Using Market-Based Indicators to Assess Banking System Resilience

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- Market-based indicators are quantitative tools that can be used to gauge the market's assessment of the resilience of the banking system. These indicators are based on information from financial markets and are thus timely, reflect expectations of future performance and offer good comparability across regions and through time.

- However, since they reflect the beliefs of market participants who could incorrectly assess banking system risks, market-based indicators could overstate or understate banking system resilience. For this reason, market-based indicators complement, rather than replace, other measures of resilience based on regulatory and accounting information.

- Market-based indicators suggest that markets perceive major Canadian banks to be currently better placed to handle adverse shocks than their counterparts in other advanced economies. Compared with regulatory capital ratios, however, market-based indicators suggest less improvement in banking system resilience since the pre-crisis period. This report discusses several explanations for this divergence.

- When compared with banking systems in other advanced economies at the onset of banking crises since the 1990s, the Canadian banking system is seen by market participants as relatively resilient. Moreover, a market-based measure of the expected capital shortfall in the banking system under stressed conditions suggests that markets view Canadian banks as able to withstand a severe system-wide shock.

Introduction

The Bank of Canada regularly assesses vulnerabilities in the Canadian financial system using the approach set out by Christensen et al. (2015). The assessment incorporates a variety of quantitative and qualitative sources of information that span the entire financial system. This report, in contrast, focuses exclusively on the information contained in market data as it pertains to the banking system. The data are processed into indicators to ensure a more structured interpretation of market information. These indicators are referred to as "market-based" because of their reliance on market

data such as stock prices. The market-based indicators shed light on how market participants evaluate the resilience of the banking system, which can complement analysis based on accounting and regulatory information.

In the sections that follow, the advantages and disadvantages of market-based indicators are discussed. An index of market-based indicators is then constructed and used to infer market perceptions of the resilience of the Canadian banking system over time and in comparison with banking systems in other advanced economies. Furthermore, we examine potential explanations for why market-based indicators show less improvement since the pre-crisis period than the generally positive trend observed in regulatory capital ratios. Lastly, historical comparisons and a "market-based stress test" are used to provide some insight into the market's assessment of the current level of resilience of the Canadian banking system.

Advantages and Disadvantages

Market-based indicators are one of the tools that the Bank uses to analyze the resilience of the banking system. Compared with other indicators, such as accounting-based measures, market-based indicators have the advantage of providing a near-real-time outlook because market prices are quick to reflect changing expectations of market participants. These indicators are also forward-looking in the sense that market prices incorporate expectations about future earnings. For these reasons, market-based indicators tend to be more responsive to changes in banking system resilience than balance-sheet metrics such as regulatory capital ratios. Furthermore, market-based indicators are less sensitive to differences in accounting regimes, which makes them especially suitable for cross-country comparisons. Finally, by reflecting the views of market participants, these indicators help us understand market funding and investment decisions such as willingness to roll over bank funding in times of stress. Since a worsening in market perceptions could potentially cause trouble for banks in the form of funding and market liquidity issues, monitoring these indicators is important even if markets incorrectly assess banking system risks.

Because market participants could be wrong about banking system risks, market-based indicators complement, rather than replace, other measures of resilience. Moreover, market-based indicators have several other limitations. First, they can reflect the noise present in market data as well as uncertainty inherent in the methodologies used to estimate them. As a result, small changes in these indicators may not be very meaningful. In addition, these indicators embed market expectations of the effects of potential government interventions to support distressed banks and therefore do not assess the stand-alone risk profile of the banking system. Confidential regulatory data may also provide a more accurate or granular view than public data available to market participants. Finally, challenges can arise in the interpretation of indicators: for example, when relying solely on market data it may be difficult to disentangle whether high correlations are due to common exposures or direct interlinkages between banks.

An Index of Market-Based Indicators

A banking system can be considered more resilient if it has a higher capacity to withstand and quickly recover from a wide array of shocks. All else being equal, a banking system is better able to withstand and quickly recover from shocks if (i) it has larger initial capital and liquidity buffers to

absorb shocks, (ii) the system-wide impact of shocks is smaller, and (iii) the banks in the system are able to quickly rebuild their capital from retained earnings after a shock occurs.

To monitor the market's perception of the current state of banking system resilience and facilitate comparisons across regions and time, we construct a composite index that broadly measures these aspects of banking system resilience.[1] The index incorporates five widely implemented market-based indicators: a market-based capital ratio (MBCR), distance to default (DD), exposure ΔCoVaR (difference in conditional value-at-risk), marginal expected shortfall (MES) and long-run marginal expected shortfall (LRMES). **Box 1** provides a brief explanation of each of these indicators.

