

Stressed Out: An Evaluation of Stress Testing Frameworks and Financial
Stability Considerations for Canada

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Introduction

A country's financial system is a key element impacting economic prosperity and growth. Its key function is to allocate financial resources to productive areas of the economy including: the facilitation of transfers of funds from savers to borrowers, transfers of risks, and the provision of liquidity. As such, it is important to ensure that the financial system functions efficiently. Financial markets are dynamic, therefore, this environment in which economic agents operate and interact is constantly changing. Consequently, risks facing financial institutions and thus, the financial system, evolve over time. It is necessary to design and employ proper risk management metrics such as stress testing to evaluate the ability of financial institutions to withstand stressed events in order to ensure the soundness of the financial system. However, it is crucial to do so in a manner that does not compromise the efficiency of the financial system as a whole.

Stress testing has been defined by the International Monetary Fund as a technique that measures weaknesses of a portfolio, institution, or a financial system under different hypothetical events or scenarios.¹ Using historical data to construct stress scenarios is an intuitive approach to stress testing scenario design. However, this is a reactionary and backward-looking technique. Constructing hypothetical scenarios is another stress testing option to anticipate potential future events. This is a forward looking approach that incorporates macroeconomic shocks, correlations among variables and market volatility. Designing scenarios that are realistic in probability of occurrence serves to evaluate the sensitivity of the bank's position as an economic agent in relation to various

¹ See International Monetary Fund (2012), Macrofinancial Stress Testing Principles and Practices.

risks. However, it is a difficult task to design potential scenarios with varying likelihoods of occurrence as this is a forward-looking technique. This requires balancing severity with plausibility of risks that may materialize in the future. Simulation analysis is also often used in stress testing to quantify losses under different scenarios. This paper presents the guidelines and the vulnerabilities that face Canadian banks and affect the financial system, as identified by regulators and monetary authorities such as The Office of the Superintendent of Financial Institutions (OSFI), The International Monetary Fund (IMF), and Bank of Canada. It reviews existing literature and presents stress testing frameworks currently used in the Canadian banking sector in addition to discussing existing financial stability vulnerabilities. An evaluation of these stress testing frameworks is conducted to address risk management effectiveness in Canada and provide insight into the challenges of balancing financial institution stability and system-wide efficiency.

Context

Although the banking industry spans the globe and these links affect systemic financial stability, the focus of this paper concerns the Canadian banking sector. This industry is significant in size, generating 3.1% of GDP, or approximately \$51 billion as reported for 2013 by Statistics Canada. This industry contributes to the tax base of various levels of Canadian government, paying \$7.9 billion in taxes for the year 2013.² The banking industry is comprised of the Big Six major banks: Royal Bank of Canada (RBC), Toronto-Dominion Bank (TD), the Bank of Nova Scotia (Scotiabank), the Bank of

² See The Canadian Bankers Association Backgrounder on Banking and the Economy.

Montreal (BMO), and Canadian Imperial Banking Corporation (CIBC). National Bank/Banque Nationale is considered to be the sixth largest bank. These Big Six Banks employ thousands of Canadians across the country and are major links in holding the financial system together, collectively they represent 90% of the Canadian banking system's assets, as reported in the IMF's Financial Sector Assessment Program for Canada. The recent financial crisis of 2008-2009 emphasized the importance of financial institutions' solvency and operational efficiency. Fortunately, Canadian financial institutions fared better than those in the US and Europe during the recent financial crisis.³ Reasons for this can be attributed to the regulatory atmosphere in Canada; including targeted risk management policies and practices of Canadian banks, as well as superior and cooperative domestic supervisory and regulatory guidance. Researchers including Arjani and Paulin (2013) have stated that Canadian banks' pre-crisis business structure, low risk appetite, and risk management techniques paired with a prudential regulatory and supervisory authority enabled the banks to perform better than others during the crisis.

In Canada, OSFI is responsible for supervising federally regulated financial institutions and pension plans in the Canadian financial sector. This includes determining the soundness of these institutions and their compliance with governing laws and regulations. Additionally, OSFI advises these institutions when corrective measures are needed to ensure financial soundness. Finally, OSFI is responsible for creating a regulatory risk management framework, and the monitoring and evaluation of system wide risks and

³ See Arjani and Paulin (2013) for detailed analysis of the factors that contributed to banks remaining resilient during the crisis and lessons for regulatory reform.

vulnerabilities. As a result, they oversee Canadian banks stress test results and their adherence to guidelines and international banking standards. Private sector banks are expected to comply with regulatory frameworks outlined by international banking organizations, such as the Financial Stability Board and the Basel Committee on Banking Supervision of the Bank of International Settlements (BIS), and adhere to regulations outlined by OSFI. Domestically, Bank of Canada also plays a key role in ensuring that the Canadian financial system is sound. One of the central bank's key functions is to maintain financial system stability, provide liquidity to the financial system and conduct on-going research regarding system-wide efficiency and risk management.⁴

There are massive costs associated with financial crisis and as a result, bankers, regulators, and researchers continue to investigate financial system vulnerabilities and ways to best mitigate risks that can trigger these events. Targeted efforts have been made to enhance financial system stability through identification of key areas of vulnerability, lower the cost of intermediation, and the introduction of regulatory reforms. Highly leveraged institutions, excessive short-term debt, low amounts of cash holdings and illiquidity were identified as some specific vulnerabilities characterizing financial institutions that faced problems during the crisis. Vulnerabilities, as described by Bank of Canada, can be thought of as pre-existing conditions that if aggravated can trigger adverse shocks throughout the financial system. It is important to focus on the management of vulnerabilities and increasing the resiliency of financial institutions, rather than simply the prediction of the occurrence of adverse shocks. Key areas that

⁴ Refer to Bank of Canada (2012), Backgrounder on the Regulation of the Canadian Financial System.

affect systemic risk are: leverage, liquidity, losses and linkages.⁵ Highly leveraged institutions, especially those with capital tied up in liabilities pose a risk to the system at large. These risks are more significant when the institution's assets are highly correlated and balance sheet driven contagion effects are transmitted throughout the system via linkages.⁶ As a result, the costs of intermediation increase. Consequently, The Bank of International Settlements' Basel III Accord emerged post crisis to target vulnerabilities in the global banking system through reforms concerning liquidity, capital requirements and the solvency of banks.⁷ Higher capital requirements prompt banks to either raise equity, reduce their lending activities, or decrease the risky assets held. However, the implementation of new regulations is not without trade-offs. For example, it has been argued that increased capital requirements increase the cost of funding and thus the operating costs of banks⁸. Increased capital requirements raise the financing costs of firms as equity financing does not share the same tax advantages of debt financing. Inefficiencies can arise when a firm is unable to raise its desired or optimal mix of funds. This impacts the real economy through the credit channel of the bank's lending activities.⁹ Other researchers such as Martynova et al (2004) suggest that increased capital requirements incentivizes the risk taking activities of banks. Researchers who assert there is no direct link between financial stability and increased capital requirements include de Haan and Klamp (2012). However, the BIS reports the economic benefits of

⁵ Referred as the "L's of financial crisis" by economist Andrew Lo in the study of systemic risks.

