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Complementing the Credit Risk Assessment of Financial Counterparties with Market-Based Indicators

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Abstract

The Bank's internal credit risk assessment abilities are regularly enhanced. In this note, we present a recent innovation that extends the set of market-based indicators used in the credit risk assessment of financial counterparties. These indicators supplement existing fundamental quantitative and qualitative credit risk analysis by providing a timely reading of markets' perceptions of the credit quality of financial counterparties.

Bank topics: Credit risk management; Financial institutions
JEL codes: G, G1, G10, G2, G24

Résumé

La Banque améliore régulièrement son dispositif interne d'évaluation du risque de crédit. Dans cette note, nous présentons des indicateurs de marché novateurs qui élargissent l'éventail des outils servant à évaluer les contreparties financières. Ces indicateurs complètent l'analyse fondamentale quantitative et qualitative du risque de crédit, en permettant une lecture rapide de la perception des marchés quant à la qualité de crédit des contreparties financières.

Sujets : Gestion du risque de crédit; Institutions financières
Codes JEL : G, G1, G10, G2, G24

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1. Introduction

In June 2010, during the aftermath of the global financial crisis, the Group of Twenty (G20 2010) raised concerns about potential over-reliance of market participants on ratings issued by credit rating agencies (CRAs). A few months later, the Financial Stability Board (FSB 2010) issued principles to reduce reliance on external ratings and instead establish stronger internal credit risk assessment practices. These principles highlight that investors—including central banks—should avoid the mechanistic use of external ratings. This guidance prompted the Bank of Canada (the Bank) and the Department of Finance to set up in 2012 a joint internal credit risk management framework to facilitate independent credit risk assessments. This new framework established an enhanced governance structure that fostered a better internal understanding of the credit risks inherent in the Bank's own financial operations and the financial operations that the Bank performs in its role as fiscal agent to the Government of Canada.[1]

Since then, the Bank has made significant progress in developing its capacity to perform credit analysis (see Wolfe 2014). In 2013, the Credit Rating Assessment Group (CRAG) was established as part of the Bank's Financial Risk Office. The role of this group is to assess the credit risk associated with the various entities that the Bank or the Government of Canada has an exposure to.[2] Consequently, internal credit risk assessments are now key inputs for investment and funding decisions.[3] For example, changes in the credit quality of counterparties identified by the CRAG can influence the allocation of financial exposures.

As part of the Bank's effort to continuously improve its approach to credit risk analysis, CRAG recently introduced a new set of market-based indicators (MBIs) to complement the range of tools it uses to assess the credit risk of major financial institutions in Canada, Europe and the United States. These indicators, which are described as "market-based" because they rely to a large extent on observable market prices, have been the subject of a growing academic literature since the financial crisis.[4] MBIs are quantitative measures that add a structured interpretation of market intelligence to the credit risk assessment of financial institutions.[5] These indicators can be instrumental in monitoring the perceptions of market participants other than external CRAs, even though the current credit risk management policies at the Bank and the Department of Finance do not directly call on MBIs for the credit risk assessment.

The remainder of this note is organized as follows. Section 2 describes the internal credit risk assessment framework for financial counterparties, highlighting the benefits it brings to the funds-management process.[6] Section 3 explains how MBIs may contribute to the methodology for credit risk assessments within this framework. Section 4 presents an overview of some of the indicators that are relevant to assess credit risks to financial institutions that could be potential financial counterparties of the Bank. Section 5 illustrates how the application of MBIs may inform the process of monitoring and assessing the creditworthiness of financial counterparties. Section 6 concludes.

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[1] The Bank of Canada manages the government's domestic cash balances, conducts auctions for domestic debt and manages the assets and liabilities of the Exchange Fund Account (EFA) and Canada's foreign exchange reserves. See Harvey and Merkowsky (2008) for more information.

[2] These entities are, for the most part, financial institutions, sovereigns, government-related entities and asset-backed securities.

[3] This shift toward internal credit risk assessments is reflected in the memorandum of understanding on treasury and credit risk management between the Bank of Canada and the Department of Finance (Department of Finance Canada 2013) and also in annual reports on the management of Canada's official international reserves (e.g., Department of Finance Canada 2014).

[4] Some widely cited studies are, for example, Adrian and Brunnermeier (2016), Acharya et al. (2017), and Brownlees and Engle (2017). For two literature reviews, see De Bandt, Hartmann and Peydró (2010) and Bisias et al. (2012).

[5] This note focuses on the application of MBIs in the context of assessing the credit risk of individual financial institutions. For an application of MBIs in the context of assessing banking system resilience, see MacDonald and Van Oordt (2017).

