the process more predictable, the Bank moved to a system of fixed announcement dates (FADs). The Bank now makes its interest rate decisions on eight pre-announced dates throughout the year, with an interval of six to seven weeks between each one. In exceptional circumstances, the Bank reserves the right to change the policy rate on dates that fall outside this schedule. This has occurred on only two

occasions over the past 13 years—on 17 September 2001, following the terrorist attacks in the United States, and on 8 October 2008, as part of a synchronized policy easing with other central banks during the financial crisis.

The timing of the FADs corresponds to the release of key economic information used for the Bank's forecasting and monitoring exercises. Four of the FADs occur shortly after the publication by Statistics Canada of the quarterly National Accounts, which report on Canada's gross domestic product and its various subcomponents. The other four FADs occur midway between these dates and are also timed to coincide with the availability of important economic information.

Decision-makers at the Bank of Canada

The major participants in the decision-making process are the Governing Council, the Monetary Policy Review Committee (MPRC) and the four economics departments at the Bank.[3]

The Governing Council, which is responsible for making the interest rate decision, includes the Governor, the Senior Deputy Governor and four Deputy Governors. The MPRC, which plays an important role in the discussions leading up to the decision, consists of the Governing Council plus five or six advisers—often supplemented by one or two special advisers—as well as the chiefs of the four economics departments, the heads of the Montréal and Toronto regional offices, and other senior personnel.

The four economics departments are Canadian Economic Analysis; International Economic Analysis; Financial Stability, which focuses largely on the activities of Canadian and foreign financial institutions; and Financial Markets, which concentrates on domestic and foreign financial markets.

These participants share their information, analysis, experience and judgment with members of the Governing Council, who make the final decision. The Bank makes every effort to minimize the inherent uncertainty and risk associated with policy-making by drawing on useful information and insights that are available both inside and outside the Bank. External information includes data series from agencies such as Statistics Canada; current analysis and forecasts from other central banks, governments, international financial institutions and private sector economists; information obtained through the Bank's *Business Outlook Survey* of firms and our *Senior Loan Officer Survey* of banks; and academic research. All of this external information is combined with the contributions of Bank staff.

The Bank makes every effort to minimize the inherent uncertainty and risk associated with policy-making by drawing on useful information and insights from both inside and outside the Bank

The information that flows from all of these sources is comprehensive and diverse and contributes, at each stage of the process, to the final decision on monetary policy.

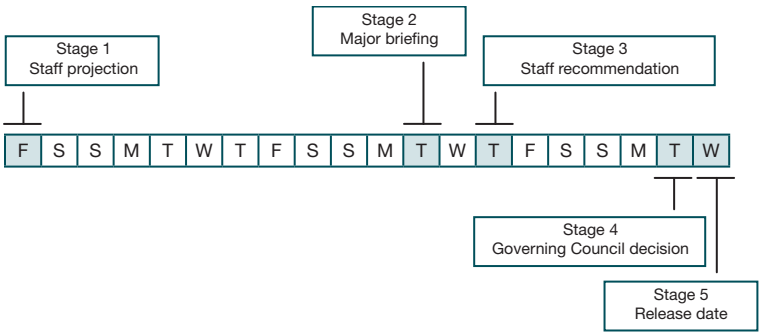
A Five-Stage Decision-Making Process

The monetary policy decision-making process comprises five key stages (**Figure 2**).

Stage 1. The presentation of the staff projection to the Governing Council occurs approximately two and a half weeks before the interest rate decision. This projection has at its centre the Bank's latest forecasting and policy

3 The exact process varies among FADs. The process described here relates to the quarterly FADs, for which a full projection exercise is conducted, following the release of Canada's National Accounts. The four FADs that occur between these projections involve fewer participants and follow a more condensed schedule.

Figure 2: The five-stage monetary policy decision-making process



simulation model, ToTEM II.[4] Results from this model are supplemented by information drawn from a number of other sources and alternative models, which examine a specific sector in greater detail (a satellite model) or view the economy using a different paradigm or set of data.[5]

ToTEM II and many of the other models used by the Canadian Economic Analysis Department rely critically on inputs provided by the International Economic Analysis Department and its global macroeconomic model, GMUSE, again supplemented by many other pieces of information and alternative models.[6] Since Canada is an open economy, international developments, such as movements in commodity prices, growth in Asian demand and prospects for the U.S. economy, play a major role in determining the path of the Canadian projection.

The combined output of all of these models and analyses is blended with judgment to produce a base-case or most likely scenario, which is presented at this first meeting with the Governing Council. A number of key risks and alternative scenarios are also identified at this meeting. Staff then work on these scenarios in preparation for Stage 2, the major briefing.

Stage 2. While Stage 1 involves mainly the Canadian Economic Analysis and International Economic Analysis departments, the major briefing, which occurs approximately one and a half weeks later, draws importantly on all four economics departments. There are six key inputs to this meeting:

(i) an updated monitoring of economic developments and risks;

(ii) the *Business Outlook Survey*, compiled by the Bank's five regional offices;

(iii) a report focusing on capacity pressures and alternative indicators of inflation;

(iv) an analysis of money and credit conditions;

4 The acronym stands for Terms-of-Trade Economic Model, version II. For more information on ToTEM and ToTEM II, see Fenton and Murchison (2006); Murchison and Rennison (2006); Dorich, Mendes and Zhang (2011); and Dorich et al. (2013).

5 For descriptions of alternative models that the Bank uses in its analysis of current economic conditions, see Binette and Chang (2013) and Granziera, Luu and St-Amant (2013).

6 GMUSE has been the main projection model used in the International Economics Analysis Department since 2011. It is a macroeconomic model comprising blocs for the United States, the euro area, Japan, China and the rest of the world. See Blagrave, Godbout and Lalonde (forthcoming) for a discussion of GMUSE, and Barnett and Guérin (2013) for a description of other models used for monitoring key foreign economies.

(v) the Bank's *Senior Loan Officer Survey*; and

(vi) an overview of financial market conditions and monetary policy expectations in Canada, the United States and the rest of the world.

Stage 3. The final policy recommendations of staff are typically presented on a Thursday, two days after the major briefing. A senior member of the Canadian Economic Analysis Department or International Economic Analysis Department summarizes and updates the outlook and risks that have been presented in stages 1 and 2, and provides a recommendation regarding any policy action to be taken. The overview and recommendation serve as the starting point for an extensive discussion by the entire MPRC. Tactical and communications issues associated with various policy options are then reviewed, based on a note prepared by the Financial Markets Department. The meeting concludes with each member of the MPRC, except for the six Governing Council members, providing a policy recommendation.

Stage 4. The Governing Council decision-making process begins on Thursday afternoon, immediately after the Stage 3 discussions, and resumes on the following Monday. Members of the Governing Council review the information and recommendations that they have received, exchange views, and explore any outstanding issues and differences in opinion. Further discussions are held on Tuesday, a decision is reached by consensus, and a press release is drafted and approved.

Stage 5. The final stage of the process focuses on the publication of the press release at 10 a.m. on Wednesday, announcing the Bank's decision and explaining the reasons behind it. Four times a year, this message is reinforced and expanded on with the synchronous release of the *Monetary Policy Report*, which provides a more detailed account of Canadian and global economic developments, the Bank's projections, and the major upside and downside risks that could affect the inflation outlook.

In addition to the *Monetary Policy Report*, two other publications are released four times a year, approximately one week before the interest rate decision. The *Business Outlook Survey* summarizes the results of the quarterly interviews that the Bank's five regional offices conduct with a representative sample of businesses across the country. This survey is an important complement to the other material that the MPRC and the Governing Council rely on and serves as a "reality check" on regional economic developments. The second publication is the *Senior Loan Officer Survey*, which is based on interviews conducted with major banks and financial institutions in Canada to determine whether lending conditions for businesses have eased or tightened in the previous three months.[7]

The final elements of the Bank's communication effort around the four issues of the *Monetary Policy Report* are a press conference by the Governor and the Senior Deputy Governor, as well as their appearances before the House of Commons Standing Committee on Finance and the Senate Standing Committee on Banking, Trade and Commerce.

The Bank places a great deal of importance on communication. It is a critical part of our accountability to Canadians and enhances the effectiveness of monetary policy by increasing the public's understanding of the economy and our actions.

7 These publications are part of the information presented at the major briefing. See the key inputs to Stage 2.

Five Common Misconceptions About Monetary Policy

Despite the Bank's emphasis on communication and the considerable time that is devoted to these activities, there is often some confusion about the objectives that underlie the Bank's decision-making process and about the constraints that some observers mistakenly assume limit the Bank's scope for independent action. Following are five of the most common misconceptions and the Bank's response to them.

Misconception 1: Monetary policy in Canada is essentially determined in the United States by the Federal Reserve. As a relatively small open economy, highly dependent on trade with its southern neighbour, Canada has no choice but to follow the Federal Reserve's lead.

The Bank pursues an independent monetary policy that is tailored to the conditions prevailing in the Canadian economy in order to achieve the 2 per cent inflation-control target. This independence is possible because Canada has a separate currency and a flexible exchange rate. If we had a common currency and/or a fixed exchange rate, this would not be the case. There have been notable differences in Canadian and U.S. interest rates over time, reflecting the varying economic circumstances in each country and differences in the appropriate monetary policy settings.

◂ *The Bank pursues an independent monetary policy that is tailored to the conditions prevailing in the Canadian economy in order to achieve the 2 per cent inflation-control target*

Misconception 2: Monetary policy in Canada is largely guided by exchange rate considerations.