⁶ See the BIS publication "Long-term Impact of Higher Capital Levels".

⁷ Refer to the Basel III Accord (2011) for in-depth details.

⁸ See BIS working paper No 338: "BASEL III: Long-term Impact on Economic Performance and Fluctuations".

⁹ Further discussed in the BIS working paper No 338: "BASEL III: Long-term Impact on Economic Performance and Fluctuations".

increased bank capital include lower probabilities of bank failure and financial crises which prevent associated output losses and lowers the cost of intermediation.¹⁰ While these regulations are designed to prevent subsequent crises, tighter rules governing the conduct of banks affect their business models and ability to operate efficiently. Regulatory and supervisory efforts must recognize the importance of the minimization of market efficiency losses.

The resilience of the Canadian banking sector during the crisis has also been recognized by the IMF in their Financial Sector Assessment Program (FSAP) report for 2013. While the IMF's FSAP stress tests and recommendations will be discussed in a subsequent section, the report credits well capitalization of banks and the targeted prudential measures with sound regulatory frameworks to be effective in managing risks. Examples of strong macro-prudential regulations and cooperative supervisory frameworks include: OSFI requiring banks to hold a 7 per cent ratio of Tier 1 capital and a 10 per cent ratio for total capital. This is more than capital ratios of 4 per cent and 8 per cent, as outlined in Basel II.¹¹ Canadian banks are also subject to leverage ratio limits that have been in effect since 1980, similar to the Basel III leverage requirements that are to be implemented in 2018-2019.¹² Bank of Canada has highlighted the importance of incorporating liquidity risk and network spill over risks into stress testing models, as

¹⁰ See the BIS publication "Long-term Impact of Higher Capital Levels".

¹¹ See Arajani and Paulin (2013) and the Basel II and III Accords for further details for capital requirement principles.

¹² See OSFI (2014) Leverage Requirements Guidelines and OSFI (2014) New chapters in the saga of regulatory reform for in-depth details regarding Canadian leverage requirements as per Basel standards.

demonstrated by the financial crisis.¹³ Improvements of risk management techniques are always necessary in times of economic prosperity and during downturns. A focus on financial institution resilience, rather than the prediction of when events will occur is necessary to increase the stability of the sector as a whole and the Canadian financial system.

International Banking Reforms

Although Canada boasts one of the world's soundest banking sectors,¹⁴ the recent financial crisis has resulted in many regulatory changes with the purpose of maintaining financial sector stability worldwide. OSFI is implementing these new regulations, as outlined by the Bank of International Settlements in the Basel III Accord, in Canada over the course of 2011-2019. This is with the goal of ensuring that Canadian banks do not jeopardize their ability to function effectively, and as a result, minimizing system-wide stability risks. Basel III, which was released in 2010, focuses on capital management by increasing the quantity and quality of capital that banks must hold through additional capital buffers and increased capital requirements. Specifically, Tier 1 Capital, measured as core capital which is composed of common stocks and reserves, has been increased to 6 per cent of risk weighted assets (RWAs) under the Basel III rule. Common Equity Tier 1 Capital, measured as the highest quality equity capital over the total risk weighted assets held, has been increased to 4.5 per cent of RWAs.

¹³ See Bank of Canada (June 2014), Financial System Review.

¹⁴ See Anand et al (2014) for further details.

The new regulatory framework also focuses on controlling leverage through a minimum leverage ratio for all banks, calculated as:

$$\text{Tier 1 Capital/Total Exposure} \geq 3\%$$

Higher ratios for banks have also been set, depending on the banks' classification of domestic vs. global systemic importance. At the present, no Canadian banks have been identified as systemically important globally.¹⁵ Liquidity management is another key feature of Basel III with the introduction of a Liquidity Coverage Ratio (LCR) and a Net Stable Funding Ratio (NSFR) for banks.¹⁶ The Liquidity Coverage Ratio is designed to ensure that banks hold a sufficient amount of highly liquid assets to cover their cash outflows for a 30-day period under a stressed event. This is calculated as:

$$\text{LCR} = \text{High Quality Liquid Assets/Total Net Liquidity Outflows over 30 days} \geq 100\%$$

The Net Stable Funding Ratio, calculated as the percentage of short-term funding to total funding.¹⁷ This will be implemented gradually over the next few years with the purpose of financial institutions maintaining a stable funding structure across on and off balance sheet items and to reduce the reliance on short-term wholesale funding.¹⁸ These features

¹⁵ The Basel Committee on Banking Supervision and the Financial Stability Board and supervisory authorities in member nations work to identify the extent of the role of banks in domestic markets as well their influence in the global financial system.

¹⁶ For details refer to OSFI's Liquidity Adequacy Requirements Guideline.

¹⁷ Refer to the BIS's Basel III technical documentation for further details.

¹⁸ OSFI has maintained that Basel III will be fully implemented by 2019.

of higher capital requirements, the net stable funding ratio and the liquidity coverage ratio are intended to promote a resilient banking sector. However, these new banking regulations are necessary, but not sufficient, to ensure financial institution stability. It is also important for institutions and regulators to engage in active risk management practices such as stress testing to continue to identify and target potential risks facing financial institutions as well as those the overall financial system may face.

Regulation Through OSFI's Guidelines

OSFI explains that stress tests are a risk management tool that feed into a financial institution's decision making process in the context of their risk appetite, the setting of exposure limits and for long-term business planning.¹⁹ Stress tests are a quantitative tool that are typically used to measure the value of assets, and in a supervisory capacity, the resiliency of the system under different scenarios. In order to promote and maintain a stable financial system stress tests should be preformed at the level of individual banks (micro-prudential) and regulatory authorities should perform system-wide tests (macro-prudential) to examine the overall robustness of the financial sector.

OSFI states that risks such as market risk, credit risk, liquidity risk, operational risk, securitization risk, reputation risk, interest rate and inflation risk; and insurance risk should be included when designing stress tests as they are key risks affecting financial institutions. Different scenarios with varying severities should be tested to gauge the level of resilience under stress. Their guidance also includes then balancing of historical data

¹⁹ See OSFI's Stress Testing Guidelines.

as well as non-historical data to avoid the underestimation of the likelihood of hidden risks and events from occurring. The impact of stress tests should be measured through changes in the values of assets and liabilities, economic capital, profit (accounting as well as economic), the level of impaired assets and write-offs, change in liquidity position as well as required regulatory capital. Emphasis is placed on the construction of scenarios that are severe in aggressiveness (i.e. impact) yet plausible in likelihood of occurrence, as this is a tool that has the potential to uncover hidden risks and interactions. An ideal stress test should be relevant for the current portfolio or institution, as “one size fits all” type of design is not effective since the risk appetite, funding, and business structure will vary among institutions.

