A Framework for Assessing International Risk to the Financial System

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Abstract: The objective of this paper is to set out a *structured framework* to identify and assess international risks to the Canadian financial system. International risks are defined as developments originating outside Canada that might be of importance to the Canadian financial system, such as banking, currency or debt crises, financial market volatility, or the risks stemming from the international real economy (e.g. the global or regional business cycle). To better understand how international risks may affect the Canadian financial system, we provide a thorough empirical description of the various transmission channels through which risks may be propagated. The paper then sets out a framework, consisting of three steps, for identifying and assessing international risks. Finally, we illustrate how the framework works in practice through a representative evaluation of the effects of a reduction in global liquidity, as defined by higher risk premia. Specifically, we utilize a five country, multi-sector version of the DSGE macro-model GEM (BoC-GEM) to generate risk scenarios, and show how this macro scenario could then be used to evaluate the impact on the Canadian financial system.

Keywords: Financial stability

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1 Introduction

The ongoing integration of global capital markets and the potential for financial market spillovers, combined with the increasing complexity of financial instruments and institutions, has sparked increased interest by central banks in financial stability. In particular, recent credit market turbulence associated with the deterioration of the U.S. subprime mortgage market reinforces the need to consider how international shocks can be propagated onto domestic financial systems. This interest in the financial system is not new, as witnessed by the recent proliferation of Financial System Reports (FSRs) worldwide. And like many other central banks, the Bank of Canada is actively engaged in these issues, from both a policy and research perspective (2006).

The aim of this paper is to outline the Bank of Canada's International Department's *structured framework* to identify and assess international risks to the Canadian and global financial system. This framework yields three key benefits. First, the framework's structure, and use of economic models to assess such risks, adds considerable rigour to the analysis of international risk. Second, it provides the basis for organizing the Bank's work on financial stability issues, from both an operational and research perspective. And lastly, we show that it is possible to structure the financial stability analysis as a parallel workstream. This means that central banks can take advantage of synergies across departments and leverage existing resources to be more productive, not only in terms of economic analysis, but also in terms of financial stability.

The paper proceeds as follows. Section 2 describes the financial stability function of the Bank and how it shares similar organizational characteristics to the monetary policy process. Section 3 describes international risk and the potential channels through which such shocks could be propagated. Section 4 presents the framework. Section 5 illustrates how the framework could be used in practice: we use BOC-GEM to evaluate how the impact of a shock to global liquidity would affect the path of output, interest rates and other macroeconomic variables. We then describe how these estimates could be used to assess their impact on the Canadian financial system.

2 The Financial System Function at the Bank of Canada

Similar to many central banks, the Bank of Canada works to promote the stability and efficiency of Canada's financial system. As part of this commitment, it seeks to identify potential risks to the system, of both domestic and international origin, so that they may be better understood and, if necessary, mitigated. However, responsibility for the financial system is shared across the Canadian government, and the Bank of Canada works in concert with other government authorities to achieve mutually shared objectives. Partners include the Canadian Finance Ministry, as well as the authorities responsible for oversight of federally regulated financial institutions (especially the major banks) and relevant deposit insurance programs.[2] Mechanisms have been established to facilitate information sharing and cooperation among these institutions.

[2] These include the Office of the Superintendent of Financial Institutions (OSFI) and the Canadian Deposit Insurance Corporation (CDIC).

Within the Bank of Canada, the financial system function is also a shared responsibility. Whereas some central banks have concentrated their relevant analytic resources in a financial stability "wing" (e.g., the Bank of England, Norges Bank), in the Bank of Canada's case, the work is undertaken within several different departments. The Monetary and Financial Analysis Department (MFA) examines the financial stability of Canadian banks, households and corporations. The Financial Markets Department analyses financial market developments both within Canada and abroad. The International Department evaluates international financial developments and risks. Finally, work on the payments and settlements system is undertaken by the Department of Banking Operations and MFA. To adequately assess risks to the Canadian financial system implies significant cooperation across these departments, and thus it is helpful to have a clear framework in place to facilitate this analysis.

The Monetary Policy Process at the Bank of Canada

The proposed framework has many similarities to the monetary policy process used at the Bank of Canada, a feature that is partly deliberate. Prior to a scheduled monetary policy decision, there is a period of analysis by Bank staff and information sharing with senior management.[3] The beginning point is the staff economic projection. Every quarter, the Bank's Research Department prepares a comprehensive multi-year outlook for the Canadian economy, known as the "base case." A key input to this process is the global macroeconomic outlook prepared by the International Department, with particular emphasis on the U.S. economy. The projection is model-based, but is supplemented by judgement that draws upon extensive and fairly continuous monitoring of the economic environment, gathering information from a variety of sources.