The level and variability of the exchange rate can have important effects on an open economy such as Canada's. However, the exchange rate is one of many variables that the Bank considers when it sets monetary policy. Most critical from the Bank's perspective is the combined influence of all of these variables on the outlook for economic activity and what this implies for meeting the 2 per cent inflation-control target. The Bank does not have a target for the exchange rate. Our only monetary policy objective is low, stable and predictable inflation.

Misconception 3: The Bank's narrow focus on inflation ignores more important objectives such as full employment and a rising standard of living.

Experience has shown that price stability is the most important contribution that the Bank can make to the economic welfare of Canadians. Since the introduction of inflation targeting in 1991, the low and stable inflation environment has allowed consumers and businesses to manage their finances with greater certainty about the future purchasing power of their savings and income. Interest rates have also been lower, in both nominal and real terms, across a range of maturities. Low, stable and predictable inflation has helped to encourage more-stable economic growth in Canada, as well as lower and less-variable unemployment.

◂ *Low, stable and predictable inflation has helped to encourage more-stable economic growth in Canada, as well as lower and less-variable unemployment*

Misconception 4: Focusing on price stability limits the Bank's ability to pursue its other major objective, financial stability.

While at times there may appear to be tensions between these objectives, they are inextricably linked; it is impossible to achieve one without maintaining the other. Although other policy levers, such as bank regulation and macroprudential tools, are typically the first lines of defence in promoting financial stability, monetary policy can, in exceptional circumstances, play a complementary role in achieving this end. Fortunately, there is sufficient

flexibility in the current monetary policy framework to promote financial stability while also meeting our inflation target over the medium term. One is not sacrificed for the benefit of the other.[8]

There is sufficient flexibility in the current monetary policy framework to promote financial stability while also meeting our inflation target over the medium term

Misconception 5: If the Canadian economy is operating close to capacity (i.e., near full employment) and inflation is at, or close to, the 2 per cent target, interest rates have to be close to their "normal" or "neutral" levels.

If there were no forces acting on the economy to push it away from this desired state, the statement would be true. However, this is seldom the case. Headwinds and tailwinds are often present, threatening to push economic activity and inflation higher or lower.[9] Monetary policy needs to lean against these forces with opposing pressure from higher or lower interest rates to stabilize the economy and keep inflation on target. Monetary policy is seldom static; it must respond as these forces ease or escalate.

Conclusion

Canada's monetary policy framework and the process that the Bank follows to make its decisions have evolved. The move to inflation targeting in 1991 and the adoption of fixed announcement dates in 2000 are certainly the most noteworthy changes, but there have been many other refinements in the way policy is formulated and implemented. The process for decision making is information-intensive and collaborative. It has also proven to be very effective. Without doubt, there will be further refinements as the Bank learns from new experiences. The effort to improve the decision-making process is ongoing.

8 This flexibility would involve adjusting, as appropriate, the time horizon over which the 2 per cent target is achieved. For more information on the Bank's inflation-control framework, see Bank of Canada (2011a).

9 An example of a headwind would be a persistent reduction in the demand for Canadian exports. An example of a tailwind would be a persistent financial shock resulting in unusually narrow risk spreads. For more information, see Bank of Canada (2011b).

Literature Cited

Bank of Canada. 2009. "Annex: Framework for Conducting Monetary Policy at Low Interest Rates." *Monetary Policy Report* (April): 25–27.

———. 2011a. "Renewal of the Inflation-Control Target: Background Information—November 2011." Available at http://www.bankofcanada.ca/wp-content/uploads/2011/11/background_nov11.pdf.

———. 2011b. "Technical Box 2: Headwinds, Tailwinds and the Policy Rate." *Monetary Policy Report* (July): 28–29.

Barnett, R. and P. Guérin. 2013. "Monitoring Short-Term Economic Developments in Foreign Economies." *Bank of Canada Review* (Summer): 22–31.

Binette, A. and J. Chang. 2013. "CSI: A Model for Tracking Short-Term Growth in Canadian Real GDP." *Bank of Canada Review* (Summer): 3–12.

Blagrave, P., C. Godbout and R. Lalonde. "GMUSE: The Bank of Canada Projection Model for the Global Economy." Bank of Canada Technical Report (forthcoming).

Dorich, J., M. K. Johnston, R. R. Mendes, S. Murchison and Y. Zhang. 2013. "TOTEM II: An Updated Version of the Bank of Canada's Quarterly Projection Model." Bank of Canada Technical Report No. 100.

Dorich, J., R. R. Mendes and Y. Zhang. 2011. "Introducing Multiple Interest Rates in ToTEM." *Bank of Canada Review* (Summer): 3–10.

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.

Granziera, E., C. Luu and P. St-Amant. 2013. "The Accuracy of Short-Term Forecast Combinations." *Bank of Canada Review* (Summer): 13–21.

Macklem, T. 2002. "Information and Analysis for Monetary Policy: Coming to a Decision." *Bank of Canada Review* (Summer): 11–18.

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

Murray, J. 2012. "Monetary Policy Decision-Making at the Bank of Canada." Speech to the Mortgage Brokers Association of B.C., Vancouver, British Columbia, 7 May.

Santor, E. and L. Suchanek. 2013. "Unconventional Monetary Policies: Evolving Practices, Their Effects and Potential Costs." *Bank of Canada Review* (Spring): 1–15.

Assessing Financial System Vulnerabilities: An Early Warning Approach

Gurnain Pasricha, Tom Roberts, Ian Christensen and Brad Howell, Financial Stability Department

- Regular surveillance of the financial system can provide market participants and policy-makers with early warning of emerging vulnerabilities, and can therefore inform decisions to take corrective actions that support financial stability and prevent losses in real economic activity.
- This article focuses on a quantitative method to identify vulnerabilities, specifically an imbalance indicator model and its application to Canada.
- The model proves useful for isolating historical imbalances that could be indicators of financial system vulnerabilities. It complements other sources of information, including market intelligence and regular monitoring of economic and financial data.

The Bank of Canada, and other central banks, regularly assesses vulnerabilities in the financial system. Such assessments can provide early indications to market participants and policy-makers of emerging areas of weakness in the financial system, and help to inform corrective actions that could be taken to support financial stability and prevent losses in real economic activity. The large costs associated with the 2007–09 global financial crisis illustrate the importance of improving this surveillance in order to reduce the likelihood and impact of future crises. Authorities worldwide are working toward this goal, as seen in the increased focus on this issue by the International Monetary Fund (IMF) and the Financial Stability Board.

Financial system vulnerabilities are conditions that make future financial system stress more likely. The degree of vulnerability may reflect, for example, the exposure of the financial system to particular risks. Imbalances create vulnerability by exposing the financial system to the risk of an abrupt correction and by reducing its ability to withstand other shocks.[1] Assessment of financial system vulnerabilities is a three-stage process: (i) detecting imbalances (vulnerability identification); (ii) estimating the likelihood of future financial system

1 The term "imbalances" refers to the conditions in a market or sector of the economy. For example, if house prices are overvalued or there is an oversupply of housing, one might say there is an imbalance in the housing market. The presence of an imbalance can be suggested by a variety of indicators associated with that market.

Bank of Canada Review articles undergo a thorough review process. The views expressed in the articles are those of the authors and do not necessarily reflect the views of the Bank. The contents of the *Review* may be reproduced or quoted, provided that the publication, with its date, is specifically cited as the source.

stress, given the imbalances; and (iii) estimating the impact of a potential stress episode on the financial system and the real economy, should it occur (impact assessment or stress testing).[2] This article focuses on vulnerability identification using an imbalance indicator model (IIM).[3]

IIMs are quantitative models that identify vulnerabilities in a financial system by comparing current economic and financial data with data from periods leading up to past episodes of financial stress. Using quantitative models to identify vulnerabilities has several advantages. These models add rigour to discussions on the evolution of imbalances by enabling more-precise comparisons with the past, thus allowing us to draw lessons from history. As well, indicators used in IIMs can provide earlier warnings of imbalances than surveys of market participants. In addition, the performance of quantitative models can be objectively measured based on actual results, helping policy-makers to improve their surveillance over time.[4] However, judgment is required in interpreting the results of these models, which need to be placed in the context of information from other complementary sources, including market intelligence gathered through discussions with participants and regular monitoring of economic and financial data.

◀ *Imbalance indicator models identify vulnerabilities in a financial system by comparing current economic and financial data with data from periods leading up to past episodes of financial stress*

The article begins by defining episodes of financial stress. It then describes the selection of countries, variables and thresholds for a typical IIM. The results of an IIM applied to Canada and several other advanced economies are presented. A few cautionary words on the mechanical interpretation of the results then follow, and the article ends with suggestions for future research into IIMs and their use for risk analysis.

Defining and Identifying Episodes of Financial Stress

Since the goal of vulnerability identification is to detect imbalances within a financial system that could signal future episodes of financial stress, it is necessary to define what is meant by a stress episode. Conceptually, a stress episode involves one or more of the following phenomena: increased uncertainty about the fundamental value of assets and the behaviour of investors, greater uncertainty about exposures of counterparties, and decreased willingness among market participants to hold risky and illiquid assets (Hakkio and Keeton 2009). Since none of these phenomena can be observed directly, financial stress must be inferred from the behaviour of asset prices and other financial variables. A severe episode of financial stress is considered a financial crisis—a systemic event that typically involves large losses in the banking or financial sector, a bailout of one or more financial institutions, activation of deposit guarantees, public injections of liquidity into financial markets, or a run on key financial markets or institutions. Financial crises are typically associated with large drops in economic activity. A period of elevated stress may not culminate in a financial crisis if the banking system is well capitalized or the policy response is adequate (as was the case in Canada during the 2007–09 global financial crisis). However, high financial stress is still associated with impaired financial market functioning and disrupted financial intermediation, and can result in a large contraction in the provision of credit and activity in the wider economy. Policy-makers therefore wish to avoid this stress by taking preventive measures to address vulnerabilities and increase the resilience of the financial system.