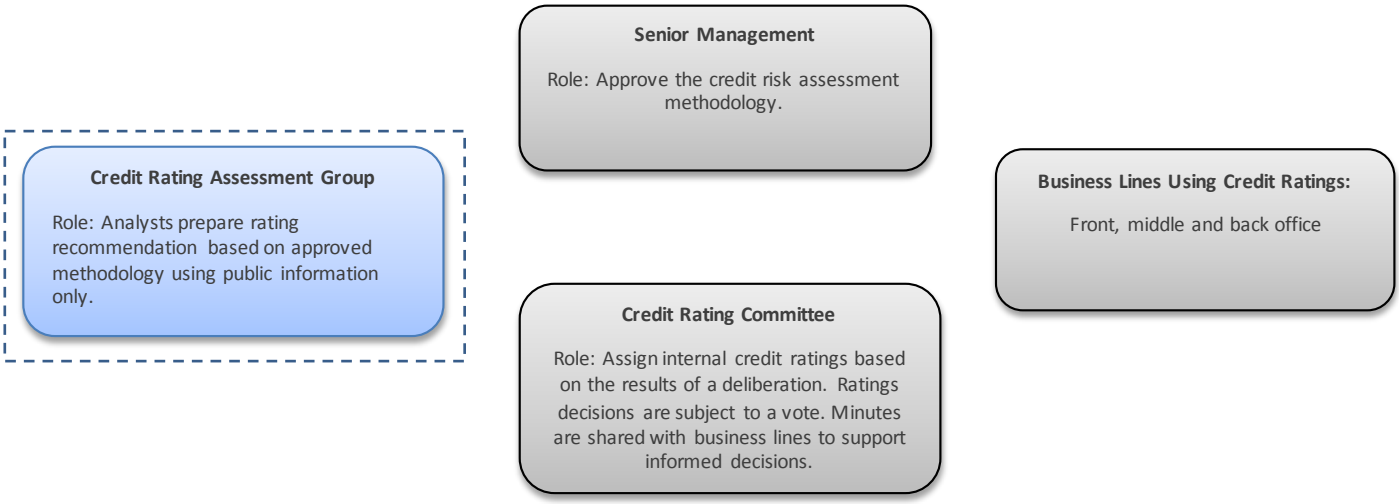
[6] See Muller and Bourque (2017) for a discussion of the Bank's methodology for assigning internal credit ratings to sovereigns.

2. Internal Credit Risk Assessment Framework for Financial Counterparties

CRAG's process to assess the credit risk of financial institutions involves several steps.[7] First, CRAG reviews the financial position and the corporate structure of the entity to evaluate whether the performance of the entity is likely to affect its capacity and willingness to meet its financial obligations. Second, the team assesses the relative creditworthiness of counterparties based on a methodology consistent with industry best practices. A credit risk assessment model is used to capture the key drivers of strengths and weaknesses underpinning the business model of the entity. These drivers, which include macro factors (e.g., the operating and regulatory environment) and institution-specific factors (e.g., its capital, earnings, funding and liquidity position) are measured with various quantitative and qualitative indicators. For example, a number of financial ratios are examined to gain a better understanding of the counterparty's fundamentals. This allows identification of trends and comparison with peer institutions. The fundamental-based analysis is complemented by an examination of the counterparty's compliance with regulatory requirements, news flows and market developments.

Finally, results of this analysis are aggregated in the form of a credit rating recommendation, which is presented to the Credit Rating Committee (CRC) for approval.[8] Discussions and the rationale supporting the final rating decision are then documented and sent to the relevant business lines (see **Figure 1**) that rely on this information for funds- or collateral-management decisions. The CRC assigns each rating annually, but the frequency may increase when concerns about a specific counterparty arise. Under this framework, the responsibility and accountability for credit assessment is internal and no longer outsourced to credit rating agencies (**Figure 1**). That said, the analysis and ratings of CRAs are used as one of the sources of information in the credit assessment and measurement of credit risk.

Figure 1: Governance and management of the internal credit risk assessment framework for financial counterparties



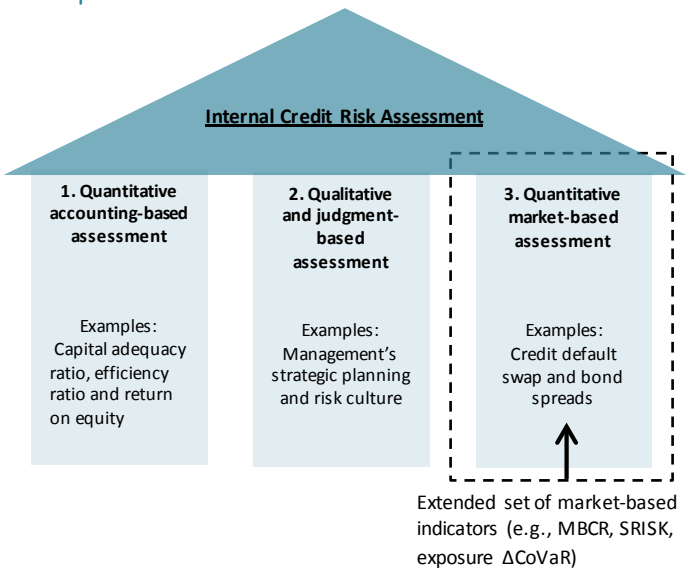
The establishment of this framework highlights the central role of internal analysis in the Bank's credit risk management process. Moreover, regular monitoring ensures the flexibility to promptly detect vulnerable counterparties and take corrective actions from a risk-management perspective. And it is in the context of monitoring that MBIs can, in particular, play a key role.