Based on discussions between the staff and senior management, one or more alternative scenarios may then be prepared focussing on some key uncertainties with respect to the macroeconomic situation. These uncertainties often originate from the external environment, such that analysis may again start in the International Department. A variety of other inputs are also prepared, e.g., analyses of developments in money and credit aggregates, in order to provide additional perspectives on recent and likely future economic developments and their implications for output and inflation. This information is shared and discussed with and among the Bank's Governing Council (GC) and senior advisers in a series of meetings that ultimately leads to a policy decision by the GC.

The proposed framework for the assessment of international risks is also based on a series of steps and information gathering that is intended to draw upon the range of perspectives that the Bank's different departments can bring to the table. Under the framework, analysis by the International Department on key risks will be an important input to the work of the Monetary and Financial Analysis Department on implications of the current environment for the Canadian financial system.

Several challenges remain in fully implementing the framework, apart from the fundamental research required to better understand the financial system and the transmission channels involved. A more comprehensive process for information

[3] The current system of Fixed Action Dates, eight per year, was introduced in 2000. For additional detail on the process leading up to monetary policy decisions see Macklem (2002).

gathering, involving the various Departments and senior management, needs to be put in place to ensure that the appropriate risks are identified. More daunting, however, is the requirement for substantially enhanced models and methodologies for evaluating the risks in a useful way. Here the process is still well behind that of monetary policy, such that a relatively heavy reliance on judgement is likely to be the case for some time. It is within this organizational structure that we intend to implement our framework.

3 International risk and channels

Threats to the Canadian financial system need not originate in Canada. Events such as the Asian, LTCM, and Argentine crises, the collapse of equity prices in the U.S. following the high-tech bubble, as well as the recent turbulence in global credit markets, are examples of risks that can affect the stability and efficiency of the Canadian financial system. In this regard, Canada is similar to many other countries, a fact that is reflected in how many central banks analyze not just domestic, but also international risks, in their FSR (see box 1). In what follows, we provide a definition of international risk, give examples of the potential channels through which risks could be propagated, and finally briefly describe the elements of the Canadian financial system that will be the ultimate focus of our financial stability framework.

3.1 International risks

For the purpose of this article, "international risks" are defined as developments originating outside Canada that might be of importance to the Canadian financial system. Broadly speaking, international risks can arise from two main sources: first, international financial system events (crises); second, real macroeconomic shocks emanating from Canada's major trading partners or at the global and/or regional levels (Table 1 provides various examples of international risks, following this classification).[4]

Table 1: Risk classification

Approach \ Risk	Real	Financial
Model-based analysis	U.S. recession Oil price increase	Global liquidity reversal Disorderly adjustment to global imbalances
Current analysis or event studies	Avian flu	LTCM-type crisis Sovereign default

Regarding the first source of risk, we define international financial system events as disruptive economic developments, including

[4] A third risk category is infrastructure risk, notably disruptions in the payment system. This type of risk is covered by work conducted at the Bank of Canada's Department of Banking Operations. As this risk is very different from the real and financial risks typically considered by ongoing monitoring or research, we do not discuss it explicitly in this study.

- banking, currency or debt crises;
- credit market disruptions;
- (high) volatility events from market activity;
- disruptive events such as avian flu or terrorist attacks

BOX 1 : Central Banks' FSRs: Various central banks have developed similar methodologies to analyze international risks. For selected central banks, this box summarizes the main focus of their FSR, a sample of important risks examined, and the main methodology to analyze them (as published).[5]

Country	Institutions	Analyzed risks include		Methodology
		Domestic	International	
Austria	Banks	Increase in non-performing loans	FX volatility	Monte Carlo simulation
ECB	Banks, insurance companies	Low long-term interest rates	Global imbalances.	Descriptive
Germany	Banks, insurance companies	Interest rate risk, stock market crash	FX volatility	Stress testing
Japan	Banks	Interest rate risk, housing market, credit losses	Financial globalization, hedge funds	Descriptive
Netherlands	Banks, insurance companies, pension funds	Risks of household debt	Global imbalances, avian flu, global recession	Reduced form equations
New Zealand	Banks, non-bank lending institutions	Risks of household debt	Global imbalances, global liquidity overhang	Descriptive
Singapore	Banks, insurance companies, non-financial sector	Housing market	US slowdown, correction of low risk premia	Merton model
South Korea	Banks	Interest rate risk, housing market, credit losses	FX volatility	Descriptive
Swiss	Banks	Stock market crash, recession	Correction of low risk premia	Reduced form equations
UK	Banks, to some extent LCFIs	Rise in UK household debt,	Global imbalances, correction of low risk premia	DSGE, reduced form equations

[5] Note that most central banks employ more than one methodology to analyze risks. Also, few publish fully detailed econometric studies or results from stress tests. For more information on FSRs see Cihak (2006).