2 The Bank has developed two stress-testing models to assess the potential impact on balance sheets in the banking and household sectors of a plausible but severe macroeconomic scenario. Côté (2012) provides an overview of these models. For a description of the MacroFinancial Risk Assessment Framework (MFRAF), see Gauthier and Souissi (2012). The Household Risk Assessment Model (HRAM) is described in Faruqui, Liu and Roberts (2012).

3 IIMs are often referred to as "early warning" models.

4 For an in-depth discussion of the benefits of IIMs, see Bussière (2013).

Box 1

International Monetary Fund Financial Stress Index

The International Monetary Fund (IMF) financial stress index (FSI) includes measures of large shifts in asset prices, an abrupt increase in risk/uncertainty, and abrupt shifts in the liquidity and health of the banking system.[1] It has seven components: volatility of the real effective exchange rate; stock market volatility; stock market decline; corporate and interbank lending spreads (i.e., the difference between the interest rates on corporate or interbank loans and on government debt of comparable maturity); the banking sector "beta" (which is a measure of the volatility of bank shares and their correlation with equity markets in general); and the inverted term spread. In tranquil periods, all of these components would have low readings, leading to little indication of financial stress.

The IMF FSI is available for 17 advanced economies at a monthly frequency. It is highly correlated with other available FSIs and produces comparable forecasts of macroeconomic performance (Kliesen, Owyang and Vermann 2012). Since FSIs are typically high-frequency measures, they allow for precision in dating episodes and also provide a measure of the severity of an episode. One of their limitations, however, is that they do not account for differences in the importance of intermediated versus market-based credit across countries.

1 The data set is described in Balakrishnan et al. (2009) and Cardarelli, Elekdag and Lall (2009), and is available at http://www.imf.org/external/pubs/cat/longres.aspx?sk=23039.0.

In this article, we use two complementary methods to identify episodes of financial stress. The first method uses a continuous measure of financial conditions, a financial stress index (FSI) developed by the IMF (**Box 1**), to identify elevated FSI periods, defined as sustained periods in which the FSI recorded extreme values, i.e., the FSI exceeded the normal historical range for at least three consecutive months.[5] Periods that are less than a year apart are counted as a single episode. Using this approach, we identify 32 periods of elevated FSI in the 17 advanced countries for which the IMF FSI is available.[6] The second method is a narrative approach that uses information from the existing literature to determine the dates of financial crises. For example, this approach identifies two financial crises for the United States—the savings and loan crisis in the late 1980s and the financial crisis that began in 2007—and none for Canada.[7] For the remainder of the article, the term "stress episodes" refers to episodes identified using either method.

Combining results from the two approaches yields a total of 37 episodes of financial stress for the countries in our sample.[8] The dark and light grey bars in **Chart 1a** and **Chart 1b** show the stress episodes identified for Canada and the United States using the two methods. The recent financial crisis originated in the United States in the summer of 2007 and quickly spread to other advanced economies through financial linkages, resulting in a high level of stress observed for all countries in our sample during the 2007–09 period,

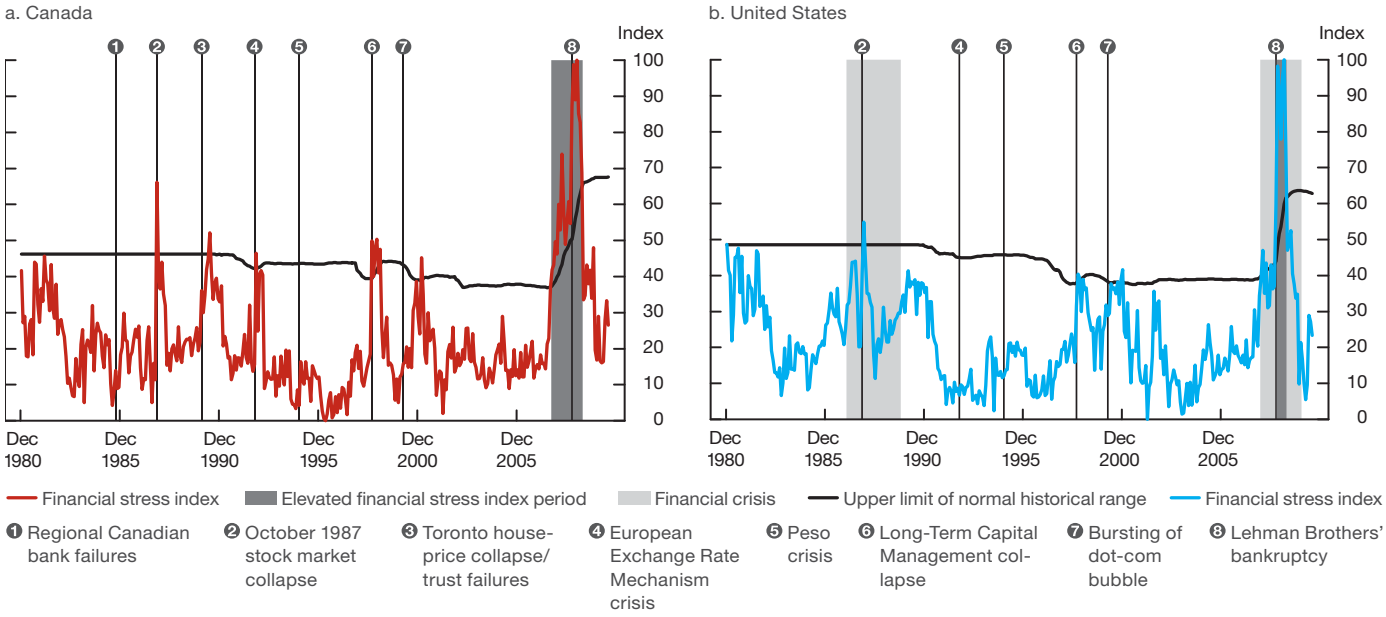
5 A country's readings exceed the normal historical range when they are higher than their 10-year rolling average by at least two standard deviations. The practical implication of taking rolling averages is that the upper limit of the normal range rises following large stress events and falls after a sustained period of relative calm. In our sample, this ensures that periods that would have been classified as stress episodes at the time that they occurred continue to be captured as stress episodes, even after the data from the 2007–09 global financial crisis are observed. Before the crisis, the threshold used is almost constant. An alternative way to set the upper limit on the normal range of the FSI is to use a historical benchmark, such as the level of the FSI observed during the Long-Term Capital Management collapse in 1998.

6 The countries in the sample are Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom and the United States.

7 The need to use the second (narrative) approach arises because the FSI is an imperfect measure of financial system stress. The elevated FSI periods do not cover all known financial crises.

8 There were 10 instances where financial crisis periods and elevated FSI periods overlapped, most of them during the 2007–09 global financial crisis. To avoid double counting, the overlapping periods were combined and counted as a single episode, starting at the earliest date provided by either method and ending at the latest date.

Chart 1: Stress episodes

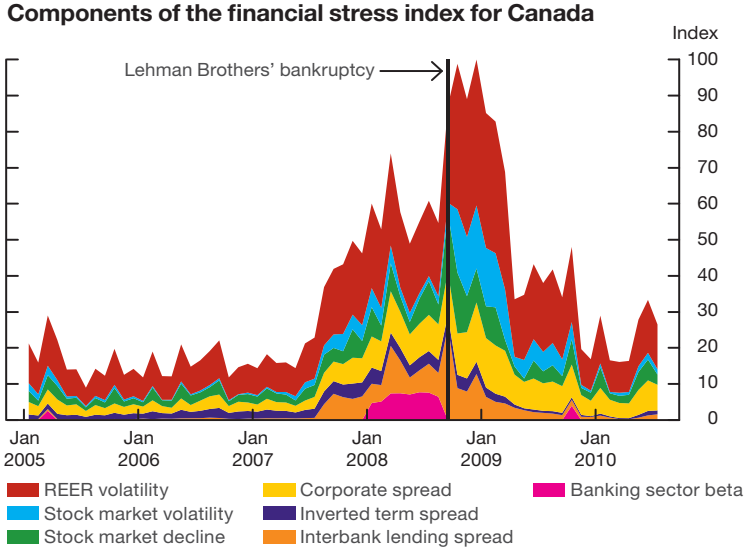


Note: The original index is centred at 0 and is rebased in the charts to lie between 0 and 100 for each country. As a result, the FSI values in the charts are not comparable across countries.

Sources: Bank of Canada and International Monetary Fund financial stress index

Last observation: July 2010

Chart 2: Components of the financial stress index for Canada



Notes: REER volatility is an index of time-varying volatility of monthly changes in the real effective exchange rate. Corporate spread is an index of the difference between corporate bond yields and long-term government bond yields. Inverted term spread is the difference between the government short-term rate and the government long-term rate. Interbank lending spread is an index of the difference between interbank rates and the yields on short-term government bonds. Banking sector beta is an index of the correlation between the total returns to the banking sector stock index and the overall stock market index.