[7] CRAG's credit risk assessments rely on publicly available information only.
[8] At the time of writing, the current Department of Finance representative on the CRC has chosen not participate in meetings that assign ratings to commercial financial institutions.

3. Integration of Market-Based Indicators in the Credit Risk Assessment of Financial Counterparties

As mentioned in the previous section, the credit risk assessment framework relies on accounting-based analysis, market intelligence and expert judgment (**Figure 2**). Most indicators used to assess the creditworthiness of financial institutions are primarily accounting-based (e.g., return on equity, non-performing loans ratio, capital adequacy ratio). While informative, these indicators have limitations because they mainly represent historical information and are available at a relatively low frequency (i.e., quarterly or annually). Therefore, they may not be able to capture material changes in the credit quality of counterparties on a timely and forward-looking basis.

Figure 2: Pillars of the internal credit risk assessment of financial counterparties



To address this issue, the CRAG adds a new set of market-based indicators (MBIs) to further complement the credit risk assessment. These MBIs measure both the credit and systemic risks of financial institutions as captured by market prices. Their use to quantify risk of exposures to financial institutions has grown significantly since the crisis (IMF 2015; OFR 2016). Based on publicly available high-frequency financial data (e.g., stock prices), MBIs process market information in a more systematic manner.[9] These new analytical tools extend the Bank's credit risk assessment capabilities by further incorporating a quantitative market view in its internal credit risk assessment framework (dashed box in **Figure 2**). In summary, MBIs bring value by making the internal credit risk assessment more nimble, while quantitative accounting-based credit analysis and qualitative expert judgment still represent key pillars of the CRAG's credit risk assessment. Consequently, the rating recommendations remain independent and do not mechanistically rely on market perceptions of credit risk.

The combination of these complementary approaches provides different perspectives on the relative creditworthiness of a financial counterparty. For example, MBIs can offer an advance signal, since they are quick to reflect changes in the expectations of market participants regarding counterparties' financial positions. Such a signal could trigger more regular surveillance and a closer examination of a specific counterparty where vulnerabilities may be building or diminishing. Additionally, MBIs and credit rating information can be compared across individual financial counterparties and over time. From a risk-management perspective, such a comparison informs our understanding of how a financial counterparty is assessed by the market relative to a fundamental-based model (i.e., a model that focuses only on the first two pillars in **Figure 2**). For example, the market assessment may provide information on market participants' willingness to maintain financial exposure to a counterparty. MBIs also facilitate cross-sectional comparisons and comparisons over time, because they benefit from fewer differences in definitions and methodology compared with accounting-based data.

However, MBIs also have drawbacks and must be interpreted with caution. MBIs may provide relatively noisy signals of credit risk for several reasons, including (temporal) pressures on market liquidity and uncertainty due to

[9] While CRAG already uses standard market data information such as credit and CDS spreads in its assessment, the MBIs presented in this note provide a more systematic framework for synthesizing information from market signals.

the models and estimation techniques used to estimate the MBIs. Another reason is that market prices are affected by time-varying discount rates, which depend on changes in risk premiums and the yield curve. Some of the MBIs' variation over time may therefore be related to factors that are not necessarily directly related to credit risk, although comparisons across counterparties at a single point in time are less affected by such common factors. Moreover, MBIs may provide misleading signals of the stand-alone creditworthiness of institutions if market participants expect government support for financial institutions in distress (Bond, Goldstein and Prescott 2010).[10]

4. Market-Based Approaches to Measuring Credit Risk

Macdonald, Van Oordt and Scott (2016) implement market-based indicators to assess potential vulnerabilities in the Canadian financial system. In this note, we apply their approach to monitor the credit risk of individual financial counterparties (i.e., major banks in Canada, the United States and Europe). We present four market-based indicators that can be categorized as indicators of either solvency or solvency under system-wide stress (**Table 1**). Both categories can be used to answer different types of questions since they relate to different aspects of credit risk.