As such, OSFI has outlined, as per international principles, four main purposes or considerations for an effective stress-testing program:

- Risk identification and control of institution wide risks, concentrations and interactions among risks in stressed period.
- A complementary risk management tool to other quantitative, statistical risk models and shock simulation tools to assess economic and financial environments.
- Capital management in order to support the financial institution’s capital position. Stress tests should be forward looking to identify severe negative events that have the potential to negatively impact the financial institution or financial system.

- Liquidity management in terms of managing funding liquidity risks that result from institution-specific and market-wide stress shocks.

OSFI has also outlined key areas of focus when designing stress-testing models for the Canadian banking sector:

- Risk Mitigation: Stress tests should include the development of contingency plans for various events that could occur. It is important to assess the effectiveness of reinsurance, hedging, and collateral during times of financial market trouble or when other financial institutions are using similar risk mitigating techniques.
- Securitization and Warehousing Risks: Stress testing is needed for securitized assets to address issues affecting these products. Examples of these issues are the underlying assets, exposure to systemic market risks, contracts, and leverage impacts. In terms of warehousing risks, the stress tests need to cover market, credit and funding risks that may arise before the securitization or sale of an asset. It is important to consider that assets may be held for a longer period of time when markets experience forms of distress.
- Risks to Reputation: Institutions must work to reduce risks to their reputation. These risks arise from market spill over effects during financial turmoil and off-balance sheet vehicles. It is important to integrate any off-balance sheet products into their stress-testing framework, as reputational spill over effects affect confidence in financial markets and how the institution is perceived. Solvency and liquidity risks, specifically, should be included in scenario assessments regarding

the size and soundness of off-balance sheet products relative to the institution's financial, liquidity and regulatory capital positions.

- Counter-party Credit Risk: Leveraged counterparties, including hedge funds, financial guarantors, investment banks and derivatives counterparties may expose institutions to specific asset types and market movements. In the case of severe market shocks, these exposures may increase in size rather quickly. Institutions must ensure that stress tests cover risks related to derivative counterparties and capture correlated tail risks.
- Risk Concentrations: These arise from risk taking activities on the part of financial institutions. It is important to mitigate these risks arising from credit counter-party risks, among other risks, that are a result of hedging of market and insurance risks. Concentrated risks present themselves as correlations among risk factors and can arise from different dimensions. Stress testing programs must consider many situations in order to avoid failing to detect these correlated risk factors.

Review of Literature and Frameworks

Economists, monetary authorities, and financial institutions have studied stress testing models and their role as a risk management technique. The IMF has advised that stress tests should be comprised of a balance of quantitative and qualitative metrics to be considered fully comprehensive. Most stress tests take the form of either bottom-up or top-down approaches.²⁰ Bottom up approaches are conducted by banks themselves and

²⁰ See BIS Working Paper No. 165: "Stress-testing financial systems: an overview of current methodologies."

the results are reported to monetary authorities or regulators. In contrast, regulatory or supervisory institutions generally employ the top-down approach. For example, Canadian banks employ their own models in performing stress-testing exercises to comply with regulations and submit the data and results to OSFI. OSFI and Bank of Canada review the results as well as conduct their own stress tests of the banks and Canadian financial system while conducting on-going research. International organizations such as the IMF evaluate financial sectors in various nations and use stress testing as part of their analysis of financial stability. Related research regarding stress testing design, the Macro Financial Risk Assessment Framework (Bank of Canada), and the IMF's Financial Sector Assessment Program (FSAP) and their results for Canada's financial system will be discussed in the following sections.

Early stress testing models date back to the 1990s, using value at risk (VaR) approaches to measuring market risks. J.P Morgan and Reuters RiskMetrics framework is an example. This methodology was brought forth in 1996 to provide a benchmark for market risk measurement in portfolio management.²¹ This methodology was designed as a micro prudential perspective as it focused on managing uncertainty regarding changes in the value of positions arising from changes in the market, which are portfolio and institution specific. Since then financial risk managers, regulators, and researchers have continued to study stress testing design extensively and develop frameworks from macro prudential perspectives as well.

²¹ Developed by J.P Morgan and Reuters RiskMetrics, is a set of techniques and data for the purpose of measuring market risks in portfolios of fixed income instruments, equities, foreign exchange, commodities, and derivatives.

The Bank of International Settlements also lays out an in-depth overview of methodologies for stress testing and recommendations for banks. Key features include characterizing a sound stress test as a tool serving to compliment risk metrics such as VaR and economic capital in addition to playing an integral role in risk governance as a tool for senior management. Coverage should include a variety of forward looking scenarios that are capable of generating the largest amount of damage for the institution. Their analysis also identifies the following risks whose coverage was not sufficiently considered in stress tests of institutions leading up to the financial crisis of 2008-2009; including contingent risks, liquidity risks, securitization risk, hedging risk, and risks emerging from complex structures under stressed conditions²².

Chicago Booth School economists Greenlaw et. al (2011) bring forth a five principle outline of a strong macro-prudential stress testing framework. They state that a strong stress test should focus on bank solvency but also account for the depletion of capital through dividend payouts. In addition, increased focus on both assets and liabilities on a bank's balance sheet is suggested when constructing stress scenarios; with particular emphasis on fire sales, credit crunch risks, as well as common exposures. These authors are opposed to the use of capital ratios, as outlined in Basel III, and suggest quantifying the dollar amount to remedy undercapitalized banks. Finally, in accordance with the new Basel III scenario, they emphasize the role of liquidity in a macro-prudential stress test.

²² Refer to the BIS's "Principles for sound stress testing practices and supervision".

These five principles have been developed with U.S and European banks in mind, however, these principles can be applied to financial institutions in other nations as well.

Researchers Schmieder, Pühr and Hasan (2011) developed an innovative framework for applied balance sheet stress testing for banks geared towards the Basel II and III Acts. These authors present a forward looking, user-friendly, Excel based framework. This framework incorporates assumptions regarding negative shocks and provides guidance in designing "plausible yet severe" scenarios to test. Emphasis is placed on the importance of the relationship between risk weighted assets under stress and risk sensitivity. The authors' framework is innovative as they recognize the impact of risk weighted assets in the assessment of a bank's solvency and capital position under stressed conditions. In addition, Gauthier et al (2014) proposed a three-part stress testing model that emphasizes the importance of funding liquidity risk. The authors outline their model which is derived from international financial institutions and central banks' stress testing models. They conduct a calibration exercise to demonstrate the importance of accounting for interactions between market liquidity risks, solvency risks, and the liquidity profiles of banks. They find that highly leveraged institutions are subject to significant risk if they have low cash holdings paired with significant short-term debt. This is consistent with the experience of some institutions during the recent crisis.

Schuermann and Wyman (2012) also proposed a framework for stress testing design and execution after the financial crisis. The authors highlight the importance of credible assessments of capital positions of financial institutions as well as a credible method to

implement increasing capital positions after the crisis. These authors, as well as Goldstein and Sapra (2013) discuss disclosure of stress testing suggesting this benefits markets in terms of market information. Other proponents of stress testing design with incentives to disclose include Bookstaber et al (2013) who discuss the importance of integrating macro-prudential metrics into stress tests to evaluate risks to the real economy.