Sources: Bank of Canada and International Monetary Fund financial stress index

Last observation: July 2010

particularly after the collapse of Lehman Brothers Holdings Inc. in September 2008. The rise in the FSI for Canada in mid-2007 reflects, in part, stresses in the non-bank asset-backed commercial paper market, which widened the spreads between the interbank interest rates and yields on government bonds, as well as corporate spreads (**Chart 2**).[9] Since the FSI-based method identifies

9 For a discussion of the events during this period, see Bank of Canada (2007).

episodes where the FSI is high for a sustained period, it does not include some relatively brief periods of high FSI, such as the collapse of Long-Term Capital Management (LTCM) in 1998 and the brief period of elevated FSI in 2001.[10]

Having identified the historical stress episodes, the next step is to determine the indicators that can help to predict these periods in advance.

Building an Imbalance Indicator Model

A key empirical challenge in building an IIM is the selection of countries to be included in the sample. Since the number of stress episodes experienced by any one country is typically small, using a broad sample of countries allows the use of others' experiences to identify the critical thresholds, as well as to test the validity of the model. Nevertheless, country-specific characteristics, such as the structure and regulation of financial markets, can differ widely across countries, potentially affecting the performance of indicators and thresholds. To increase comparability in economic and structural aspects, our model uses data on only advanced economies. The data are monthly and the model is estimated for 17 advanced economies over the period from December 1980 to December 2009.

A broad range of variables could be leading indicators of stress episodes, including those related to the financial, corporate, government, household and external sectors. To ensure that the exercise is relevant for informing preventive policy actions, we consider a variety of indicators for each sector that could be expected to signal a stress episode up to two years before the event. For example, the financial indicators used include the growth in return on equity for the banking sector and the ratio of overall private sector credit to GDP. To address the issue of limited comparability in the levels of variables, due to structural differences across countries, alternative transformations of the same data series, such as growth rates over different horizons and deviations from trends for every variable, are considered.

◀ *A broad range of variables could be leading indicators of stress episodes, including those related to the financial, corporate, government, household and external sectors*

In our model, an indicator signals future stress when it rises above a threshold level that tends to be associated with historical stress episodes. Readings of an indicator above the threshold therefore suggest an imbalance. We consider several possible values of the threshold for each indicator and choose the one that simultaneously minimizes two errors: the error of failing to signal before stress occurs and the error of signalling an imbalance even when stress does not subsequently occur (see **Box 2** and Roberts (forthcoming) for further details on the methodology for selecting the thresholds).[11] This approach helps to identify the best threshold for each variable and to determine the most robust predictors of stress episodes (that is, those with the lowest error rates). Extracting signals from these indicators on a regular basis can highlight changes in existing imbalances and detect potential imbalances that merit more-intensive analysis or debate.[12]

Identifying Imbalances

The IIM is reasonably successful at identifying imbalances with considerable lead time. **Table 1** shows the signals given by a set of indicators before the recent financial crisis and other selected periods.[13] Data up to December 2009 are used to estimate the thresholds, and these estimated thresholds are then applied to data from recent (2010–11) and current (2012–2013Q2) periods.

10 One caveat here is that the FSI measures the outcomes and does not take into account policy responses. For example, the LTCM collapse is not identified as an elevated FSI period, because a quick policy response limited the duration and intensity of financial system stress.

11 See also Davis and Karim (2008) and Manasse and Roubini (2005).

12 This approach is typically referred to as the "signal extraction" approach.

13 Not all of these periods were followed by stress events as defined by our criteria.

Box 2

Estimating Thresholds for Indicators

An indicator signals a potential imbalance if it breaches its estimated threshold. A signal is considered "true" if a stress episode follows in the next 24 months and "false" if a stress episode does not follow in the next 24 months. For any given threshold, the performance of the indicator can be judged using the categories in **Table 2-A**:

Table 2-A: Assessment of true and false signals of stress episodes

	Stress occurs in next 24 months (pre-stress periods)	No stress occurs in next 24 months (normal periods)
Signal	A (number of true imbalance signals)	B (number of false imbalance signals)
No signal	C (number of false balance signals)	D (number of true balance signals)

"A" is the number of months in which the indicator issued an imbalance signal and a stress episode followed; "B" is the number of months in which the indicator issued an imbalance signal but a stress episode did not follow (Type I error); "C" is the number of months in which the indicator did not signal an imbalance but a stress episode followed nonetheless (Type II error); and "D" is the number of months in which the indicator did not issue an imbalance signal and none was called for (since a stress episode did not occur in the next 24 months).

A perfect indicator will have no observations in B and C, A will equal the total number of pre-stress months, and D the total number of normal months in the sample. To optimize the value of each indicator, its threshold is chosen at the point where the following "loss function" is minimized:

$$f(\overline{x}) = \frac{1}{A + B + C + D} * \left[\frac{CD}{C + D} + \frac{AB}{A + B}\right].$$

We then calculate the adjusted noise-to-signal ratio and use it to eliminate indicators that have no predictive power.[1]

1 The adjusted noise-to-signal ratio is computed as [B/(B + D)]/[A/(A + C)] or the proportion of false imbalance signals in normal periods (the noise) divided by the proportion of true imbalance signals among the pre-stress periods (Kaminsky, Lizondo and Reinhart 1998). A value greater than one indicates that the indicator performs worse than a coin flip.

The indicators cover four key areas of potential vulnerabilities: broad leverage, asset prices, the banking sector and the external sector. Within each category, indicators were selected based on their performance in signalling stress events, while also reflecting our judgment on the range of sectors in which financial stress would materialize. The indicators are shown for Canada as well as for the United States, the United Kingdom and Australia.

The second column in the table reports the threshold estimated for each indicator using cross-country data, and the third column indicates its accuracy, as measured by the adjusted noise-to-signal ratio (the lower, the better). The row for each indicator reports the percentage of quarters during the selected period that the indicator exceeded its estimated threshold.[14] The cells are shaded red if the variable exceeds the estimated threshold for at least three quarters during the selected period, and yellow if the indicator breaches the threshold for one or two quarters. The remainder of this section discusses the key results, and the next section focuses on how judgment can be applied to interpret the results.

Historical event 1: The 2000 dot-com crash

Throughout 1998 and 1999, the indicator for the growth of equity prices signalled an imbalance for all four countries. The dot-com crash occurred shortly afterward; however, since the FSI did not reach a sustained high level during this period, the dot-com crash is not considered an episode of financial stress according to our methodology. Many of the other indicators did not issue an imbalance signal. An explanation for why this event did not

14 We tested five alternative dependent-variable specifications. The broadest specification is described in the text and its results are reported in Table 1. The estimated thresholds are similar across the different specifications for most indicators.

Table 1: Indicators of financial system vulnerabilities

	Threshold	Noise-to-signal ratio	Pre-dot-com crash 1998–99				Pre-financial crisis 2005Q3–07Q2				Recent period 2010–11				Current period 2012–13Q2			
			CA	US	UK	AU	CA	US	UK	AU	CA	US	UK	AU	CA	US	UK	AU
Broad leverage																		
Credit-to-GDP gap (percentage points)	4.7	0.50						100%	100%	88%	88%		38%	13%	67%			
Ratio of household debt to GDP (per cent)	70.9	0.43			13%		50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Deviation of ratio of household debt to GDP from 10-year moving average (per cent)	10.9	0.52				100%	100%	100%	100%	100%	100%		25%	75%	100%			
Asset prices																		
Equity prices, 3-year real growth (per cent per year)	7.5	0.62	88%	100%	100%	63%	100%	100%	100%	100%	13%				17%	33%	17%	
House prices, 5-year real growth (per cent per year)	6.9	0.45					75%	75%	100%	63%								
House-price gap	12.6	0.27					63%	100%	100%		13%			25%				
Ratio of house prices to income (index, long-term average = 100)	110.5	0.18					38%	88%	100%	100%	100%		100%	100%	100%		100%	100%
Banking sector																		
Deviation of return on equity for banks from 10-year moving average (per cent)	17.1	0.47	38%		50%		63%	50%	100%	63%								
External sector																		
Current account deficit (per cent of GDP)	4.8	0.22				63%		100%		100%				13%				
Deviation of real effective exchange rate (REER) from 10-year moving average (per cent)	20.2	0.12			13%		100%			100%	75%			100%				100%

Legend

Indicator does not exceed threshold (no signal).
X% Indicator exceeds threshold for one or two quarters in the time frame (weak signal).
X% Indicator exceeds threshold for three or more quarters in the time frame (strong signal).

CA = Canada
US = United States
UK = United Kingdom
AU = Australia

Notes: The thresholds for each variable are calculated using pooled data for 17 countries from December 1980 to December 2009. A grid search identifies thresholds by minimizing a loss function that measures the classification error of signals. The blank cell indicates missing data. The house-price gap is the deviation of the house-price index (January 2010 = 100) from its trend, as measured by the Hodrick-Prescott filter. Growth rates are calculated as: *Growth Rate = 100 * [(Value$_t$ /Value$_{t-h}$) ^ (12/h) - 1]*, where *h* is the number of months.

have a more widespread impact is suggested by the credit-to-GDP gap,[15] which serves as an approximate measure of excessive leverage across the private sector. This indicator did not signal an imbalance at that time.

Historical event 2: Global financial crisis

In the two years leading up to the 2007–09 global financial crisis, a variety of measures signalled the presence of imbalances in all four countries. Based on the estimated threshold of 4.7 per cent, the credit-to-GDP gap signalled that there was an imbalance in credit conditions—a credit boom—in three of the countries—the United States, the United Kingdom and Australia—before the financial crisis. The indicators that signalled imbalances for both Australia and Canada during the 2005Q3–07Q2 period should not be interpreted as suggesting that these imbalances caused the recent period of financial stress, which was triggered by factors external to these countries. For Canada, the signals in 2005Q3–07Q2 suggest that signs of the imbalances in the housing sector began to emerge during that period. The average annual growth of real house prices over the previous five years was above the estimated threshold of 6.9 per cent per year for six of the eight quarters in 2005Q3–07Q2.