The indicators in the solvency category can inform our judgment on the relative stand-alone creditworthiness of counterparties.

- The **market-based capital ratio (MBCR)** is based on market valuations rather than accounting-based measures of capital. It can be defined as the ratio of a bank's market capitalization to its total assets.[11] It provides a real-time view of solvency risk for financial institutions, which can act as a potential early-warning indicator in the face of quick and sharp changes to credit quality.[12]
- **Distance-to-default** is based on the structural approach of the Merton (1974) model and the Black and Scholes (1973) option pricing model.[13] The distance-to-default is a proxy for the number of standard deviations in the value of a financial institution's assets that could erase its capital. For example, a distance-to-default of two means that the asset value of a bank would have to drop by two standard deviations over one year to be in default. Credit rating agencies also use this framework to extract point-in-time probability of default for non-financial companies and financial institutions.

Table 1: Mainstream market-based indicators

Category	Mainstream indicators
Solvency (stand-alone view)	- Market-based capital ratio - Distance-to-default
Solvency under system-wide stress (portfolio view)	- SRISK - Exposure ΔCoVaR

The second category of indicators, which focuses on solvency under system-wide stress, provides insight into which counterparties are considered most vulnerable to a scenario involving banking system stress. These measures are affected by market perceptions of common exposures, the interconnectedness among financial institutions and the risks of contagion. They add a portfolio perspective to the assessment of risks related to exposures to counterparties, since they measure the potential deterioration in creditworthiness of a specific

[10] The Bank's internal ratings do not factor in potential government support, whereas markets and external ratings typically do.
[11] This can be viewed as a market-based variant of the Basel III leverage ratio.
[12] Haldane (2011) provides anecdotal evidence that MBCRs performed better than conventional risk-weighted capital ratios in identifying bank distress.
[13] See Kozak, Meyer and Gauthier (2006) for an application of the distance-to-default indicator in the Canadian business sector.

counterparty if other counterparties are simultaneously hit by a severe shock. This second category represents a relatively novel set of tools to measure and assess the evolution in the creditworthiness of financial counterparties.

- **SRISK** is defined as the bank's expected capital shortfall after a system-wide stress event, where the capital shortfall is calculated as the difference between a target level for the MBCR and the stressed capital ratio. This amount can be interpreted as an estimate of the amount of capital that a financial institution would need to raise to function normally, conditional upon a stress scenario (Archaya, Engle and Richardson 2012). A capital shortfall occurs if the firm's expected losses in the stress scenario exceed its capital buffer over the target ratio. The capital shortfall is a function of the size of the firm, its leverage and its expected losses in the stress scenario, which we model as the 1 per cent worst declines in an index constructed from the stock returns of the other financial institutions in the system over a six-month horizon. This method can be considered analogous to a "market-based stress test."
- **Exposure ΔCoVaR** assesses the sensitivity of the tail risk of counterparties to system-wide shocks in the banking system (Adrian and Brunnermeier 2016). It is computed as the increase in the daily value at risk of an institution, conditional upon the system experiencing a loss equal to the financial system's value at risk. An appealing feature of the exposure ΔCoVaR is that it focuses on the potential bad outcomes in the tail, while the SRISK measure focuses on the *expected* outcome. However, exposure ΔCoVaR measures risk over a short horizon (i.e., daily in our application) compared with the SRISK measure, which focuses on a six-month stress scenario.

5. Estimation and Results

This section presents an application of these MBIs in the context of monitoring risks associated with potential counterparties of the Bank of Canada. Although most charts in this note show indicator values aggregated by jurisdiction, in practice, the indicator levels of individual counterparties are compared with the levels in their peer group for internal credit risk assessment purposes. Details on the methodology and the list of institutions in our sample are provided in the Appendix.

Charts 1a and **1b** illustrate how a market-based indicator, such as the MBCR, may complement signals obtained from external ratings or accounting-based data. In addition to the MBCR of European and US institutions on an aggregated level, these charts show the unweighted capital ratio, calculated as the ratio between the book value of common equity and the book value of total assets, and an external rating composite index (ERCI), which is constructed from the ratings issued by four credit rating agencies.[14] Two observations can be made regarding the financial institutions included in our sample:

- While the MBCRs of those institutions started to deteriorate from January 2007 onward, the external ratings of European and US banks continued to improve on average in the run-up to the financial crisis. Moreover, none of the European financial institutions had been placed on negative watch until the end of January 2008. This illustrates that, in certain situations, market-based indicators can provide an earlier signal regarding an increase in counterparty risk than potential downgrades in credit ratings or ratings placed under review.[15]