Huang, Zhou, and Zhu (2009) use a methodology similar to that of the IMF in the assessment of financial stability risks of major institutions through stress tests. They use public information found in financial markets, rather than banks' private information, and statistical bootstrapping methods to measure systemic risks. This highlights the importance of utilizing innovative econometric techniques in stress testing.

What most of the research has in common is the need for expanding the risks that are considered and increasing the number of stress testing scenarios across a wide range of outcomes for a comprehensive risk management program. It also raised questions about data gathering and compilation, in addition to how transparent the results should be.

Bank of Canada's Macro Financial Risk Assessment Framework (MFRAF)

Bank of Canada's MFRAF is a three module framework designed for the purpose of providing a system-wide assessment of Canadian banking sector. This model focuses on identification of the channels in which risks are transmitted in the Canadian banking sector. The MFRAF is comprised of a bottom-up stress test, it is, however a hybrid approach as it also analyzes individual banks as an aggregate to identify the

effects/impacts of the stress scenario on the banking system. The MFRAF is unique as it goes beyond the scope of most stress tests, which typically consider the effects of solvency risk on banks' capital ratios during times of stress. However, major losses can also result from liquidity risks and systemic exposures through network spill overs and through market contagion. The MFRAF is innovative as Bank of Canada has also included liquidity risk and network spill over risk as key areas of focus in this stress-testing framework.

The model assesses the three types of risks mentioned above to demonstrate the problem of highly leveraged institutions with low cash holdings and large amounts of short-term debt as well as resulting network effects. The model begins from a generic banking environment that is similar to the state observed during the recent crisis. The model consists of three modules for each respective risk. It presents how the risks could materialize within a one-year period due to a large negative macroeconomic shock and how this would affect the capital position of banks and the financial system. Decline in capital position is measured using the Common Equity Tier 1 capital ratio and regulatory capital standards. First, declines may arise from losses on bank's balance sheets due to credit losses from non-bank borrower defaults at the midpoint of the time horizon (the six-month mark) and again at the end of the one-year time period. The variables used in this module include exposures at default (EAD), probability of default (PD), and losses given defaults (LGD). Operating income as reported by banks is also used to measure the capital positions.

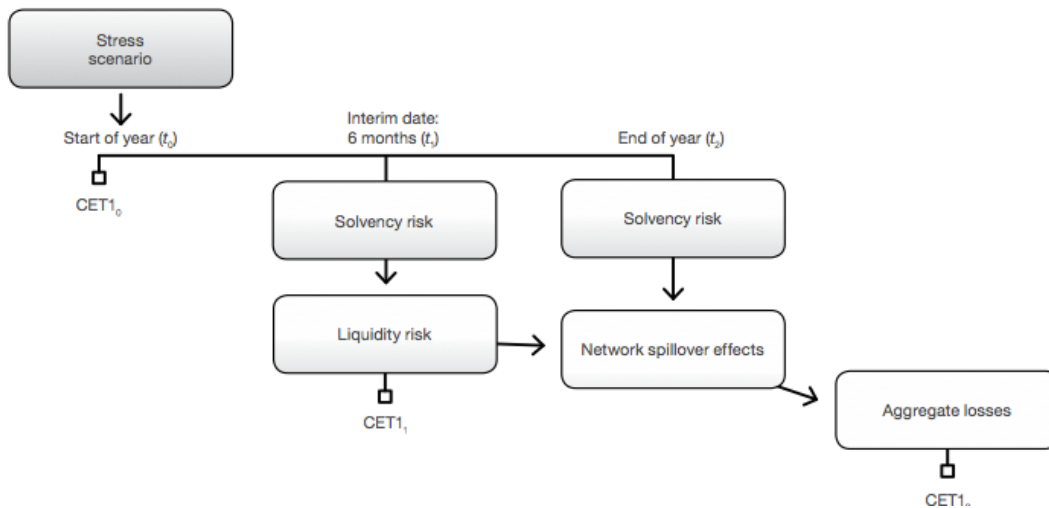
The second module focuses on the materialization of liquidity risks. If investors begin to question a bank's future solvency and its liquidity position, then liquidity funding risk and market risks are triggered. Short-term investors then avoid rolling over their debt in the anticipation of the bank's future default. The liquidity position of the banks in the model are characterized by the balance sheet liquidity, measured as the ratio of liquid assets and illiquid assets value at the expected fire-sale discount, to the stress condition of liabilities susceptible to a bank run at the six-month mark. These parameters are measured using regulatory data as well as Bank of Canada calibrations. Liquidity parameters are calibrated in accordance with international standards outlined by the Basel Committee on Banking Supervision. Assets such as cash holdings and various securities can be pledged to the central bank as collateral. Illiquid assets are comprised of loans made to households and businesses that cannot serve as collateral but are sold in the secondary market. The liabilities susceptible to a bank run are based on different funding instruments stability and maturity profiles. The liquidity module is designed to assess the likelihood of a run on major banks endogenously in the model.

Third, there is the inter-bank module that is designed to capture the spill over effects of counter-party defaults. At the end of the one-year horizon other banks may also be unable to pay inter-bank counterparties, leading to network spill over effects. The materialization of the three main risks contribute to decline in the capital positions and liquidity profiles of individual banks. The data used for measuring inter-bank exposures is taken from regulatory data compiled from the Big Six Banks reports.

To sum up, the model takes a bank level approach but also considers the interactions between banks to address system-wide stability issues and exposures. An illustration of the model is shown in Figure 1.

Figure 1:

MFRAF: A modular approach to systemic risk



Source: Bank of Canada

Bank of Canada’s 2014 *Financial System Review* presents the results of the materialization of the three major risks that contribute to the weakening of bank capital of the Big Six Banks. The results show that at the aggregate level the total capital position of the major Canadian banks would decline by 20 % under severe stress.²³ These results are consistent with those obtained by the IMF’s stress tests of the MFRAF which will be discussed in the next section. In addition, Bank of Canada reports that liquidity risk explains 65 per cent of additional decline in the Common Equity Tier 1 capital ratio.

They state that the network spill over effects accounts for the remaining 35 per cent. This

²³ As reported in the central bank’s 2014 *Financial System Review*.

highlights the added value of the inclusion of liquidity risk and the resulting spill over effects in their stress testing model.

The IMF's Financial Sector Assessment Program Stress Tests

As mentioned earlier, the IMF has evaluated the Canadian financial sector using stress testing frameworks. The FSAP stress tests focus on the importance of tail risks which can be characterized as extreme yet realistic risks when evaluating a country's financial system stability and the degree to which supervisory authorities and financial institutions respond to these events. The results of the IMF's evaluation provide valuable feedback for the updating of supervisory tools and internal models to best assess financial institution and sector soundness.