15 The credit-to-GDP gap is the deviation of the ratio of aggregate private sector credit to GDP from its trend.

In summary, the results in **Table 1** suggest that the IIM is reasonably successful in isolating imbalances in key sectors. Before the global financial crisis, several indicators consistently signalled stress for at least two years before the event. In addition, for the entire sample, there were nearly as many signals one to two years before a stress episode as there were within one year of the episode. These results indicate that the signals of imbalances are persistent and that policy-makers could have warnings more than a year before a stress episode.[16] Our results are broadly consistent with results in the literature on IIMs, which has found excessive leverage and elevated asset prices to be key leading indicators of financial system vulnerabilities in advanced economies.[17]

◀ *Results indicate that policy-makers could have warnings more than a year before a stress episode*

Recent imbalances in Canada

During more recent periods, from 2010 to 2011 and from 2012 to the second quarter of 2013, the credit-to-GDP gap signalled elevated private sector debt in Canada in 11 out of 14 quarters. For the housing sector, the indicators appear to give varying signals. The ratio of house prices to income has been above the estimated threshold levels since the fourth quarter of 2006, but the house-price gap exceeded the threshold in only one quarter during 2010 and 2011 (while remaining elevated—ranging from 7 per cent to 15 per cent—until the second quarter of 2012). The average annual growth rate of real house prices over the previous five years was below the estimated threshold in 2010 and 2011 (although it remained elevated—ranging from 3.7 per cent to 6 per cent—until the second quarter of 2011). The variation among different indicators highlights the need to apply judgment in interpreting the signals. The growth in house prices eased before the other two variables, which are slower moving and reflect a buildup of imbalances resulting from a prolonged period of moderately high growth in house prices at the national level. As of the second quarter of 2013, the growth in house prices suggested a further easing of the housing market imbalances (with the growth rate falling to 2.9 per cent), although, as expected, the ratio of house prices to income suggested that the imbalance persisted. Also of note, there are no warning signals from indicators of banking sector health and external imbalances during this period.

Interpreting the Results

There are several areas where judgment needs to be applied when drawing conclusions about the financial system vulnerabilities identified by the IIM.

First, as noted in the previous section for Canada, indicators in the same sector can give different signals. An additional example is seen in the results for other countries, where, in the current period (2012–13Q2), the two measures of leverage (the credit-to-GDP gap and ratio of household debt to GDP) provide quite different signals for the United States, the United Kingdom and Australia. One reason for these different signals from related indicators is a basic distinction in the implicit views they embody regarding long-run trends. Some variables are measured in levels (for example, the ratio of nominal house prices to income) and others as deviations from a trend (for example, the house-price gap). After a long period of growth in house prices, the measured trend in house prices will rise, causing the house-price gap to diminish. This would give a false sense of security in a long-lived

16 The results are robust to ending the sample at the fourth quarter of 2006, rather than December 2009. The predicted thresholds are similar to those from the baseline specification and thus the indicators are able to predict the 2007–09 financial crisis out of sample.

17 Babecký et al. (2013); Barrell et al. (2010); Borio and Drehmann (2010); Frankel and Saravelos (2010).

housing bubble (in which the measured trend does not reflect an increase in prices based on fundamentals). On the other hand, the ratio of house prices to income will overstate the extent of the true imbalances if part of the growth in house prices reflects fundamentals. Policy-makers therefore need to apply judgment when interpreting signals and assessing the degree of the imbalance in a sector.

Second, the indicators by themselves do not contain information about the triggers of any given crisis. For example, as noted earlier, the signals for the 2005Q3–07Q2 period in Canada cannot be interpreted as the causal factor in the development of the crisis itself, which largely originated in the United States and was transmitted to Canada.

Finally, these models are statistical and reduced-form in nature, which means that they will not be able to fully account for the impact of changes in economic structure or in the financial system (either through innovation or regulation).

For these reasons, the indicator signals should not be interpreted mechanically. Rather, information about underlying trends in these and other indicators as well as policy-makers' judgment are crucial to translating signals into an assessment of vulnerabilities. While monitoring several variables presented here, the Bank of Canada's *Financial System Review* takes a broader range of information into account in its overall assessment of risks.

Information about underlying trends in indicators as well as policy-makers' judgment are crucial to translating signals into an assessment of vulnerabilities

Conclusion

The analysis in this article has focused on identifying potential imbalances that could predict episodes of financial stress. By providing quantitative assessments, imbalance indicator models can instill more discipline and consistent analysis into the judgment of policy-makers. The model illustrated here provides useful and reasonable measures for isolating historical imbalances, thus providing the basis for assessing vulnerabilities in the financial system.

The model could be refined in several ways. First, it could be extended to take into account global factors in determining domestic vulnerabilities and data on additional sectors of the economy (e.g., sovereign risk). Second, the thresholds could be estimated separately for different types of stress events (e.g., a currency, housing or banking crisis). Third, policy-makers need to be able to summarize information from different indicators to get a sense of the overall level of risk. This could be done by combining the different indicators into a composite indicator, by using a multivariate model to estimate thresholds simultaneously for several indicators, or by using probability models that use information from all variables to predict the overall probability of a crisis (Christensen and Li 2013). Research on these topics is ongoing at the Bank.

Literature Cited

Babecký, J., T. Havránek, J. Matějů, M. Rusnák, K. Šmídková and B. Vašíček. 2013. "Leading Indicators of Crisis Incidence: Evidence from Developed Countries." *Journal of International Money and Finance* 35: 1–19.

Balakrishnan, R., S. Danninger, S. Elekdag and I. Tytell. 2009. "The Transmission of Financial Stress from Advanced to Emerging Economies." International Monetary Fund Working Paper No. WP/09/133.

Bank of Canada. 2007. *Financial System Review* (December).

Barrell, R., E. P. Davis, D. Karim and I. Liadze. 2010. "Bank Regulation, Property Prices and Early Warning Systems for Banking Crises in OECD Countries." *Journal of Banking & Finance* 34 (9): 2255–64.

Borio, C. and M. Drehmann. 2010. "Toward an Operational Framework for Financial Stability: 'Fuzzy' Measurement and Its Consequences." In *Financial Stability, Monetary Policy, and Central Banking*, edited by R. Alfaro, 63–123. Vol. 15 of *Central Banking, Analysis and Economic Policies*. Santiago: Central Bank of Chile.

Bussière, M. 2013. "In Defense of Early Warning Signals." Banque de France Working Paper No. 420.

Cardarelli, R., S. Elekdag and S. Lall. 2009. "Financial Stress, Downturns, and Recoveries." International Monetary Fund Working Paper No. WP/09/100.

Christensen, I. and F. Li. 2013. "A Semiparametric Early Warning Model of Financial Stress Events." Bank of Canada Working Paper No. 2013–13.

Côté, A. 2012. "Modelling Risks to the Financial System." Speech to the Canadian Association for Business Economics, Kingston, Ontario, 21 August.

Davis, E. P. and D. Karim. 2008. "Comparing Early Warning Systems for Banking Crises." *Journal of Financial Stability* 4 (2): 89–120.

Faruqui, U., X. Liu and T. Roberts. 2012. "An Improved Framework for Assessing the Risks Arising from Elevated Household Debt." Bank of Canada *Financial System Review* (June): 51–57.

Frankel, J. A. and G. Saravelos. 2010. "Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the 2008–09 Global Crisis." National Bureau of Economic Research Working Paper No. 16047.

Gauthier, C. and M. Souissi. 2012. "Understanding Systemic Risk in the Banking Sector: A MacroFinancial Risk Assessment Framework." *Bank of Canada Review* (Spring): 29–38.

Hakkio, C. S. and W. R. Keeton. 2009. "Financial Stress: What Is It, How Can It Be Measured, and Why Does It Matter?" Federal Reserve Bank of Kansas City *Economic Review* (2nd Quarter): 5–50.

Kaminsky, G., S. Lizondo and C. M. Reinhart. 1998. "Leading Indicators of Currency Crises." International Monetary Fund *Staff Papers* 45 (1).

Kliesen, K., M. Owyang and E. K. Vermann. 2012. "Disentangling Diverse Measures: A Survey of Financial Stress Indexes." Federal Reserve Bank of St. Louis *Review* (September/October): 369–98.

Manasse, P. and N. Roubini. 2005. "'Rules of Thumb' for Sovereign Debt Crises." International Monetary Fund Working Paper No. WP/05/42.

Roberts, T. "An Early Warning Model for Financial Vulnerability Assessment." Bank of Canada Discussion Paper (forthcoming).

Fragmentation in Canadian Equity Markets

Corey Garriott, Anna Pomeranets, Joshua Slive and Thomas Thorn, Financial Markets Department

- Changes in technology and regulation have resulted in an increase in the number of venues for equity trading in Canada. This market fragmentation has both costs and benefits: it has the potential to make trading more difficult by segmenting liquidity, but it can also increase efficiency through innovation and intensified competition.
- Overall, we find that market fragmentation has reduced trading fees and created an environment that facilitates innovation. It has had no clear effect—positive or negative—on market quality, as measured by liquidity and price efficiency.
- Fragmentation has, however, required market participants to invest in technology to manage trading at multiple venues. The cost advantages from reduced trading fees do not necessarily offset the large, fixed costs of this investment, especially for smaller dealers. Fragmentation has also created new complexities in the market that may increase operational risks. These effects could be controlled through a carefully adapted regulatory response.