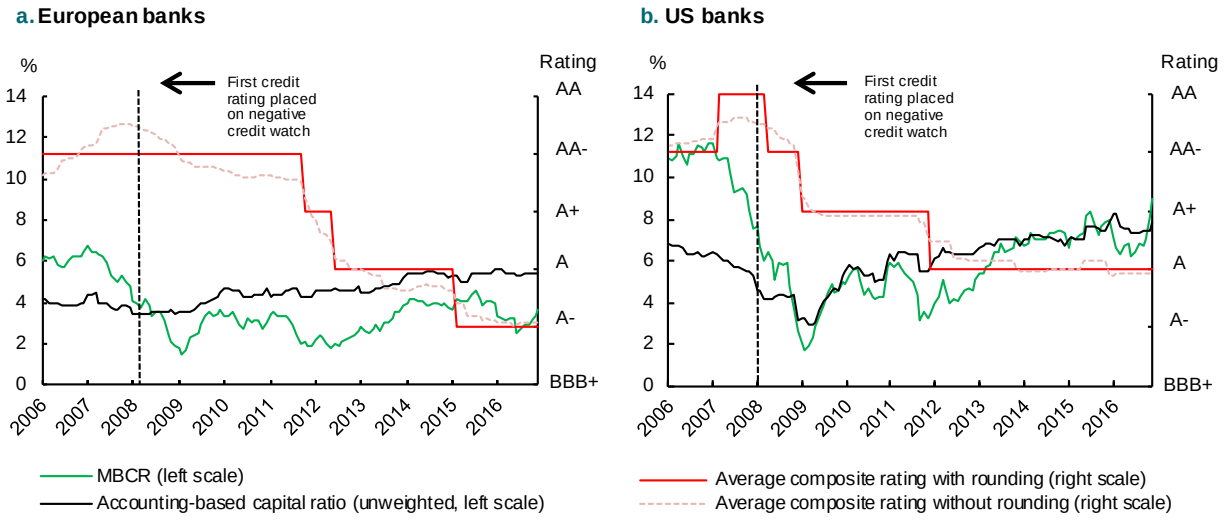
[14] The ratings are all-in long-term ratings (i.e., take into account potential support by its parent entity and/or the government) in local currencies for the financial institutions in our sample from Moody's, Standard & Poor's, Fitch and DBRS. Before taking an average across CRAs, their respective ratings (an ordinal variable) are translated into a numerical interval variable, with equal distance between ratings. After calculating the average, the numerical value is translated back into a composite rating by using the same scale.

[15] The deterioration of the MBCRs in our sample started before a substantial increase in the spreads of credit default swaps during the 2007–09 market turmoil. This is in line with theoretical models, such as the Merton model, which suggest that the relationship between capital buffers and credit spreads is nonlinear, i.e., the response of credit spreads to a change in the market value of equity is smaller if entities are further away from the point of default.

- Throughout the financial crisis, accounting-based capital ratios were remarkably stable, particularly for European institutions (**Chart 1a**). This is despite the fact that, during this period, European and US banks experienced such financial difficulties that they required government support in the form of capital injections and guarantees. In contrast to the relatively stable accounting-based ratios, the average market-based capital ratios show a strong decline, reaching a 16-year low in February 2009. This suggests that developments in market-based indicators can, in certain situations, better reflect the risk of counterparties than accounting-based data.

These observations can be explained by the forward-looking nature of MBCR, which is affected instantaneously by changes in market perceptions of the capital buffers and funding profiles of banks. The MBCR differs from the backward-looking accounting-based leverage and the through-the-cycle credit ratings, two measures that are less likely to react to changes in the creditworthiness of an entity in a timely manner.

Chart 1: Evolution of market-based capital ratios (MBCRs) and external ratings



Sources: Bloomberg, Thomson Reuters Datastream and Bank of Canada

Last observation: December 2016

Another observation is that European banks seem to operate with a structurally lower MBCR and unweighted capital ratios than US banks, even after adjusting for accounting differences across jurisdictions.[16] This reflects the fact that the business models of European banks have been characterized by higher leverage (Crawford, Graham and Bordeleau 2009), partly because they tend to retain a higher proportion of mortgage loans on their balance sheets.

Chart 2 shows the evolution of the MBCRs of a selection of potential financial counterparties based in Canada. At their lowest levels during the 2007–09 financial crisis, the MBCRs of the major Canadian banks remained above the average MBCRs observed in Europe and the United States (**Chart 1**). Moreover, the MBCRs of those banks show a stronger recovery after the financial crisis. While overall trends are similar, some differences exist between the