The indicators can be roughly categorized into two types. The first is based on the market valuations of banks (MBCR and DD), which in turn depend on the level of the banks' capital buffers and expectations of their future profitability. These aspects are relevant to the resilience of individual banks regardless of whether shocks are bank-specific or system-wide. In comparison, the second type of indicator mainly considers resilience related to the system-wide impact of severe shocks (exposure ΔCoVaR, MES and LRMES). These indicators account for the degree of interlinkages and common exposures within a banking system as perceived by market participants,[2] which can increase the system-wide impact of shocks. Moreover, they are also sensitive to vulnerabilities associated with unstable funding profiles, which can threaten the continuity of banks and thus future earnings (López-Espinosa et al. 2012, 2013).

We construct a banking system resilience index for different countries and regions by averaging the individual indicators using weights based on their standard deviations.[3] This ensures a roughly equal contribution of each indicator to changes in the index. The level of the index for Canada in 2004, which covers the Big Six banks (see the **Appendix**), is taken as the base value of zero, and all other values are expressed relative to that. With this base year, the long-term average for Canada since 1990 is close to an index value of zero. An increase in the level of the index corresponds to a higher level of banking system resilience based on market perceptions. In particular, every 100-point increase in the index is equivalent to a doubling of the indicators related to the banks' capital buffers and their future profit-ability (MBCR and DD), and a halving of indicators related to the system-wide impact of shocks (exposure ΔCoVaR, MES and LRMES).

The level of the index is comparable across regions and time.[4] However, in terms of resilience, the comparability over time is affected by variation in market valuations on an aggregate level that is related to discount rates and not to expected future dividends. Discount rates are affected by changes in the yield curve and risk premiums over time (Cochrane 2011), which depend on saving behaviour and global risk appetite, among other factors, but they

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1   There may be other aspects of resilience that are not completely captured by these indicators. Including indicators that better capture these other aspects would result in a broader index but could also affect the historical and geographical availability of the index because of additional data requirements.

2   Market-based measures for the degree of interlinkages and common exposures tend to be highly correlated to broad regulatory measures of interconnectedness used to classify systemically important banks (Van Oordt and Zhou 2015).

3   These are Australia, Canada, the euro area, the United Kingdom and the United States.

4   To ensure greater comparability between the MBCRs of banks reporting under International Financial Reporting Standards (IFRS) and US Generally Accepted Accounting Principles (US GAAP), we adjust the amount of total assets of US banks for differences in derivatives netting following the procedure described by the IFRS Foundation (2015).

Box 1

Market-Based Indicators in the Index of Banking System Resilience

This box briefly explains the five indicators used in calculating the banking system resilience index. Each indicator is calculated for individual banks and then aggregated for the banking system by calculating a weighted average. Details on the methodology to estimate each of these indicators and other background information is provided in MacDonald, Van Oordt and Scott (2016).

The **market-based capital ratio** (MBCR) is a measure of a bank's capital buffer based on market valuations. More precisely, the MBCR is defined as the market value of common equity as a percentage of the market value of total assets, where the market value of total assets is calculated as the sum of the market value of common equity and the book value of total debt. The MBCR is somewhat analogous to the Basel III leverage ratio in the sense that assets are not risk-weighted.

The **distance to default** (DD) is a proxy for the number of standard deviations of a shock to the market value of a bank's assets that would erase its equity capital. A smaller DD indicates that a less extreme shock could potentially eliminate the institution's capital, suggesting a higher probability of default. Its level is calculated as roughly the difference between the market value of assets and the face value of debt, expressed as a ratio of the annualized volatility of the asset value.[1] Since the DD includes a correction for asset risk, it is somewhat analogous to risk-weighted regulatory capital ratios such as the common equity Tier 1 ratio.

The **marginal expected shortfall** (MES) and the **long-run marginal expected shortfall** (LRMES) measure the expected loss of an institution if the banking system suffers a sudden adverse shock. While the MES measures one-day losses of a bank conditional upon a system-wide shock, the LRMES

provides an expected cumulative loss of market value over a longer period (typically six months).[2] The higher the MES (or LRMES), the greater the impact of a system-wide shock. The MES is estimated as the average of a bank's equity returns during the worst 5 per cent of days for the banking system in that country or region over the past two years (Acharya, Engle and Richardson 2012). Our procedure to estimate the LRMES of a bank involves modelling the relationship between an individual bank's equity returns and the returns on an index with all other institutions in the banking system, while allowing for volatility and correlations to vary over time (Acharya et al. 2017; Brownlees and Engle 2017). This relationship is used to simulate a large number of potential paths for the bank's and the system's equity returns over the next six months. The LRMES is then calculated as the median return of the bank in the simulations with the worst 1 per cent of outcomes for the system.