As recently as 2001, there was only one senior equity marketplace in Canada, the Toronto Stock Exchange (TSX). Today, 10 trading platforms compete for market share, and more are on the way. Canadian equity trading has undergone a decade of market fragmentation—the creation of new and separate venues for trade. Financial participants can now exchange Canadian equities at many venues, each with different trading rules and fee structures.

This market fragmentation has created both costs and benefits. One of the benefits is intensified competition among new trading venues, which can reduce trading fees, encourage efficiency-enhancing product innovation and promote market resilience. However, fragmentation can also introduce new problems. It can significantly increase system- and technology-related costs by requiring market participants to connect with and monitor multiple trading venues. It can also complicate markets and segment trading by isolating groups of trading participants. If buyers cannot easily find sellers and vice versa, trading becomes difficult. This segmentation of trading can result in poor market liquidity and the presence of stale prices.

Bank of Canada Review articles undergo a thorough review process. The views expressed in the articles are those of the authors and do not necessarily reflect the views of the Bank. The contents of the *Review* may be reproduced or quoted, provided that the publication, with its date, is specifically cited as the source.

While segmented trading has been a primary concern in Canada historically, it is much less of a problem in modern markets. New technologies, trading practices and regulations have knit together separate venues. Market participants have the technology to integrate their view of markets on a single computer terminal, and financial intermediaries match orders across markets at speeds measured in fractions of a second. Although segmentation is of less concern than before, the "bricks and mortar" costs of market fragmentation have grown in importance. The technologies, practices and regulations that have driven markets to fragment have also made expensive technological investment necessary for participants to continue to connect with and monitor multiple exchanges. Moreover, participants now communicate with one another through a variety of complicated protocols, which may create operational risks. It is necessary to consider whether these costs are offset by the benefits that accrue from the increased competition that market fragmentation fosters.

The structure of equity markets is important for the Bank of Canada, not only because of the importance of these markets to the Canadian economy, but also because equity markets act as a leading indicator of likely developments in other markets. Equity markets are often early adopters of technology because of the wide participation in equity trading. Developments in equity trading could help shed light on upcoming developments in fixed-income trading, which has seen some movement to organized electronic trading platforms, and could also inform potential rule changes in over-the-counter derivatives markets, where standardized contracts will be increasingly traded electronically.

This article updates a previous *Bank of Canada Review* article on competition in Canadian equity markets (Boisvert and Gaa 2001), addressing the substantial changes to the regulation and structure of these markets in recent years.[1] It describes the factors that have driven market fragmentation over the past decade and discusses the impact of this fragmentation on different aspects of the Canadian equity markets. It concludes by suggesting areas for further study.

Factors Driving Market Fragmentation

Historically, a stock exchange featuring national listings has been the dominant equity trading venue in virtually all jurisdictions, unchallenged except by regional exchanges that served the specific needs of local markets. Central stock exchanges were dominant for so long because they benefited from two gains by concentrating trade:

(i) **Economies of scale**. Most of the costs of operating a trading venue do not vary with its level of activity. Increasing trading activity at a single venue is therefore much cheaper than opening a second venue.

(ii) The **liquidity externality** (Pagano 1989). Simply put, liquidity attracts liquidity. The more buyers in a market, the more attractive the market is to sellers, and vice versa. Conversely, isolating buyers and sellers can cause liquidity to dry up.

1 Research for this article included interviews with financial industry participants and regulators: Stephen Bain (Royal Bank of Canada), Tal Cohen (Chi-X), Kevan Cowan (TMX Group), Darryl Mackenzie (Canada Pension Plan Investment Board), David Panko (TD Canada Trust), Randee Pavalow (Aequitas Innovations Inc.), Cindy Petlock, John Reilly (Royal Bank of Canada), Doug Steiner (Perimeter Financial Corp.), Tracey Stern (Ontario Securities Commission), Nick Thadaney (ITG Canada) and the Ontario Teachers' Pension Plan. While these interviews inform the analysis, the opinions expressed are those of the authors, and any errors should be attributed to them.

A stock exchange derived enough advantage from these gains to be considered a good example of a natural monopoly (Pirrong 2000). But, since the 1980s, advances in technology and new regulatory environments have fundamentally changed this situation. Today, it is far less costly for entrants to deploy a new trading venue.

Technology has eroded the natural monopoly advantage of a single exchange, and…

Advances in technology have long influenced market structure. Communications technologies from the telegraph to the fibre optic cable have enabled participants to bypass a local trading floor in favour of a more desirable stock exchange located elsewhere. More recently, cheap computer hardware and open-source software slashed the cost of deploying a new trading venue to a level that invites competition from new entrants. Operational economies of scale are no longer a barrier to entry. In addition, technology has made it easier to use multiple venues. A single computer terminal can generate a consolidated view of multiple markets, and smart-order routers automatically scan all marketplaces and dispense orders to the venue offering the best prices. Although liquidity is physically dispersed across markets, the market is consolidated virtually. Technology has eroded the natural monopoly advantage of a single exchange.

…competition has been encouraged by regulatory liberalization

Competition has been encouraged not only by advances in technology, but also by regulatory liberalization. In the 1990s, Canadian regulators were monitoring increasing competition in U.S. equity markets and received requests to enter the Canadian market from potential new trading platforms such as Instinet and Versus. In 2001, a regulatory framework for trading on an alternative trading system (ATS) was established. This framework included requirements for registration, reporting, transparency and record keeping, and it obliged brokers to achieve a good price ("best execution") for their clients. With a clear set of rules in place for the entry and operation of ATSs, the Canadian marketplace was ready for competition among trading venues.

Fragmentation in Canadian Equity Markets over the Past Decade

Competition among equity venues in Canada lagged the United States by more than 15 years, and Canadian participants did not have public discussions on liberalizing the entry of ATSs until the 1990s.[2] This delay can be explained in part by the technological leadership of the TSX, which reduced the incentive for other technology innovators to compete. The TSX was an early adopter of electronic trading: in 1977, it was the first primary national exchange to enable a fully electronic matching system, a technology it sold worldwide. But the technological leadership of the TSX began to erode in the 1990s. Some participants began to express concerns that the monopoly status and mutualized ownership structure of the TSX reduced its incentive to keep pace with the evolution of technology.

After ATS regulations were put in place in the early 2000s, new trading platforms opened in Canada: the Canadian National Stock Exchange (CNSX) in July 2003, Perimeter Financial Corp.'s BlockBook in 2004 and the Shorcan ATS in 2006. While these venues were pioneers as the first competitors, they failed to capture more than a 5 per cent share of the market. They suffered from a lack of liquidity and did not receive much support from financial intermediaries, probably because no Canadian intermediaries were

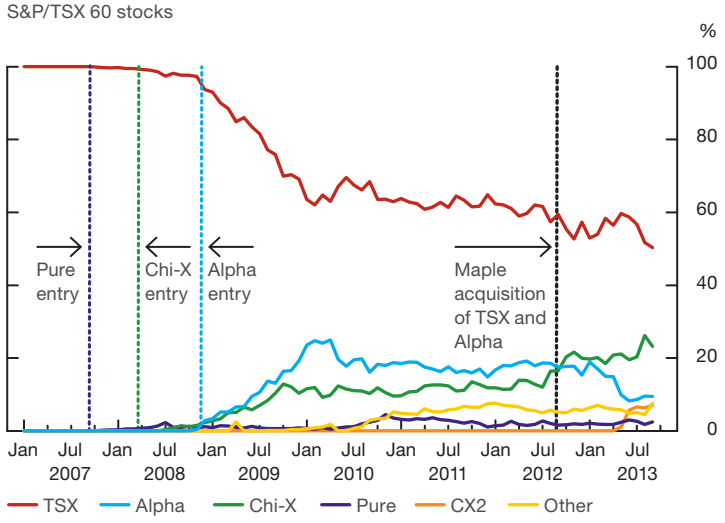
2 Competition from electronic trading systems (known then as electronic communications networks), such as Instinet and Posit, began in the United States in the 1980s and intensified in the late 1990s.

stakeholders. Trading venues typically encourage major financial intermediaries to supply liquidity by giving them an ownership stake. Ownership may be preferred to the alternative of contracting for liquidity supply—for example, by hiring market-makers such as New York Stock Exchange specialists or TSX-registered traders to maintain market quality—because it is difficult to define a good such as liquidity and give terms for its provision in a contract (Shleifer 1998). Moreover, a share of the dividends and a certain amount of control over strategy are often necessary to get intermediaries to participate in an operation that might threaten established business lines. It is particularly necessary for venues to secure participation from liquidity suppliers in Canada's concentrated financial markets.

In contrast to these early ATS entrants, Alpha ATS, which entered in December 2008, was developed and owned by major industry participants. Its company motto was "By the industry, for the industry." The Canadian broker-dealers contributed to Alpha's eventual 20 per cent market share (**Chart 1**) by directing traders to give preference to Alpha over the TSX when possible under best-execution rules. Alpha later merged with the TSX when it was acquired by Maple (now TMX Group Limited) on 1 August 2012. Another later entrant, Instinet's Chi-X in March 2008, distinguished itself by offering a free equity stake to Canadian broker-dealers. Although no Canadian participants accepted, Chi-X had already obtained investments from financial intermediaries in the United States, and its liquidity support would help it to capture 10 to 15 per cent of equity trading volumes by the end of 2009.