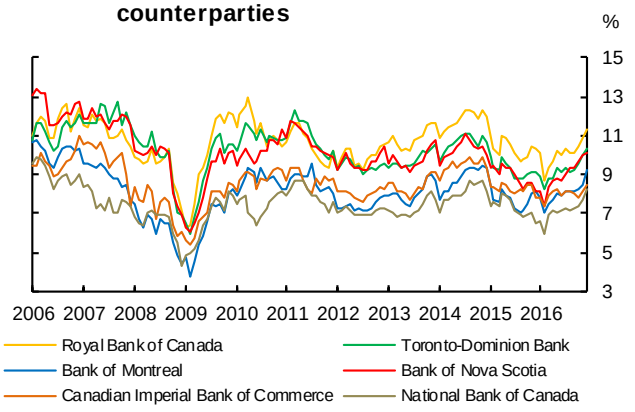
[16] To ensure greater comparability of the MBCR and SRISK across regions, we adjust the amount of total assets reported by US banks following the procedure suggested by the IFRS Foundation (2015). US banks report under US GAAP, while European and Canadian banks have reported under IFRS since 2005 and 2012, respectively. While US GAAP allows derivatives instruments to be netted, Canadian GAAP (prior to the adoption of IFRS in 2012) and IFRS require the reporting of gross derivative positions. In the context of financial institutions, this difference can lead to substantial differences in the reported amount of total assets. The data for the adjustment are available from 2006 onward.

MBCRs of individual banks. This suggests that market perceptions of the relative resilience of individual banks change over time.

Similar to the MBCR, the distance-to-default also provides a stand-alone view of a bank's solvency. However, unlike the MBCR, the distance-to-default accounts for the risk of the assets, where the risk of the assets is derived from the volatility of the stock prices. **Chart 3** shows the weighted-average distance-to-default for potential counterparties in Canada, Europe and the United States. The lowest level of the average distance-to-default has been higher for Canadian banks than for European and US banks. This is in line with the relatively strong performance of Canadian banks during the financial crisis, when they did not have to resort to capital injections or explicit guarantees from the government (Arjani and Paulin 2013).

The weighted-average distance-to-default in **Chart 3** exhibits a similar pattern across regions, suggesting that these indicators are influenced by common factors. However, there are also differences across regions. For example, the declines in the distance-to-default for Canadian banks from January 2014 to December 2015 coincide with the sharp oil price decline and concerns about the global growth outlook. The magnitude and speed of this decline reflected growing market concerns about the asset quality of direct and indirect exposures of Canadian banks to the oil and gas sector.

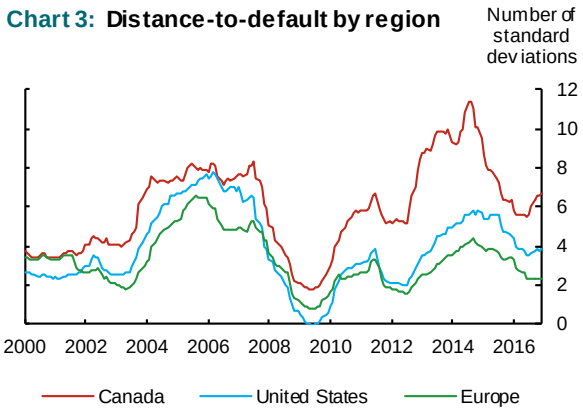
Chart 2: Market-based capital ratios of potential counterparties



Sources: Thomson Reuters Datastream and Bank of Canada calculations

Last observation: December 2016

Chart 3: Distance-to-default by region



Sources: Thomson Reuters Datastream and Bank of Canada calculations

Last observation: December 2016

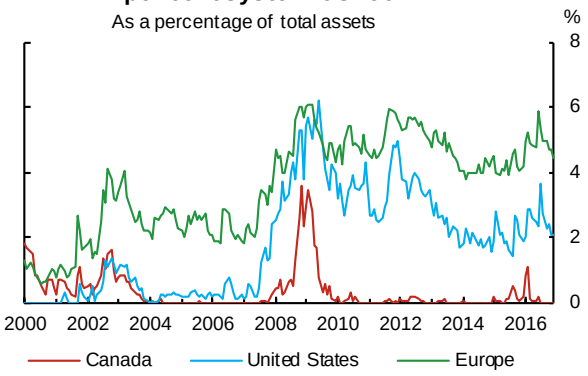
Chart 4 shows the aggregate SRISK, which corresponds to the expected capital shortfall after a 1 per cent system-wide stress event over a 6-month period. The capital shortfall is calculated relative to a target MBCR of 6 per cent, which is in line with the target ratios commonly used in the literature.[17] The results suggest that European and US counterparties are expected to have larger capital shortfalls after a system-wide stress event than Canadian counterparties. All counterparties show an increase during the 2007–09 financial crisis. In particular, counterparties in the United States experienced a strong increase, since they were at the centre of the crisis, and their peak level is at a similar level to that of the European counterparties, which had a weaker starting position. After 2009, the levels of SRISK for European counterparties remained higher than those for US banks. This reflects the weak recovery in European MBCRs following the crisis (**Chart 1a**) and the potentially large impact of system-wide stress given the evolving European sovereign debt crisis and high ratios of non-performing loans. Outside of these geographical differences, the SRISK levels of individual counterparties can be compared with the SRISK of

[17] The aforementioned adjustment in the amount of total assets to account for differences in the accounting treatment of derivatives netting allows us to use the same target ratio for all banks in our sample.

peers to obtain a forward-looking view of which entities are expected to underperform if a portfolio-wide stress scenario materializes.