The MES and LRMES both focus on the expected loss in a hypothetical stress scenario. In contrast, **exposure ΔCoVaR** (difference in conditional value-at-risk) focuses on the increase in downside tail risk of a bank, conditional upon a system-wide shock (Adrian and Brunnermeier 2016). Its level depends not only on the level of expected losses but also on how risk evolves in a potential stress scenario. A larger exposure ΔCoVaR therefore indicates a higher degree of sensitivity of a bank's individual distress to shocks in the banking system. The exposure ΔCoVaR is computed as the increase in an institution's daily value-at-risk with a 95 per cent confidence level conditional upon the system suffering a loss equal to the system's own value-at-risk. The level of the exposure ΔCoVaR is calculated using quantile regression techniques.

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1   The measure is estimated based on the Merton model (Merton 1974).

2   Historical experience shows that banking crises have the potential to last much longer than six months (Laeven and Valencia 2013).
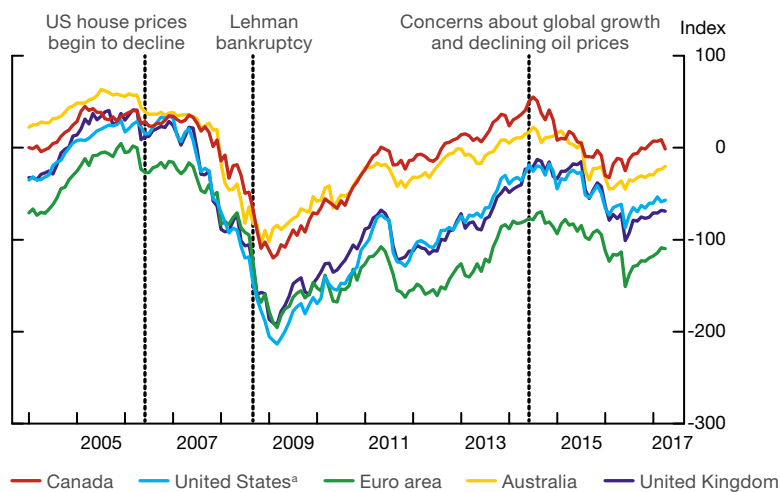
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are also influenced by the unconventional monetary policies of some central banks over the past few years. Cross-country comparisons at the same point in time are less affected by the changes in the yield curve and risk premiums over time.

The Evolution in Global Banking System Resilience Since the Financial Crisis

Chart 1 provides a summary view of how the resilience of the banking systems of Canada, the United States, the United Kingdom, Australia and the euro area has evolved over the past decade. The overall pattern of movements in the index is broadly similar across countries and regions, which suggests that market perceptions of banking system resilience at the

Chart 1: Evolution in market perceptions of banking system resilience, by region

Index: Canada in January 2004 = 0, higher values imply greater perceived resilience

Notes: The resilience index is constructed as a weighted average of five sub-indexes based on the following indicators: MBCR, DD, MES, LRMES and exposure ΔCoVaR (see **Box 1**). The sub-index weights function to normalize for differences in volatility across indicators. See MacDonald, Van Oordt and Scott (2016) and the Appendix for more details on the calculations behind the index.

a. When calculating the MBCR of US banks, total assets are adjusted to account for differences in derivatives netting across accounting regimes.

Sources: Thomson Reuters Datastream and Bank of Canada calculations   Last observation: April 2017

regional level are strongly influenced by global events. However, the magnitude of changes in the index in response to these events has varied across countries and regions.
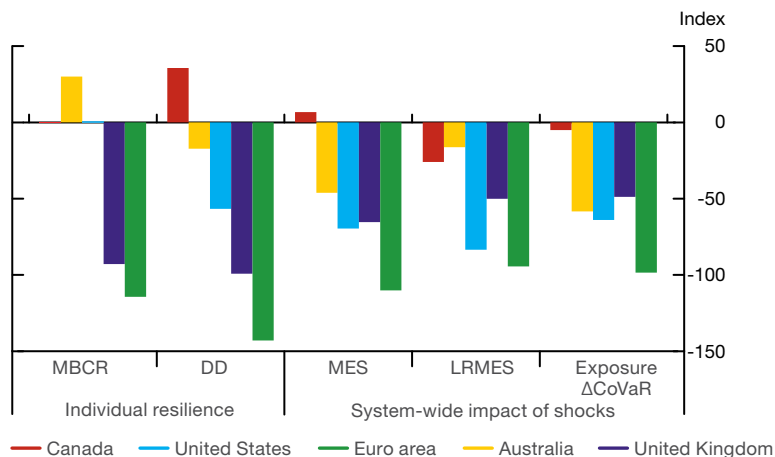
The evolution of the resilience index levels for the Canadian and Australian banking systems during the 2008–09 financial crisis supports the view that these countries were relatively less affected than other advanced economies (see also Sarin and Summers 2016, 101). At the beginning of 2008, the resilience index for the US, UK and euro area banking systems had reached levels between -70 and -90. At the trough in March 2009, the index for these regions had fallen to levels around -190 in the euro area and the United Kingdom and -210 in the United States. In comparison, the resilience index for Canada had fallen to a value of -120. The nearly 100-point difference implies that, at the deepest point in the crisis, the US banking system was substantially worse off in measures of resilience compared with the Canadian banking system.