Chart 1: Volume shares of the largest trading venues in Canada, 2007–13

S&P/TSX 60 stocks



Source: Bloomberg

Last observation: 30 September 2013

The Impact of Market Fragmentation

Trading volumes in Canada have fragmented among 10 trading venues now competing for market share. Has the change been good for markets overall? We assess its impact on different aspects of Canadian equity markets: fees and innovations, market quality, and complexity.

Trading fees and product innovations

Competition among trading venues has been associated with an overall reduction in trading fees…

Competition among trading venues has been associated with an overall reduction in trading fees in Canada. The amount that the TSX charges per transaction has fallen substantially—by nearly 80 per cent from 2006 to 2010—specifically in response to increased competition (TMX Group 2010). Venues have also adopted new ways to charge fees such as maker-taker pricing, which gives a rebate to participants when their limit orders are filled. Such a pricing scheme can encourage the supply of liquidity (Malinova and Park 2011). The TSX introduced maker-taker pricing for all securities in 2006 and, in 2008, it introduced price breaks for electronic liquidity providers aimed at competing for flows from U.S.-based high-frequency traders (TMX Group 2008).

…as well as a number of product innovations and performance improvements in Canada

Increased competition has also led to a number of product innovations and performance improvements in Canada. To compete for trades, Canadian venues began to offer tools aimed at enhancing execution for end-users (CSA/IIROC 2009). The tools include new order types, which enable participants to accomplish with a single command an operation that once required continual monitoring of the market. A specific example is the introduction of "dark" orders, i.e., orders that can be submitted without pre-trade disclosure to other market participants. A participant will use a dark order if it intends to take action only when certain conditions are right. These orders appeal in particular to participants who wish to transact a large quantity without revealing their interest, which would affect prices. Arguably, dark orders provide incentive for informed market participants to price their orders more competitively (Boulatov and George 2013). Data show that, so far, dark trading in Canada has been associated with better liquidity and price efficiency (Foley and Putniņš 2013), although there is a concern that too much dark liquidity could make it difficult for participants to agree on a fair price.

Many in the industry also credit market fragmentation with contributing to the improved performance of both trading venues and market participants. The most dramatic improvement has been in areas such as latency, which is the time it takes for an order or trade to reach its intended recipient. For example, in response to competition, the TMX phased in a faster trading engine, TMX Quantum, in 2013.

Market quality

A key question concerning market fragmentation is whether it improves the quality of markets—their ability to facilitate trades quickly and at fair prices. Several measures of market quality are available, including measures of market liquidity, such as the bid-ask spread and the depth of available volume on the order book, and measures of price efficiency, such as volatility.[3]

Economic theory suggests that an increase in the number of venues should intensify competition among intermediaries to have the best bid or ask price, because fragmentation breaks the strict time priority of orders in an order queue (Foucault and Menkveld 2008). In a fragmented market, different participants can be first in an order queue at different venues. Participants would prefer to be the first market-wide, and they can do so only by improving on price.

3 Trading volume has also been used to measure market quality, but volume tends to increase with market fragmentation because of cross-market trading strategies, not necessarily because of a rise in liquidity.

Case studies suggest that the relationship between fragmentation and measures of liquidity is unclear. For example, Foucault and Menkveld (2008) study competition between two limit-order markets in Europe and find that increased competition improves market depth (the number of shares available at the best prices). A number of other studies similarly find that increased fragmentation improves various measures of market quality (Davies and Kim 2009; Battalio 1997; O'Hara and Ye 2011). In contrast, some comparisons of stock exchanges with more-fragmented dealer markets (such as NASDAQ) find that consolidated exchanges provide better liquidity (Bennett and Wei 2006; Gajewski and Gresse 2007). Other studies also find that greater consolidation increases market quality (Amihud, Lauterbach and Mendelson 2003). Results are similarly mixed on market fragmentation involving dark orders or completely dark venues (Weaver 2011; Degryse, De Jong and Van Kervel 2013; Foley and Putniņš 2013).

These mixed results suggest that a range of elements determine whether fragmentation improves market quality. Outcomes have been sensitive to the prevailing institutions, technologies, trading rules and regulations in a jurisdiction. In Canada, the rules, technologies and practices are designed to unify trading across different venues, making it less likely that market fragmentation would result in segmented liquidity. Market participants have access to smart-order routers that can automatically find the best execution across multiple venues. High-frequency traders quickly remove any price differences between markets through arbitrage. And regulation prevents segmentation through the order-protection rule, which requires marketplaces to have procedures to ensure that trades are executed at the best price offered on any market, thus ensuring that traders cannot neglect good prices wherever they are posted. Given these factors, the multiple equity markets in Canada act far more like a unified market than they do a series of segmented venues, which is consistent with evidence in other jurisdictions, such as the United States (O'Hara and Ye 2011).

In Canada, the rules, technologies and practices are designed to unify trading across different venues, making it less likely that market fragmentation would result in segmented liquidity

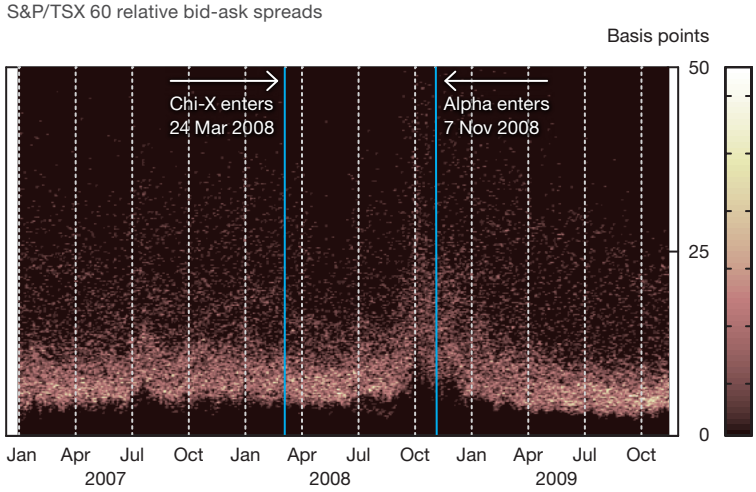
The intuition that technology has knit together markets is supported by the history of certain measures of market quality in Canada. Market-quality measures of the S&P/TSX 60 stocks trading on the TSX were not obviously affected after Chi-X entered in March 2008. Similar measures around the entry of Alpha in December 2008 are unfortunately obscured by the financial crisis, but they do not show negative effects.

Chart 2 shows that S&P/TSX 60 relative spreads—bid-ask spreads divided by prices—dropped to a lower equilibrium after Alpha's entry in late 2008, but it is difficult to know how much of this drop is attributable to Alpha, how much to coincidental changes in market structure and how much to the recovery from the financial turmoil of 2008. The 2008 financial crisis is the most obvious aspect of the chart, making it difficult to analyze the impact of Alpha's entry. Nevertheless, market fragmentation was not at any time associated with worsening spreads. Furthermore, the more recent spreads are slightly narrower than they were before the crisis, and trading fees were declining throughout the 2007–09 period.

Chart 3a and **Chart 3b** provide a closer examination of three averaged measures of market quality at the time of the entry of Chi-X and Alpha. Market depth improves dramatically after Alpha's entry, although some of this is because of duplication of offers across venues (Van Kervel 2012). Bid-ask spreads and volatility (as seen in the standard deviation of prices) either stay the same or perhaps improve slightly with market fragmentation, although (again) Alpha's entry is obscured by the recovery of the market after the financial crisis.

Chart 2: Relative spreads of the stocks of the S&P/TSX 60, 2007–09

S&P/TSX 60 relative bid-ask spreads

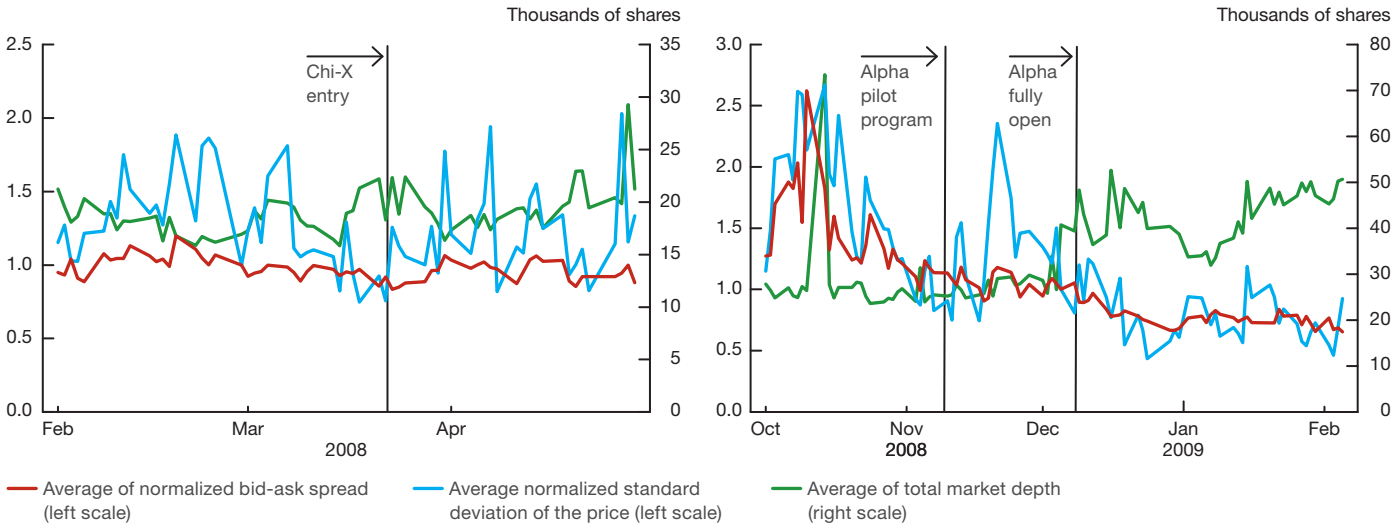


Note: The relative spread is the bid-ask spread divided by the mid-quote price. A lighter dot indicates that a greater number of stocks have the same relative spread near a certain date.