These stress testing scenarios include a "normal" economic condition which is based on the IMF's World Economic Projections as of early 2013 and a "stressed" condition characterizing an extreme recession. The timeline of these stress tests is specific to the 2013-2017 horizon, overlapping with the implementation of changes in banking regulations (Basel III). The stress scenario was constructed from a model-based simulation arising from a severe crisis originating from the euro-zone. This stressed scenario would trigger domestic vulnerabilities and negatively impact the Canadian financial system through the materialization of risks to the housing market and to household finances. The resulting impacts on Canadian markets via euro-zone stress

include declines in commodity prices, credit tightening and deleveraging of households²⁴. This results in a three-year decline in GDP to represent the most severe recession Canada has ever seen, eventual recovery after five years. The consolidated data used consists of the returns of the individual Big Six Banks for October 2012 as reported to OSFI.

The FSAP uses four approaches to assess the Canadian financial sector; a micro prudential bottom-up stress test, a top-down stress test conducted by OSFI, a top-down solvency test conducted by the IMF, and Bank of Canada's MFRAF. Each approach used the same supervisory data from OSFI, input parameters and formulas for risk weighted assets. The risk weighted assets are computed in the standard manner as a function of four variables; probability of default (PD), loss given default (LGD), type of exposure, exposure at default (EAD), and maturity. A common set of assumptions concerning risk inputs, probabilities of default and losses given default were used to enhance ease of compatibility of results. In addition, each approach was consistent in employing the Basel III capital conservation buffer.²⁵ The risk factors tested in the bottom-up approach were banks' resilience in regard to credit, market, and operational risks. The MFRAF model was used to evaluate the liquidity risk impact on bank solvency resulting from contagion-driven funding effects and counterpart credit losses from inter-bank and network exposures in scenarios spanning 2013 to 2015.

²⁴ For more details regarding the stress scenario view the FSAP Technical Document for Canada.

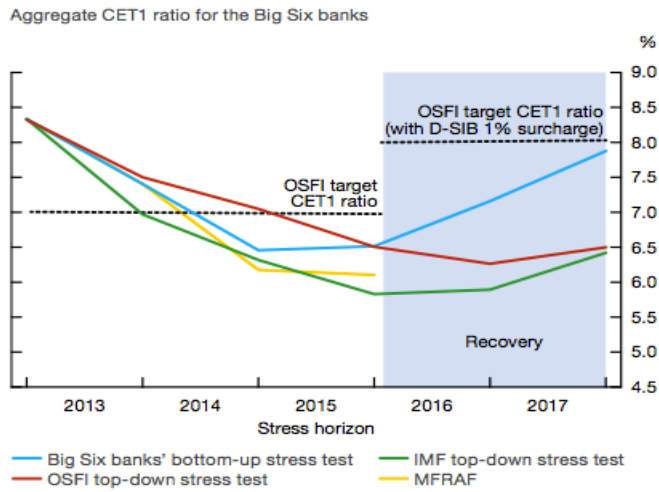
²⁵ See Bank of Canada's 2014 *Financial System Review*, "Application of the MFRAF in the 2013 FSAP" section.

The results of their investigation of Canada’s financial sector were favourable, as Canada’s major financial institutions passed the “severe stress” scenario. Canadian bank solvency was subject to stress testing and while all banks were projected to withstand severe stressed scenarios, there would be recapitalization needs. The stress tests assessed the banks’ level of Common Equity Tier 1 ratios in relation to the “all in” regulatory thresholds of 7 per cent for the first three years and then 8 per cent for the last two years. This was meant to capture the regulatory changes of Basel III, required by 2019, characterized by the “all in” level of capital requirements.²⁶ All stress tests showed sizeable but manageable declines in the Common Equity Tier 1 ratio. Key features of the bottom up stress test results show that a decline of 8.33 % of aggregate bank Common Equity Tier 1 ratio would be expected under the severe stress scenario.²⁷ In addition, a system wide decline in Common Equity Tier 1 capital for 2013-2015 under the “recession” scenario was estimated at 180 basis points under the bottom up stress test. Under this approach, five out of six banks would fall short of the “all in” regulatory threshold for Common Equity Tier 1 capital. Under the IMF top down approach, four banks would fall below the “all in” threshold in 2016. However, the IMF deems the shortfalls in capital as manageable, noting the strength of the Canadian banking sector. Figure 2, from Bank of Canada’s 2014 *Financial System Review* shows the decline in the capital ratios over the 2013-2017 horizon under the IMF’s stress scenario, per the bottom up and top down approaches.

²⁶ The IMF defines the “all in” level as the regulatory capital threshold under Basel III rules.

²⁷ A discussion of the IMF’s test of the MFRAF are presented in Bank of Canada’s 2014 *Financial System Review*.

Figure 2:



Note: CET1 is the common equity Tier 1 capital ratio.
 Sources: Bank of Canada, International Monetary Fund, Office of the Superintendent of Financial Institutions and major banks

Source: Bank of Canada.

The baseline liquidity scenario results for the IMF’s test of MFRAF model suggests that banks would be able to withstand a liquidity stress scenario. However, under the adverse scenario that allows for the materialization of significant liquidity funding risk, the results show that the Common Equity Tier 1 ratios of four banks would decline by approximately 4.5% below the regulatory threshold.²⁸ The IMF reports that central bank intermediation for liquidity support would range between 5 to 9 billion CAD\$ under the baseline scenario and under the extreme stress event between 86 to 155 billion CAD\$.

The results show spill over risks would be low as Canadian banks’ exposures are small in

²⁸ In depth details of the decline in Common Equity Tier 1 ratios in relation to the “all in” level of capital is discussed in the Technical Document for the FSAP.

the inter-bank market, suggesting that contagion effects would not be pronounced.

However, it is important to analyze the linkages among banks.

The IMF has made recommendations for stress testing frameworks employed by banks and regulatory authorities in Canada. They recommend the inclusion of longer time-series data, the implementation of consistency in bank's bottom up stress tests in terms of inclusion of key elements for bottom up tests of banks, the forecasting of income and balance sheet items to complement existing OSFI framework, and inclusion of the Net Stable Funding Ratio and Liquidity Coverage Ratio to incorporate liquidity metrics. In addition, recommendations of more communication between provinces and federal entities in order to monitor risks in a comprehensive manner is suggested.

The next section deals with the costs of financial instability, highlighting the importance of the effectiveness of stress testing frameworks. The evaluation of previously discussed frameworks will be presented from an economic manager's perspective.

Analysis and Evaluations

Recent experience has taught us that financial instability is costly and wasteful in terms of economic resources, reflected in economic performance. Financial system instability triggered by adverse shocks or exacerbation of existing vulnerabilities can be transmitted through the entire economy resulting in mounting costs. Direct costs arise through lost output and may result in recession. For example, Canada's Gross Domestic Product

(GDP) contracted by 3.6% from 2008Q3 to 2009Q2 during the recent crisis.²⁹

Fortunately, the decline in Canadian GDP was far less than that of European countries and the U.S. whose banking sectors were not as resilient. In addition, mispriced financial assets, excessive risk taking, and inadequate management of key risks can also trigger system wide failures as observed during the crisis. Under such a scenario, the economy suffers from an misallocation of resources. Labour and investment funds are shifted away from productive areas of the economy, negatively affecting productivity. Subsequently, during stressed financial conditions, credit can become less and less available to the point that financial institutions ration credit. The absence of available credit is an impairment to financial market efficiency as the channelling of funds from savers to borrowers is thwarted. Such a situation has the ability to create long term problems which hinder the economy's ability to functioning efficiently and grow.