Another example of the differences across regions is observed in the recovery phase after their index levels had reached their lowest point in the crisis. In particular, the improvement in the index was much slower for the euro area than for other regions once the European sovereign debt crisis began escalating in 2010. In contrast, the resilience index for Canada reached into positive territory for the first time since the crisis in September 2012.

In the second half of 2014, the generally positive trend reversed following rising concerns about the global growth outlook that coincided with a significant decline in oil and other commodity prices. The initial reversal was more pronounced for Canada, suggesting that market participants viewed the weakened outlook and the exposure of Canadian banks to the resource

Chart 2:   Comparison of index components across regions as of April 2017

Index: Canada in January 2004 = 0, higher values imply greater perceived resilience

Sources: Thomson Reuters Datastream and Bank of Canada calculations   Last observation: April 2017

sector as limiting their ability to quickly recover from additional setbacks in the future, although not to the same extent as in 2008–09. Since early 2016, the index for Canada has once again been improving along with the outlook for global growth and a partial recovery in commodity prices, while the euro area and UK banking systems have faced additional setbacks from uncertainty surrounding the Brexit referendum and non-performing loans at Italian banks.

The current level of the resilience index for Canada remains above that of all other regions examined. This is consistent with the typically narrower credit spreads of Canadian banks compared with many of their global peers (see, e.g., Bank of Canada 2016, 23). Moreover, the ranking of regions was fairly similar across the different index components in April 2017 (**Chart 2**), suggesting that the relative resilience of the Canadian banking system is independent of the weights used to construct the index from the individual market-based indicators.
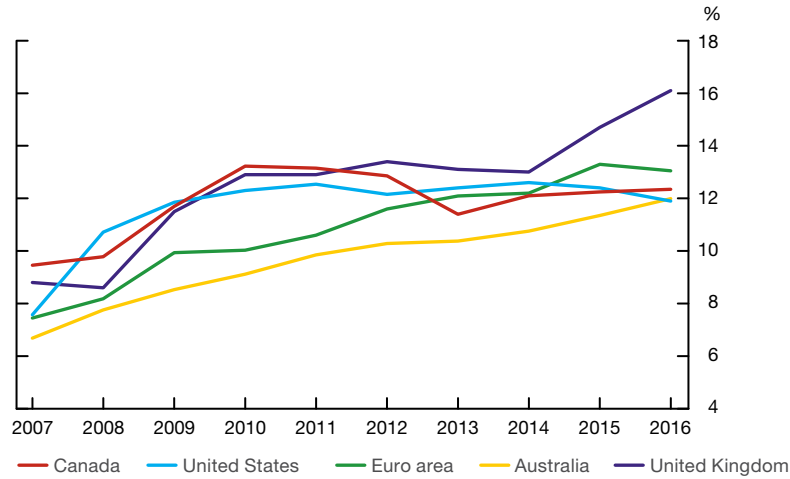
Banking System Resilience and Regulatory Capital Ratios

Market-based indicators suggest less improvement in banking system resilience than regulatory capital ratios do. The previous section shows that market-based indicators suggest markets do not regard banks as substantially more resilient than they were in the pre-crisis period. This is particularly true for banks in the euro area, which market-based indicators suggest are *less* resilient than before the crisis. This is a different picture than that provided by regulatory capital ratios, which have improved substantially in all jurisdictions since the pre-crisis period (**Chart 3**). There are several possible explanations for this divergence.[5]

First, market-based indicators of banking system resilience reflect the expectation that banks have a reduced ability to replenish capital buffers as a consequence of weaker profitability, while regulatory capital ratios omit this information. Regulatory and accounting-based capital ratios provide a backward-looking measure of bank resilience and are unaffected by changes in expected future profits. In contrast, a reduction in expected

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5   See also Calomiris and Nissim (2014) and Sarin and Summers (2016).