Source: Thomson Reuters Last observation: 6 November 2009

Chart 3: Market quality measures surrounding the entry of alternative trading systems

a. Chi-X (24 March 2008) b. Alpha (7 November 2008 and 5 December 2008)



Source: Thomson Reuters Last observation: 23 May 2008 Last observation: 5 February 2009

Market complexity, costs and risk

Fragmented trading has placed new demands on market participants. They must install costly systems that handle multiple venues, new types of orders, new pricing regimes and new trading strategies. As well, regulation requires market intermediaries to make similar costly investments to achieve compliance. In addition to increasing costs, market fragmentation has made markets more complicated, which raises operational risks.

A particular concern of Canadian market intermediaries is the order-protection rule. Dealers feel that the rule requires them to monitor all prices available on all trading platforms in case any have a better price.[4] To monitor all venues,

4 The order-protection rule does not explicitly protect every single price, but participants try to avoid any possibility of violating the regulation by interpreting it strictly.

participants must pay connection and data fees to each venue regardless of its importance, subsidizing new venues and increasing costs. The additional costs have made it difficult for smaller brokers—who lack the funds to make repeated investments in technology—to remain in the Canadian market, although some have adapted by buying services from larger intermediaries.

As markets grow more fragmented, the concerns about complexity multiply, since…

As markets grow more fragmented, the concerns about complexity multiply. The entry of every new trading venue raises the number of prices and the amount of activity that participants have to monitor. The amount of activity increases substantially because participants in each market react to changes observed in the others. When there are multiple venues, high-frequency trading strategies, already active by design, are particularly prone to increased activity, which can generate a deluge of information. For example, the enormous amount of data generated during the flash crash of 6 May 2010 made isolating the cause more difficult (Kirilenko et al. 2011). Complexity also creates opportunities for traders and infrastructure providers to profit at the expense of other market participants. For example, electronic traders may be able to exploit timing differences between venues to gain an information advantage (a practice known as "latency arbitrage").[5]

…complexity can create new operational risks

Complexity can in turn create new operational risks. Each trading platform uses different and often proprietary technology and communications protocols. The need to write trading software that is compatible with multiple trading platforms raises the likelihood of glitches, which are increasingly common. In the United States, a coding problem was responsible for an August 2012 disruption in markets that cost Knight Capital more than US$400 million. More recently, in August and September 2013, operational failures were responsible for two outages at NASDAQ, an options market halt at the Chicago Board Options Exchange, an outage at Eurex, a sequence of options trading errors by Goldman Sachs and a national U.S. options market outage. So far, operational failures have been relatively short and contained, and have not caused wider financial problems. But the risk remains that a glitch could precipitate or accelerate a systemic shock.

Market fragmentation can be both a cause of software glitches and a cure, given the right regulations and trading practices

Market fragmentation can nevertheless be both a cause of software glitches and a cure, given the right regulations and trading practices. Operational failures triggered by problems with exchanges, participants or the connections between them are inevitable. Work should therefore focus as much on making the system resilient to such failures as on avoiding them. For example, the presence of multiple trading venues can improve financial stability by reducing the systemic importance of each individual venue. Participants should be able to continue trading despite the failure of even the largest venue by routing trading activity to other venues. But this works only if single points of failure are minimized, and market participants are prepared and permitted to bypass failing infrastructure to reach markets.

There is a broad appetite among market participants for regulators to introduce some thoughtful improvements to the market structure. Regulators are currently examining issues related to fees for market data, the order-protection rule and high-frequency trading.[6] These initiatives may lead to some limits on innovation and competition in the Canadian marketplace

5 Differences in access to markets are, of course, far from new. For example, before the advent of electronic trading, floor traders had a huge latency advantage over other market participants.

6 See Ontario Securities Commission, "CSA Staff Consultation Paper 21-401 Real-Time Market Data Fees," 12 November 2012, available at http://osc.gov.on.ca/en/SecuritiesLaw_csa_20121108_21-401_real-time-data-fees.htm; and Investment Industry Regulatory Organization of Canada, "The HOT Study: Phases I and II of IIROC's Study of High Frequency Trading Activity on Canadian Equity Marketplaces," 2001, available at http://www.iiroc.ca/Documents/2012/c03dbb44-9032-4c6b-946e-6f2bd6cf4e23_en.pdf.

in exchange for reduced cost and complexity for market participants. In deciding what regulatory changes to make, careful consideration of the potential effects on market quality will be essential.

Conclusion

The fragmentation of equity trading in Canada has brought competition, both on price and on product. Our simple analysis of measures of market quality finds that the long-term trend of improving market quality has continued alongside increasing market fragmentation. Nonetheless, more rigorous econometric techniques are necessary to disentangle the many factors at play, and more-sophisticated measures of market quality should be employed.[7] Much work is still to be done to fully assess the impact of fragmentation and other changes to the structure of the equity markets in Canada, including recent events such as the Maple Group's acquisition of Alpha and the potential future entry of the Aequitas trading venue. A full assessment of the impact of these events on market quality would provide regulators and market participants with a foundation for analyzing additional instances of fragmentation that will likely occur in the future.

We have described a number of costs and complexities associated with market fragmentation that deserve to be studied independently of the classical trade-off between concentration and competition, which we view to be less relevant given modern trading technology. In particular, the increased expenditures on technology and expertise are not trivial, and increased market complexity can bring greater operational risks. These are concerns that regulators must carefully manage.

7 For example, Bain and Mudassir (2013) show a recent increase in intraday volatility.

Literature Cited

Amihud, Y., B. Lauterbach and H. Mendelson. 2003. "The Value of Trading Consolidation: Evidence from the Exercise of Warrants." *Journal of Financial and Quantitative Analysis* 38 (4): 829–46.

Bain, S. and S. Mudassir. 2013. "Evolution of Canadian Equity Markets." RBC Capital Markets *Global Electronic Trading* (February).

Battalio, R. H. 1997. "Third Market Broker-Dealers: Cost Competitors or Cream Skimmers?" *Journal of Finance* 52 (1): 341–52.

Bennett, P. and L. Wei. 2006. "Market Structure, Fragmentation, and Market Quality." *Journal of Financial Markets* 9 (1): 49–78.

Boisvert, S. and C. Gaa. 2001. "Innovation and Competition in Canadian Equity Markets." *Bank of Canada Review* (Summer): 15–30.

Boulatov, A. and T. J. George. 2013. "Hidden and Displayed Liquidity in Securities Markets with Informed Liquidity Providers." *Review of Financial Studies* 26 (8): 2095–137.

Canadian Securities Administrators/Investment Industry Regulatory Organization of Canada (CSA/IIROC). 2009. "Dark Pools, Dark Orders, and Other Developments in Market Structure in Canada." Consultation Paper No. 23-404.

Davies, R. J. and S. S. Kim. 2009. "Using Matched Samples to Test for Differences in Trade Execution Costs." *Journal of Financial Markets* 12 (2): 173–202.

Degryse, H., F. De Jong and V. Van Kervel. 2013. "The Impact of Dark Trading and Visible Fragmentation on Market Quality." TILEC Discussion Paper No. 2011-026. Available at http://ssrn.com/abstract=1815025.

Foley, S. and T. J. Putniņš. 2013. "Should We Be Afraid of the Dark? Dark Trading and Market Quality." Available at http://ssrn.com/abstract=2279719.

Foucault, T. and A. J. Menkveld. 2008. "Competition for Order Flow and Smart Order Routing Systems." *Journal of Finance* 63 (1): 119–58.

Gajewski, J.-F. and C. Gresse. 2007. "Centralised Order Books Versus Hybrid Order Books: A Paired Comparison of Trading Costs on NSC (Euronext Paris) and SETS (London Stock Exchange)." *Journal of Banking and Finance* 31 (9): 2906–24.

Kirilenko, A. A., A. S. Kyle, M. Samadi and T. Tuzun. 2011. "The Flash Crash: The Impact of High Frequency Trading on an Electronic Market." Available at http://ssrn.com/abstract=1686004.

Malinova, K. and A. Park. 2011. "Subsidizing Liquidity: The Impact of Make/Take Fees on Market Quality." American Finance Association 2012 Chicago Meetings Paper. Available at http://ssrn.com/abstract=1787110.

O'Hara, M. and M. Ye. 2011. "Is Market Fragmentation Harming Market Quality?" *Journal of Financial Economics* 100 (3): 459–74.

Pagano, M. 1989. "Trading Volume and Asset Liquidity." *Quarterly Journal of Economics* 104 (2): 255–74.

Pirrong, C. 2000. "A Theory of Financial Exchange Organization." *Journal of Law and Economics* 43 (2): 437–72.

Shleifer, A. 1998. "State Versus Private Ownership." *Journal of Economic Perspectives* 12 (4): 133–50.

TMX Group. 2008. "TMX Group Targets Liquidity with Reduced Equity Trading Fees." Press release, 29 October.

———. 2010. "TMX Group Reduces Equity Trading Fees." Press release, 19 March.

Van Kervel, V. 2012. "Liquidity: What You See Is What You Get?" Available at http://ssrn.com/abstract=2021988.

Weaver, D. G. 2011. "Internalization and Market Quality in a Fragmented Market Structure." Available at http://ssrn.com/abstract=1846470.