Chart 4: SRISK: Additional capital needed in a 1 per cent systemic shock

As a percentage of total assets

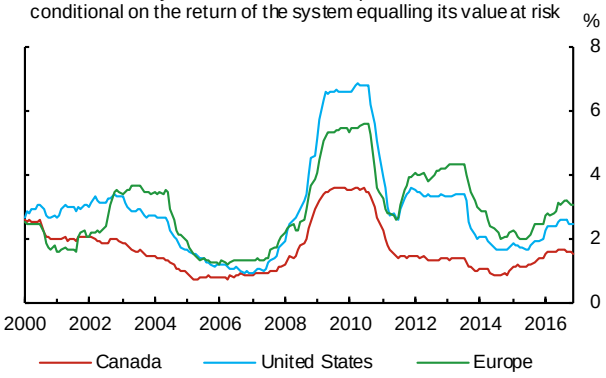


Sources: Thomson Reuters Datastream and Bank of Canada calculations

Last observation: December 2016

Chart 5: Exposure ΔCoVaR

Increase in daily value at risk at the 95 per cent confidence level conditional on the return of the system equalling its value at risk



Sources: Thomson Reuters Datastream and Bank of Canada calculations

Last observation: December 2016

Chart 5 shows the exposure ΔCoVaR. For both the US and European counterparties, the exposure ΔCoVaR reached its peak in the financial crisis period, with the highest average level for US banks. However, after the peak, the average level in the European counterparties remained consistently above that in the US sample. In comparison, the lower level of the exposure ΔCoVaR for the sample of Canadian banks suggests a smaller increase in downside tail risk due to system-wide stress than for US and European banks. Similar to the SRISK measure, bank-specific levels of the exposure ΔCoVaR can help evaluate which potential counterparties are expected to face the largest increase in downside tail risks in the scenario of portfolio-wide distress.

6. Conclusion

The Bank's internal credit risk assessment framework relies on a broad set of indicators. In this note, we provide an illustration of the recent addition of market-based indicators to complement fundamental quantitative and qualitative credit analysis.

Overall, the contribution of MBIs is twofold. First, they bring a quantitative market view that allows for a comparison of the risks posed by each entity at a relatively high frequency. Second, MBIs are valuable in processing market prices in a more systematic manner. This brings value to the analysis of the creditworthiness of potential financial counterparties by making the assessment more nimble, while quantitative accounting-based credit analysis and expert judgment still represent key pillars of the internal credit risk assessment.

In keeping with the objective of continuously improving the credit risk assessment of financial counterparties, the CRAG will continue to conduct further analysis and review the methodology it uses. This could include, for example, investigating the empirical relationships between MBIs and accounting-based indicators under different market circumstances.

Appendix: Sample of Financial Institutions in our Analysis

For each financial institution listed in **Table A-1**, institution-specific market-based indicators are calculated following the methodology in MacDonald, Van Oordt and Scott (2016). The computations for these indicators are standardized within the Bank and can be computed at a high frequency and at a low cost. Numbers presented in the charts are weighted averages at the country or regional level. The weights to calculate the average of the MBCR are based on the book values of total assets; the weights to calculate the average distance-to-default are based on the book values of total debt; and the weights to calculate the average exposure ΔCoVaR are based on the market capitalizations. For SRISK, the numbers represent the aggregated capital shortfall as a percentage of the aggregated amount of total assets.

Data used in this report are from the following sources. Market prices and accounting data are obtained from Thomson Reuters Datastream. For Europe, the data for institutions outside the euro area were converted to euro values. Data used to adjust the amount of total assets reported by US institutions for the different treatment of derivatives netting under US GAAP compared with IFRS are obtained from Fitch Connect. The all-in ratings to compute the ERCIs in **Chart 1** are from Bloomberg.