Chart 3:   Median Tier 1 capital ratio of major banks, by region

Canada   United States   Euro area   Australia   United Kingdom

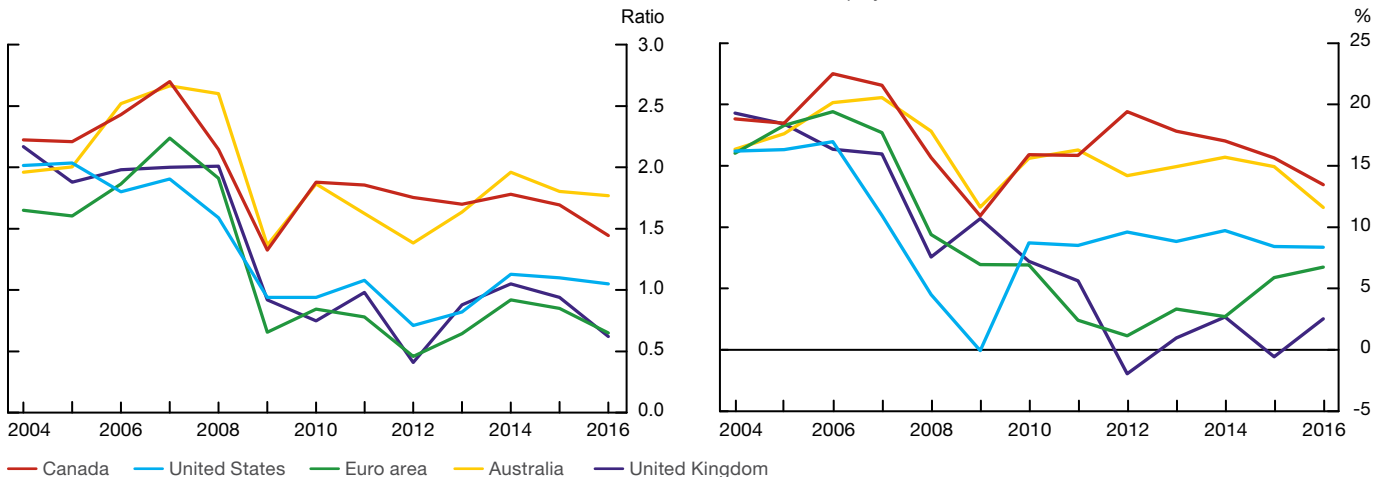Source: Fitch Connect   Last observation: 2016

future profits does lower the market valuation of a bank. This component of a bank's market valuation related to future profits is reflected in the premium of a bank's market value relative to its book value. Indeed, price-to-book ratios have fallen along with a downward trend in return on equity across jurisdictions since the crisis (**Chart 4**).

Several factors could be driving the weaker outlook for bank profitability, including the impact of a relatively flat yield curve on banks' net interest margins, a weaker global economic outlook than before the crisis, a reduced impact of implicit government guarantees on bank funding costs, increased regulatory compliance costs and regulatory restrictions on profitable business lines such as proprietary trading (United States), elevated political and economic uncertainty (euro area, United Kingdom and United States) and depressed commodity prices that have recovered only partially (Australia and Canada).

Chart 4:   Median price-to-book ratio and return on equity of major banks, by region

a. Price-to-book ratio

b. Return on equity

Canada   United States   Euro area   Australia   United Kingdom

Source: Thomson Reuters Datastream   Last observation: 2016

Second, market-based indicators of banking system resilience suggest that the system-wide impact of shocks has remained relatively high since the financial crisis, which could be due to a remaining high level of interconnectedness, common exposures and complexity within banking systems as well as banking system consolidation and elevated global uncertainty in the post-crisis period. The Tier 1 capital ratios shown in **Chart 3** do not account for these aspects of resilience.[6]

Third, the improvements in banking sector resilience relative to the pre-crisis period might not be fully captured by market-based indicators if market participants underestimated banking system risks before the financial crisis. This explanation assumes markets have become more aware of, or better at internalizing, the risks associated with unstable funding profiles and interconnected banking systems since the financial crisis, resulting in an overly optimistic base case and therefore an underestimation of the actual improvement in resilience. Moreover, international efforts to implement bail-in regimes that allow authorities to recapitalize banks by converting eligible debt of a failing bank into common shares could have contributed to markets better internalizing risks since the crisis.

Fourth, markets may discount the improvements in regulatory capital ratios because of variation across banks arising from diversity in regulatory definitions and banks' methodological choices. For example, a significant amount of variation in average risk weights has been attributed to differences in bank and supervisory practices (Basel Committee on Banking Supervision 2013; Plosser and Santos 2014).

Market-Based Indicators During Banking System Stress

The analysis so far does not address whether the market perceives the Canadian banking system as able to withstand a severe system-wide shock. This section applies two approaches to provide further insight into this question, with each approach having its own caveats.