Financial instability is also transmitted through improperly priced assets and network contagion effects. Indirect costs arise due to declines in consumer and investor confidence which should not be overlooked as returns are negatively impacted. This generally spurs declines in borrowing and can result in credit reduction, as stated previously.³⁰ Fortunately, Canada's markets were not affected to the same extent as those of the U.S in the recent financial crisis. Statistics Canada has reported that Canadian household borrowing declined by 3% from 2007 to 2009, while the U.S. experienced a decline of approximately 3 times this amount and the growth rate eventually become negative. Another indirect cost can be observed in the labour market as unemployment

²⁹ As reported by Statistics Canada.

³⁰ See Statistics Canada's 2009 Year End Review.

generally increases in response to output contractions, including cost-saving measures taken by firms, resulting in the misallocation of productive resources. These costs of financial instability emphasize the importance of proper risk management models and the value of stress testing.

Key Vulnerabilities

As mentioned previously, existing vulnerabilities should not be overlooked in the risk management practices of financial institutions and authorities. These risks can amplify the costs associated with distressed financial markets and institutions. The Canadian housing market, household imbalances, and the shadow banking sector are specific vulnerabilities worth noting.

Much attention has been focused on the Canadian housing market's role in the economy and the degree to which it is overvalued in recent years. Deutsche Bank has reported the Canadian market is overvalued by approximately 63% while the Economist and Bank of Canada have asserted that overvaluation is within the 25-30% range.³¹ As fundamental asset values are hard to pinpoint, there is no consensus regarding the precise extent to which the Canadian housing market is overvalued. Nonetheless, Bank of Canada, the IMF and private banks agree that the overheated market presents a system-wide vulnerability if the economy were to be subjected to a negative shock. Bank of Canada has warned Canadians that the housing market is a key vulnerability facing the domestic

³¹ See Deutsche Bank's Torsten Slok's charts, The Economist's April 16th 2015 Article "Global House Prices", and Bank of Canada's December 2014 *Financial System Review*.

financial system, as growth in house prices continues to outpace growth in incomes.³²

The Bank has maintained that they predict a “soft landing” as the most likely scenario for the housing market rather than an asset market crash.³³ However, the central bank continues to monitor this market and communicate risks to the financial stability outlook.

Household imbalances such as highly leveraged households in addition to low mortgage rates and the rise of subprime borrowing in Canada are also considerations in the analysis of system-wide stability and efficiency. Although household debt-to-disposable income stands at 163.3% in the first quarter of 2015, this is following three quarters of positive growth and still remains elevated.³⁴ In the December 2014 *Financial System Review*, Bank of Canada reported that 40.3% of aggregate debt is carried by households that are highly leveraged with debt-to-income ratios of more than 250 per cent. As such, highly leveraged households remain a risk to financial stability and ought to be considered in stress testing scenarios. The debt-service ratio, which Statistics Canada measures as household mortgage and non-mortgage interest paid as a proportion of disposable income, is at 6.74 for the first quarter of 2015.³⁵ In the past fifteen years, the debt-service ratio reached its peak of 9.17 in the fourth quarter of 2007. Nonetheless, this household

³² Refer to Bank of Canada’s December 2014 *Financial System Review* and *Monetary Policy Reports* for 2014.

³³ See Bank of Canada *Monetary Policy Reports* for 2014 and 2015.

³⁴ See Statistics Canada’s National balance sheet and financial flow accounts, first quarter 2015.

³⁵ Refer to Statistics Canada Table 384-0042.

sector measure has remained relatively stable at record lows over the past eight quarters indicating a positive signal for the household sector.³⁶

However, subprime lending, the form of mortgage lending that was scrutinized for its contribution to the 2008-2009 financial crisis, has risen in Canada in recent years. Bank of Canada has reported that approximately 35% of new uninsured mortgages issued by smaller federally regulated banks were considered subprime for the year 2012.³⁷ The central bank states that unregulated financial institutions are also engaging in subprime lending which poses a risk to financial stability, as these institutions are not subject to the same regulatory requirements as regulated entities. Although, they tend to be smaller institutions that specialize in non prime lending and are not a large component of the aggregate banking system, the issuing of riskier loans exposes an institution to potential defaults. Balance sheet links between these smaller subprime lenders and the major banks are important to consider. As this sector and these links are not analyzed in macro level stress tests, it would be beneficial to consider the system-wide implications of these trends. Lowered mortgage rates also support the increased housing market activity. These market trends have implications for financial stability, as adverse events such as loss of employment could trigger the inability of highly leveraged households to service their debts and could lead to an asset price correction. Resulting reduced consumption and slowed housing construction could be seen as a negative wealth and investment shocks. Balance sheet links among financial institutions amplify the transmission of losses and

³⁶ See Statistics Canada National Balance Sheet and Financial Flow Accounts for 2013Q3 to 2015Q1.

³⁷ See the December 2014 *Financial System Review*.

defaults throughout the system, proving the value of incorporating these links into micro-prudential models. Existing vulnerabilities would be exacerbated under stress events. It is recommended these vulnerabilities be considered when designing stress scenarios for current stress testing frameworks. Furthermore, the Canadian economy has recently been affected by the oil price shock. This has dampened exports which are a major component of GDP. As such, Canada's GDP has contracted considerably during the first half of 2015. The year-over-year real GDP growth rate has declined to 1.1% from 2.5% in the fourth quarter of 2014 and is expected to average a 1.1% growth rate for the year.³⁸ On the July 2015 Fixed Announcement Date, Bank of Canada lowered the overnight interest rate by 25 basis points to 0.5 per cent. This was designed to stimulate the economy and create an optimal borrowing environment that has the potential incentivize risky borrowers. These vulnerabilities pose threats, as eventual interest rate increases and a potential housing market correction will leave many Canadians and banks financially vulnerable if these imbalances persist and grow.

While domestic imbalances and inter-bank networks among federally regulated banks are of key focus when studying system-wide risks, other non-bank financial institutions operating in a similar fashion to banks, such as shadow banking entities, also pose risks to the financial system. The shadow banking sector is subject to many different definitions among financial professionals and researchers. Examples include activity based definitions that constitute credit intermediation activities as the shadow banking segment or entity based approaches that measure this segment by the entities or firms

³⁸ See the Bank of Canada's July 2015 *Monetary Policy Report*.

engaging in such activities. Bank of Canada defines this segment of the financial sector as credit intermediation taking place outside of the traditional banking sector; this can include hedge funds, money market mutual funds, asset backed commercial paper, pension funds, and private equity firms for example. From a risk perspective, this sector is far less regulated than the traditional banking sector. Post-crisis regulatory reforms such as Basel III target banks and their behaviour. It is important to recognize that regulations that increase costs and restrict activities can create incentives for banking activities to move to the shadow banking sector. The Financial Stability Board (FSB) refers to non-bank, shadow banking entities as Monitoring Universe of Non-Bank Financial Intermediation (MUNFI). In their 2014 Global Shadow Banking Monitoring Report the FSB states that these entities hold 25% of global financial assets, which represents approximately 50% of the assets in the banking system. In the Canadian context, Bank of Canada has reported that the shadow banking sector constitutes approximately 40% of nominal GDP for 2012.