Table A-1: List of financial institutions

Country or region	Financial institutions
Canada	Bank of Montreal, Bank of Nova Scotia, Canadian Imperial Bank of Commerce, National Bank of Canada, Royal Bank of Canada, Toronto-Dominion Bank
Europe	Banco Santander (Spain), Barclays Group (United Kingdom), BNP Paribas (France), Commerzbank (Germany), Credit Suisse Group (Switzerland), Deutsche Bank (Germany), Groupe Crédit Agricole (France), HSBC Holdings (United Kingdom), ING Groep (Netherlands), Intesa Sanpaolo (Italy), Lloyds Banking Group (United Kingdom), Natixis (France), Nordea Bank (Sweden), Royal Bank of Scotland (United Kingdom), Société Générale (France), Standard Chartered (United Kingdom), UBS Group (Switzerland); UniCredit (Italy)
United States	Bank of America, Bank of New York Mellon, Citigroup Inc., Goldman Sachs Group Inc., JPMorgan Chase & Co., Morgan Stanley, State Street Corporation, Wells Fargo & Company

Note: Financial institutions were selected to represent potential financial counterparties in each country or region.

References

- Acharya, V. V., R. Engle and M. Richardson. 2012. "Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks." *American Economic Review* 102 (3): 59–64.
- Acharya, V. V., L. H. Pedersen, T. Philippon and M. Richardson. 2017. "Measuring Systemic Risk." *Review of Financial Studies* 30 (1): 2–47.
- Adrian, T. and M. K. Brunnermeier. 2016. "CoVaR." *American Economic Review* 106 (7): 1705–1741.
- Arjani N. and G. Paulin. 2013. "Lessons from the Financial Crisis: Bank Performance and Regulatory Reform." Bank of Canada Staff Discussion Paper No. 2013-4.
- Bisias, D., M. Flood, A. W. Lo and S. Valavanis. 2012. "A Survey of Systemic Risk Analytics." *Annual Review of Financial Economics* 4: 255–296.
- Black, F. and M. Scholes, 1973. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy* 81 (3): 637–654.
- Bond, P., I. Goldstein and E. S. Prescott. 2010. "Market-Based Corrective Actions." *Review of Financial Studies* 23 (2): 781–820.
- Brownlees, C. and R. F. Engle. 2017. "SRISK: A Conditional Capital Shortfall Measure of Systemic Risk." *Review of Financial Studies* 30 (1): 48–79.
- Crawford, A., C. Graham and É. Bordeleau. 2009. "Regulatory Constraints on Leverage: The Canadian Experience." Bank of Canada *Financial System Review* (June): 45–50.
- De Bandt, O., P. Hartmann and J. L. Peydró. 2010. "Systemic Risk in Banking: An Update." In *The Oxford Handbook of Banking,* edited by A.N. Berger, P. Molyneux and J. O. S. Wilson, 633-672. Oxford: Oxford University Press.
- Department of Finance Canada. 2013. "Memorandum of Understanding on Treasury and Credit Risk Management between the Bank of Canada and the Department of Finance." Available at https://www.fin.gc.ca/treas/Goveev/mou-trm-eng.asp.
- Department of Finance Canada. 2014. "Report on the Management of Canada's Official International Reserves: April 1, 2013–March 31, 2014."
- Financial Stability Board. 2010. "Principles for Reducing Reliance on CRA Ratings."
- Group of Twenty (G20). 2010. "The G-20 Toronto Summit Declaration," Annex 2, June 26–27. Available at http://www.g20.utoronto.ca/2010/g20_declaration_en.pdf.
- Haldane, A. G. 2011. "Capital Discipline." Speech given at the American Economic Association, Denver, Colorado, 9 January.
- Harvey, N. and M. Merkowsky. 2008. "The Role of Credit Ratings in Managing Credit Risk in Federal Treasury Activities." Bank of Canada *Financial System Review* (June): 61–66.
- IFRS Foundation. 2015. "Sizing Up the Balance Sheet." *The Essentials,* Issue No. 3 (May).
- International Monetary Fund (IMF). 2015. "Global Financial Stability Report."
- Kozak, M., A. Meyer and C. Gauthier. 2006. "Using the Contingent Claims Approach to Assess Credit Risk in the Canadian Business Sector." Bank of Canada *Financial System Review* (June): 43–51.
- MacDonald, C. and M. R. C. van Oordt. 2017. "Using Market-Based Indicators to Assess Banking System Resilience." Bank of Canada *Financial System Review* (June): 29–41.
- MacDonald, C., M. R. C. van Oordt and R. Scott. 2016. "Implementing Market-Based Indicators to Monitor Vulnerabilities of Financial Institutions." Bank of Canada Staff Analytical Note No. 2016-5.
- Merton, R. C. 1974. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance* 29: 449–70.
- Muller, P. and J. Bourque. 2017. "Methodology for Assigning Credit Ratings to Sovereigns." Bank of Canada Staff Discussion Paper No. 2017-7.
- Office of Financial Research (OFR). 2016. "Financial Stability Report."
- Wolfe, E. 2014. "Assessing Credit Risk Post-Crisis at a Central Bank." *CentralBanking.com* (19 November).