The first approach is to compare the current level of the Canadian index of banking system resilience with the levels of other banking systems at the onset of historical episodes of severe banking distress. The index levels for the banking systems in these regions can provide reference points for when banking system resilience was insufficient to withstand a severe system-wide shock. The idea behind this approach is that a banking system that does not have an index value above these levels is unlikely to be sufficiently resilient.

Table 1 shows the results of this first approach, noting the levels of the banking system resilience index and each of the market-based indicators for a sample of major banks in countries at the onset of historical stress episodes.[7] For each indicator, higher values are associated with more resilience. The last row of the table reports the current levels for Canada for comparative purposes. The current level of the banking system resilience index for Canada in **Table 1** is substantially higher than that of other economies at the onset of episodes of banking system distress, except for the Asian crisis, for which the difference is smaller. This suggests that, based on

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6   These factors are, to some extent, accounted for in the Basel Committee on Banking Supervision's assessment frameworks to determine the additional loss absorbency requirement for systemically important banks.

7   Except for the US and euro area crises, the level of the resilience index is not substantially higher in the 12 months before the selected dates, but it is generally much lower in the 12 months that follow.

Table 1: Market-based indicators of local banking system resilience at the onset of historical stress episodes

	Resilience index	MBCR (per cent)	DD	LRMES (per cent)	MES (per cent)	Exposure ΔCoVaR (per cent)	Date[a]	Number of banks
Nordic crisis	-52	4.1	2.9	-29.9	-2.0	-1.6	1991 (August)	8
Japanese crisis	-54	7.5	3.5	-32.2	-3.2	-2.2	1992 (March)	15
Asian crisis	-26	6.0	2.4	-25.7	-1.5	-1.3	1997 (June)	37
Argentine crisis	-101	4.0	1.7	-53.7	-2.2	-2.1	2001 (November)	4
US crisis	-81	7.7	3.1	-56.6	-3.5	-2.2	2008 (February)	25
Euro area crisis	-152	3.3	2.5	-57.6	-7.2	-5.4	2010 (April)	30
Canada (for comparison)	-1	10.1	8.9	-32.6	-2.0	-1.5	2017 (April) (current)	6

Note: Higher values are associated with more resilience.

a. The selected dates precede some of the major events that happened relatively early in these crises. For the Nordic crisis, August 1991 precedes the autumn in which Sweden and Finland stepped in in response to banks facing liquidity shortages, and Norway's Government Bank Insurance Fund started to directly provide capital support to problem banks. For the Japanese crisis, March 1992 is the month preceding the first quarterly decrease in the Japanese nominal house price index in a long slump in Japanese real estate prices during the 1990s. For the Asian crisis, June 1997 precedes the month with severe currency depreciations leading up to the Asian crisis. For the Argentine crisis, November 2001 precedes the restrictions in bank withdrawals that were introduced in December and the abandonment of the peg of the Argentine peso to the US dollar in January 2002. For the US crisis, February 2008 precedes the failure of Bear Stearns in March 2008. For the euro area crisis, April 2010 is the month before the members of the euro area agreed to create the European Financial Stability Facility.

Sources: Thomson Reuters Datastream and Bank of Canada calculations

the indicators, markets perceive the Canadian banking system to be more resilient than foreign banking systems that were insufficiently resilient to recover from historical episodes of severe system-wide stress.
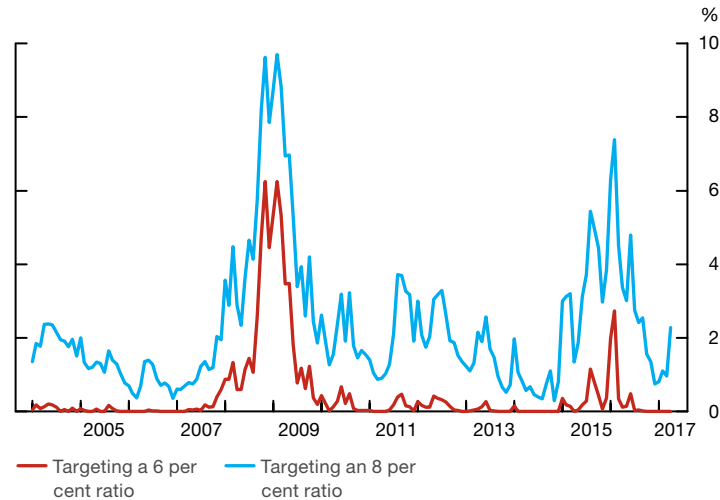
There are several caveats to this approach, however. The first caveat is that there is no uniform method to choose the date at which banking systems were at the onset of episodes of severe distress. Historical crises often refer to a chain of events. Academics regularly disagree on the precise timing of crises because different methodologies may lead to differences regarding the years that a crisis actually took place; see, e.g., Laeven and Valencia (2013) and Chaudron and De Haan (2014). Another caveat of comparisons to the levels of indicators in historical crises is that some indicators are affected by changes in accounting standards over time (in particular, the MBCR), although less so than regulatory or accounting-based measures. Finally, the macroeconomic and regulatory environments for each of these historical stress episodes differ significantly from the current environment in Canada.