Consequently, this sector's sprawl and growth in recent years generates financial sector risks to financial stability. Systemic risks that spill over from the shadow banking sector are important to measure and analyze. These stability risks can be transmitted through both direct and indirect channels. Direct channels include credit exposure, as some of these non-bank financial institutions are bank-owned. In addition, risks can arise from balance sheet links between non-bank financial institutions and banks in the form of a direct link through funding interdependence via asset holdings. For example, banks and shadow banks holding each other's debt securities. In addition, counter-party risks arise

when shadow banks and regulated banks invest in similar assets or hold similar portfolios. If these non-bank financial institutions are highly leveraged and hold illiquid assets, a stress event can trigger defaults and liquidity problems. Financial system stress can thus be transmitted through these different channels, creating a contagion effect similar to the inter-bank network channel. Information and data is needed to better uncover and to mitigate the systemic risks arising from links between the shadow banking sector and the banking sector. Risk analysis methodology comprised of an aggregate balance sheet of non bank financial institutions which are shadow banks, and banks is presented by the FSB. High level risk metrics include ratios of assets held by the bank to shadow banking entity over bank assets and vice versa, as well as the liabilities held by the bank to shadow banking entity over bank assets and vice versa. These are intended to represent measures of credit risk for the bank and the shadow banking entity as well as funding risks. Current data constraints impede the assessment of the interconnectedness of the two sectors, as the shadow banking sector is broadly defined and this data is not easily accessible. A fully comprehensive macro-level stress test would require this detailed data be made available in order to fully assess the soundness of financial institutions under stress and the network effects. Further research and monitoring of this sector is encouraged to analyze the role of this sector, and identify risks potentially impacting financial stability considerations. Cooperation and sharing of information among rating agencies, regulatory bodies, and industry firms is required to measure and quantify the links and interconnectedness of the financial sector to perform integrated stress testing and to promote system-wide stability in Canada.

Evaluations of the presented frameworks will next be conducted with a focus on the framework's fit with the OSFI guidelines and the coverage of risks. Suggestions for improvement will be made based on analysis. Bank of Canada's MFRAF model is first examined, followed by the IMF's FSAP stress tests as well as short discussion of the risk management approach in Canada.

Evaluation of Bank of Canada MFRAF Model

Bank of Canada's MFRAF model is designed to assess the impact of various risks facing Canadian financial institutions and the channels in which they would be transmitted throughout the system. The model's risk coverage is broad, as focus is beyond solvency or credit risk and includes liquidity risks as well as risks arising from the interconnectedness of banks. This model effectively identifies risks as well as interactions among risks, quantitatively simulates stress scenarios to assess the Canadian economy, focuses on capital and liquidity management, and therefore includes the four main pillars of a comprehensive stress testing program outlined by OSFI.

The MFRAF addresses risks as per OSFI's guidelines as it considers: solvency risk, liquidity risk, network spill over effects, bank run risk, and counter-party risks. This model considers the role of counter-party risks in the inter-bank market to study financial system robustness. It recognizes that transmission of spill over effects due to deteriorations in banks' capital positions can result in defaults triggered by counter-party credit losses and further bank defaults. The size of exposure as well as levels of solvency risk and liquidity risks are accounted for in the MFRAF to comprehensively examine

counter-party risk from a system-wide approach. Risk to reputation is also incorporated through the inter-bank module as these risks can arise from spill-over effects which can also drive bank runs and defaults. It also considers the risk that creditors will run on a bank in the network after obtaining information indicating that other banks' capital ratios have declined below the 7 per cent regulatory threshold. This model captures market liquidity risk and creditor sentiments in a fashion that reflects the situation that unfolded during the financial crisis of 2008-2009. Recent experience from the crisis has show that large scale pessimism can trigger credit rationing and runs. This model endogenously considers the materialization of such risks and their concentration, stemming from solvency and liquidity risks, a contribution to the stress testing literature.

The model's use of a balance sheet approach for the measurement of changes in asset and liability values and capital position of banks is consistent with OSFI's guidelines. This model accounts for risk correlations as it illustrates the intricacies between bank losses, asset correlations, and network effects driven by illiquidity and solvency risks. When accounting for liquidity risk and spill over risks, the results show that aggregate capital positions would further decline by 20 per cent,³⁹ illustrating the importance of considering the interaction of these risks. Banks should also note the impact of illiquid assets and fire sale discounts to avoid subjecting themselves to selling off assets to raise additional funds to meet their obligations. The IMF's recommendation of fine tuning the calibration of liquidity losses would be beneficial for Bank of Canada and OSFI. This is sensible as it would improve and better quantify the measurement of the impacts of

³⁹ Refer to "Stress Testing the Canadian Banking System: A System-Wide Approach" in the 2014 *Financial System Review*.

balance sheet illiquidity and resulting losses. Although the model shows the strength of the Canadian banking sector, the model also highlights the importance of mitigating spill over risks to avoid system-wide failures and associated costs. This model contributes to innovatively uncovering and measuring network spill-over effects in the Canadian banking sector.

As it is a hybrid model designed to test system-wide robustness, the MFRAF provides less details than a purely micro-prudential stress test which is a drawback. Suggested improvements noted by the IMF include fine tuning the calibration of liquidity losses to accurately measure its impact on the Common Equity Tier 1 capital as well as the incorporation of the MFRAF into an econometric or dynamic stochastic general equilibrium (DSGE) model for analysis from a macroeconomic model perspective. As the liquidity module measures changes in the capital positions endogenously, it would be beneficial for banks and supervisory authorities to obtain more accurate measurements of losses in order to improve to current risk management frameworks. Additionally, if the MFRAF were to be incorporated into a DSGE model, system wide stability could be assessed for Canada in a macroeconomic environment to better capture the effects of interest rate risks and inflation risks as well as the better measurement of the impact of systemic risks on Canada's GDP. Evaluating the impacts and transmission of shocks to the aggregate economy is beneficial in conducting optimal monetary policy for various points throughout the business cycle and promoting market efficiency.