The second approach to provide a reference point for the resilience of banks is the SRISK methodology developed by Acharya et al. (2017) and Brownlees and Engle (2017). The idea behind this approach is that major issues in the banking system are relatively unlikely as long as banks' MBCRs meet some target level. The banking system can then be considered resilient if banks still meet the target ratio after the system suffers from a hypothetical severe shock. By assessing forward-looking post-stress capital ratios, the SRISK methodology is more akin to a market-based stress test.

The aggregate SRISK measures the expected capital shortfall of the banking system after a system-wide shock. More specifically, it is the sum of money that would be needed to restore the capital ratio of each institution in the system to the target level following a six-month period of systemic stress. This amount depends on banks' total assets, their initial MBCRs and

Chart 5:   **Expected capital shortfall of the Big Six Canadian banks after six months of severe system-wide stress as measured by SRISK methodology**

Capital shortfall relative to a target of the market-based capital ratio, as a percentage of GDP

Targeting a 6 per cent ratio   Targeting an 8 per cent ratio

Sources: Thomson Reuters Datastream and Bank of Canada calculations   Last observation: April 2017

the impact of the system-wide shock. The impact of the system-wide shock is based on the LRMES measure described in **Box 1** and corresponds to the expected loss in a bank's market capitalization in the worst 1 per cent of outcomes for the regional banking system over a six-month period. The SRISK measure for an individual bank is obtained by applying this shock to its current MBCR. The aggregate SRISK measure is then calculated as the sum of the capital shortfalls across banks.

Although the SRISK methodology can be considered a market-based stress test, it is not directly comparable to supervisory stress tests in every respect. Regulatory data on banks' portfolio exposures can provide more information on the specific drivers of results in supervisory stress tests that are not identified by SRISK. Moreover, stress test models, such as the Bank of Canada's MacroFinancial Risk Assessment Framework (MFRAF), can shed light on the marginal impact of liquidity risk and network spillover effects (Anand, Bédard-Pagé and Traclet 2014). Supervisory stress tests also typically estimate the impact of more specific scenarios beyond the six-month horizon used in the market-based stress test based on the SRISK methodology.

Chart 5 shows the level of the SRISK measure for target ratios of 6 per cent and 8 per cent.[8] For comparability over time, the SRISK measure is expressed as a percentage of nominal gross domestic product (GDP). The chart suggests that the Big Six banks in the Canadian banking system are currently able to withstand a six-month period of severe system-wide stress with a relatively small expected capital shortfall given a conservative target ratio of 8 per cent.[9]

8   The target ratio based on market valuations cannot be directly compared with regulatory minimum capital ratios. In the academic literature, target ratios generally range from 5.5 per cent to 8 per cent. The 8 per cent level also corresponds to the average MBCR of Canadian domestic systemically important banks in October 2008, when the Bank of Canada announced exceptional liquidity measures.

9   The numbers in **Chart 5** are different from those reported by New York University's Volatility Laboratory for several reasons. First, we do not include non-bank financial institutions. Second, the target capital ratio before November 2011 is increased by a factor of 1.062 to adjust for a lower balance of total assets reported by banks under the pre-IFRS accounting standards; see, e.g., MacDonald, Van Oordt and Scott (2016). Third, our numbers focus on a 1 per cent worst outcome for the index of the Canadian banking system instead of a 40 per cent decline in a global market index.

From mid-2014 until early 2016, however, the level of the SRISK measure increased as commodity prices slid and global uncertainty grew. The initial low level around the summer of 2014 indicates that Canadian banks, at that time, were considered more resilient than after the fall in oil prices. The higher level in early 2016 suggests that an additional six-month period of severe system-wide stress in an environment of depressed commodity prices could have resulted in an MBCR significantly below the target of 8 per cent. As such, market participants deemed the banking system to have a lower capacity to recover from additional setbacks during that period. The relatively high level of the peak in early 2016 is also due in part to the growth in the Canadian banking system, which has outpaced the growth in nominal GDP. As a result, the economic and fiscal consequences of instability in the banking system would be larger.

Conclusion

Market-based indicators are one of many tools used to assess banking system resilience. They are complementary to regulatory measures such as capital and leverage ratios as well as stress tests. These indicators help monitor the market's current perception of the banking system's capacity to withstand and quickly recover from a wide array of shocks. They reflect market information regarding the level of buffers in the banking system, the possible system-wide impact of shocks and the system's ability to rebuild buffers from retained earnings after a shock.