Evaluation of the IMF's FSAP

The IMF's FSAP framework analyzes the strength of the Canadian banking sector using four approaches, including a test of Bank of Canada's MFRAF model. This framework emphasizes the materialization of tail risks, as the four approaches analyze how institutions fare under extremely severe yet plausible scenarios. The stress scenario constructed is more severe than any recession Canada has ever seen, constituting an extreme event. In this scenario the Canadian economy faces nine quarters of negative growth and reaches an unemployment rate of 13.2%. The severity of the scenario is consistent with OSFI's guidelines of constructing extreme scenarios likely to cause major damage to a bank under stressed conditions. The approaches focus on the changes in the capital ratios of the banks as per international regulatory standards (Basel III). Thus, the FSAP comprehensively measures the impact on capital positions as well as the financial system as a whole under extreme stress. The stress scenario incorporates existing vulnerabilities in the Canadian economy such as household imbalances and an overheated housing market. Plausibility in scenario selection is maintained as the stress event would originate outside of Canada in European markets and subsequently be transmitted to the Canadian economy. This is consistent with the past experience of the recent financial crisis, which originated in the U.S. The IMF's framework is strong in terms of balancing historical events with forward looking scenarios to capture the materialization of tail risks and their resulting impacts on the banking sector.

The FSAP also encompasses the four main pillars of an effective stress testing framework. Solvency risks and liquidity risks are analyzed comprehensively under the

four approaches. Emphasis is on capital management which is key to financial institution health. The IMF is able to project the recapitalization needs of the banks under the stressed scenario as per the Basel III standards. The IMF recommends that OSFI and Bank of Canada integrate the Basel III metrics into stress testing frameworks. While Canadian banks are sufficiently well capitalized, under an extreme stress event such as the example used in the FSAP tests, recapitalization to meet the regulatory “all in” ratio would be necessary. This would improve information available to financial institutions and supervisory and regulatory authorities about the possible outcomes or capital shortfalls under the new regulatory regime which is to be fully implemented in coming years. Financial institutions would now be able to prepare themselves more fully in accordance to the new capital requirements and liquidity regulations in addition to improving their risk management strategies. Maintaining adequate high quality economic and regulatory capital is important for banks in order to meet their operational needs, in addition to strengthening their resilience in times of stress.

Liquidity management is comprehensively covered under the four approaches. This is consistent with the focus of managing funding liquidity risks as outlined in OSFI’s guidelines. Although the results show that the banking sector as a whole would be able to withstand severe stress arising from market liquidity and funding shocks, their solvency would be under pressure, posing a significant risk. Consequently, takeaways from the FSAP should prompt Canadian banks to reevaluate their liquidity positions as the capital ratios fell short of the 7 per cent ratio under all four approaches, indicating that the

impact of funding risk on capital ratios are sizeable. Mitigation of funding liquidity risks due to bank illiquidity is necessary to promote financial stability in Canada.

The IMF suggestions include a requirement that banks perform the same stress test. However, the Superintendent of OSFI, Jeremy Rudin, has explained that requiring all banks to adhere to the same stress test is not advantageous or realistic, as each bank faces different types of exposures.⁴⁰ This is sensible from an economic risk management perspective, as an integral part of stress testing is to evaluate how the financial institution would fare under a variety of different scenarios with varying levels of severity given their financial position. Requiring a “check the box” standardized stress test does not promote active risk management as banks will become complacent rather than innovative in risk assessment. Here lies the importance of supervisory discretion, as rigid compliance measures can result in underestimation of risks, losses in efficiency and a lack of management attention.

A discretionary “principles based” risk management approach of supervisory and regulatory authorities has contributed to financial stability and market efficiency in Canada. This approach incorporates a cooperative relationship between regulatory authorities and financial institutions, cultivating an environment where innovation in risk management is possible. This approach is unique to Canada and allows for dialogue and discretion between financial institutions and financial authorities, opting for innovation in managing risks rather than monitoring compliance through “one size fits all” regulations.

⁴⁰ Refer to the Superintendent of Financial Institutions, Jeremy Rudin’s remarks at the International Finance Club of Montreal in March 2015.

In his recent publication,⁴¹ former Bank of Canada Governor David Dodge explains how stringent regulations and compliance monitoring can result in a less robust financial system as well as loss of productivity through diverted resources and increased costs. It is important not to lose sight of the goal of maintaining a stable financial sector when designing and implementing risk management regulations and models such as stress tests. Loss of efficiency as well as the potential creation of new or unintended risks may be the result if banks are to allocate resources towards compliance measures instead of productive operations. Holding large amounts of capital without actively and continuously assessing risks can result in economic inefficiency. Prudential regulation without discretionary supervision and without dialogue between key agents can result in a high amount of dead weight compliance costs. In addition, this may incentivize a shift in focus of banks from active risk management strategies to goals of producing favourable compliance reports. Rather than shift resources away from productive areas, the policy makers may consider the creation of a special auditing unit which would, of course, be publically funded. For these reasons, capital and liquidity management measures are necessary but not sufficient in promoting system wide stability and efficiency. As such, Canada should continue to balance the goals of managing financial system stability risks and market efficiency through cooperation between the financial institutions and the guidance from regulatory and supervisory authorities.

⁴¹ This publication “Financial Regulation and Efficiency: “Trade-offs in the Post-Financial Crisis Era” is available through the C.D Howe Institute.

Concluding Remarks

This paper has presented a summary of important stress testing guidelines, existing literature, current frameworks and post financial crisis regulations. Notably, affirming that stress tests should be forward-looking and innovative while including key risks that face financial institutions. The importance of looking beyond credit/solvency risk and considering network spill over effects as well as liquidity risks is emphasized in the evaluated frameworks. It has discussed the strength of the Canadian financial sector and the importance of balancing financial market efficiency goals with risk management strategies. Well capitalization and low risk appetites of banks paired with a strong supervisory and regulatory environment consistent with international regulatory principles are key factors in Canada's continued ability to maintain a stable financial sector. Analysis of the Bank of Canada and IMF's frameworks in relation to the guidelines provided by OSFI assert that effective risk management practices such as stress tests should actively identify, assess and mitigate potential risks while balancing goals of market efficiency. Recommendations are to incorporate the Basel III metrics into existing bottom up and top down models to measure changes in capital positions, asset and liability values and liquidity positions as per the new regulatory regime and the development of the liquidity module in the MFRAF to better measure market and funding liquidity losses which provides more information regarding financial system stability. In addition, the incorporation of current stress testing frameworks into aggregate models of the Canadian economy is suggested. Furthermore, as the financial environment is constantly changing, thorough analysis requires quality data and information to assess risks and develop effective risk management metrics such as stress tests. Risk managers,

financial professionals and researchers are encouraged to broaden sources of data used to assess financial institution soundness and uncover hidden risks. Inclusion of existing vulnerabilities into current frameworks is important. Specifically, the inclusion of housing market trends, household imbalances and the shadow banking sector is recommended as stress events exacerbate these existing vulnerabilities. System-wide stability and efficiency under these conditions should be analyzed and tested. Continued work is also needed to fill the data gaps and increase availability of information in areas such as the shadow banking sector in order to comprehensively stress test the system and to analyze the interconnectedness of financial institutions. Furthermore, there is a need for the development of extreme yet plausible scenarios that are forward looking to mitigate underestimation of risks. Finally, identifying common risks but maintaining discretionary supervision instead of a “one size fits all” compliance approach avoids complacency and works to promote market efficiency.

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