Overall, the indicators suggest that market participants perceive the Canadian banking system to be relatively resilient when compared with both the current situation in other advanced economies and with historical episodes at the onset of banking crises. This is consistent with the stress test conducted in the context of the International Monetary Fund's Financial Sector Assessment Program, which demonstrated the resilience of the major financial institutions in Canada to risks arising from a severe stress scenario (IMF 2014). However, market-based indicators do not show a meaningful increase in resilience compared with the pre-crisis period, despite improvements in the levels of regulatory capital ratios. This can be partly explained by the additional aspects of banking system resilience captured by market-based indicators, including expectations regarding future earnings and the system-wide impact of shocks, but it may also reflect the market's inability to detect the lack of resilience in the pre-crisis period. Market-based indicators should therefore be used as a part of a larger tool kit that takes into account other sources of information.

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Appendix: Technical Details and List of Institutions

The index values in this report are calculated using the following formula:

$$I_{c,t} = \frac{100}{\ln(2)} \times \left[\begin{array}{l} 0.192 \ln\left(\frac{MBCR_{c,t}}{10.1\%}\right) + 0.168 \ln\left(\frac{\max\{DD_{c,t},1\}}{6.92}\right) + 0.168 \ln\left(\frac{-2.05\%}{MES_{c,t}}\right) \\ + 0.291 \ln\left(\frac{-27.2\%}{LRMES_{c,t}}\right) + 0.180 \ln\left(\frac{-1.42\%}{exposure\ \Delta CoVaR_{c,t}}\right) \end{array} \right],$$

where $I_{c,t}$ refers to the level of the indicator and where, for example, $MBCR_{c,t}$ corresponds to the weighted average of the market-based capital ratio in region c at time t. Bank-specific market-based indicators are calculated for each of the financial institutions listed in **Table A-1** following the methodology in MacDonald, Van Oordt and Scott (2016). The weights to calculate the average $MBCR_{c,t}$ in region c at time t are based on the book values of total assets at time t; the weights to calculate the average $DD_{c,t}$ are based on the book values of total debt; and the weights to calculate the average $MES_{c,t}$, $LRMES_{c,t}$ and *exposure* $\Delta CoVaR_{c,t}$ are based on the market capitalizations at time t. The numbers in the formula are the indicator weights as well as the indicator values for Canada in January 2004.

Table A-1: List of institutions

Region	Institutions
Canada	Big Six Canadian banks: Bank of Montreal, Canadian Imperial Bank of Commerce, National Bank of Canada, Royal Bank of Canada, Bank of Nova Scotia, Toronto-Dominion Bank
Australia	Australia and New Zealand Banking Group, Commonwealth Bank of Australia, National Australia Bank, Westpac Banking Corporation
Euro area	ABN AMRO Bank (the Netherlands), Allied Irish Banks (Ireland), Alpha Bank (Greece), Banco Bilbao Vizcaya Argentaria (Spain), Banco BPI (Portugal), Banco Comercial Português (Portugal), Banco Popular Español (Spain), Banco de Sabadell (Spain), Bank of Ireland (Ireland), Bank of Valletta (Malta), BNP Paribas (France), Caixa Economica Montepio Geral (Portugal), Commerzbank (Germany), Criteria CaixaHolding (Spain), Deutsche Bank (Germany), Erste Group Bank (Austria), Eurobank Ergasias (Greece), Groupe Crédit Agricole (France), ING Group (the Netherlands), Intesa Sanpaolo (Italy), KBC Groep (Belgium), Monte de Paschi di Siena (Italy), National Bank of Greece (Greece), Piraeus Bank (Greece), Raiffeisen Bank International (Austria), Santander (Spain), Šiaulių Bankas (Lithuania), Société Générale (France), Tatra banka (Slovakia), UniCredit (Italy)
United Kingdom	Barclays Group, HSBC Holdings, Lloyds Banking Group, Royal Bank of Scotland Group, Standard Chartered
United States	Ally Financial Inc., American Express Company, Bank of America Corporation, The Bank of New York Mellon Corporation, BB&T Corporation, Capital One Financial Corporation, Citigroup Inc., Citizens Financial Group, Comerica Inc., Discover Financial Services, Fifth Third Bancorp, Goldman Sachs Group Inc., Huntington Bancshares Inc., JPMorgan Chase & Co., KeyCorp, M&T Bank Corporation, Morgan Stanley, Northern Trust Corporation, PNC Financial Services Group, Regions Financial Corporation, State Street Corporation, SunTrust Banks Inc., U.S. Bancorp, Wells Fargo & Company, Zions Bancorporation

Note: Institutions are selected with the intention to capture the major listed banks in each country.