These crises/events can have both direct and indirect affects on the Canadian financial system. For example, banking and currency crises, or volatility events in international markets, can manifest themselves directly i) through effects on bank balance sheets, and ii) losses to the market portfolios of assets of financial institutions, or indirectly, through downward pressure on global asset markets, that then affect the foreign exposures of Canadian financial intermediaries, or iv) higher domestic interest rate spreads and the impact on the supply of credit for firms and households.

The second set of risks stem from the real side, e.g. the global or regional business cycle. Slower economic growth or recessions in Canada's main trading partners could negatively affect firm's financial health, increasing credit risk for Canadian banks. Also, a downturn in the global economy can lead to lower commodity prices, which can negatively affect Canadian firms by raising credit risk, or lowering asset prices. Lower commodity prices can also affect the exchange rate, while conversely, strong global economic growth can lead to a strong appreciation of the Canadian dollar. This latter effect may disadvantage some sectors of the economy, leading to balance sheet concerns. Given the weakening in financial positions, the credit risk in the Canadian financial system might increase.

It is worth noting that the Bank's macroeconomic models are much better able to identify and assess risks related to real macroeconomic shocks than those arising from economic and financial crises. This is due to the fact that the disruptive nature of financial crises are typically non-linear in nature, as is their potential impact on the economy, neither of which is straightforward to analyze in conventional economic models.[6] For example, the Asian crisis of the late 1990s is still not well explained by most macroeconomic models. Likewise, it is not straightforward how to assess risks like Avian flu in a formal model.

3.2 The propagation of risks and the Canadian financial system

The identification and assessment of risks, and their potential impact on the Canadian financial system, naturally relies on an understanding of the channels (vulnerabilities) by which shocks, both financial and real, can be propagated. In this section, we describe these channels. A short description of the elements of the Canadian financial system that the framework will cover follows.

In order to determine which channels matter for the transmission of international shocks, we briefly examine the foreign exposures of the Canadian economy.[7] Canada's foreign exposures can be viewed through the balance of payments, and its underlying components. Thus, we examine the current account, and the international investment position. Then, more detailed analysis is provided with respect to the exposures of Canadian financial institutions, with a particular focus on banks. Finally, we examine the potential linkages between Canadian and foreign capital markets.

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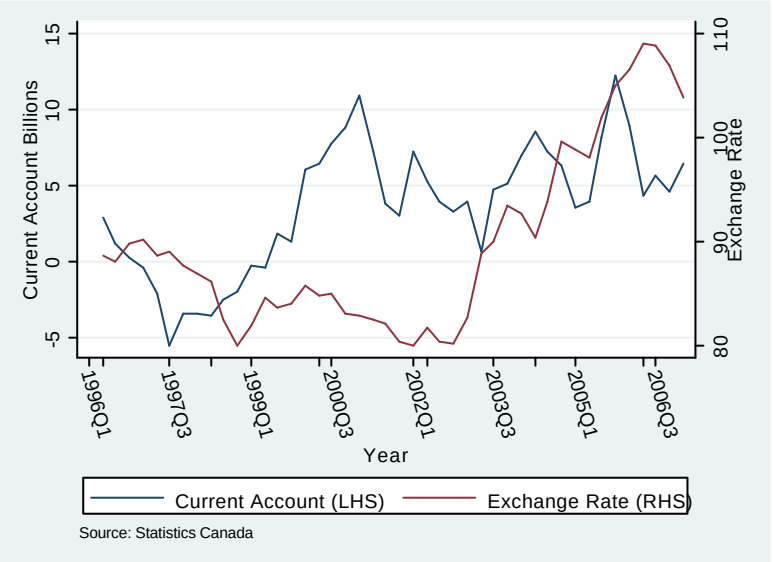
[6] Note that disruptive events often also lead to non-linear effects in crisis countries or sectors. These are typically hard to incorporate in an economic model. Our main focus is, however, not in forecasting the effects of a crisis in the respective country, but rather in analyzing the effects of an international risk on the Canadian economy. Such analysis is less hampered by non-linearities.

[7] For a full examination of the foreign exposures of the Canadian economy, see Aaron, Gomes, Maier, Santor and Vasishtha (2008).

The Balance of Payments: The Current Account, the Flow of Funds and the IIP

The balance of payments measures Canada's trade balance and financial flows. This analysis is motivated by the fact that, in many instances, the transmission of disruptive economic events is linked to the balance of payments. Many studies have found that large and prolonged current account deficits may result in sudden reversals, and thus, macroeconomic and financial instability.[8] Canada's current account is shown in Figure 1. For much of the 1980s and 1990s, the current account was in deficit, but it has turned strongly positive since 1999. This improvement in the current account reflects two trends: a continuing strong positive balance in goods trade, combined with a declining deficit in income. This improvement in the current account has occurred within the context of a rapid appreciation in the trade weighted value of the Canadian dollar (see Figure 1).[9] To understand what risks may matter for Canada, a closer look at the components of the current account are required.

Figure 1: The Current Account and the Exchange Rate



The Trade Account

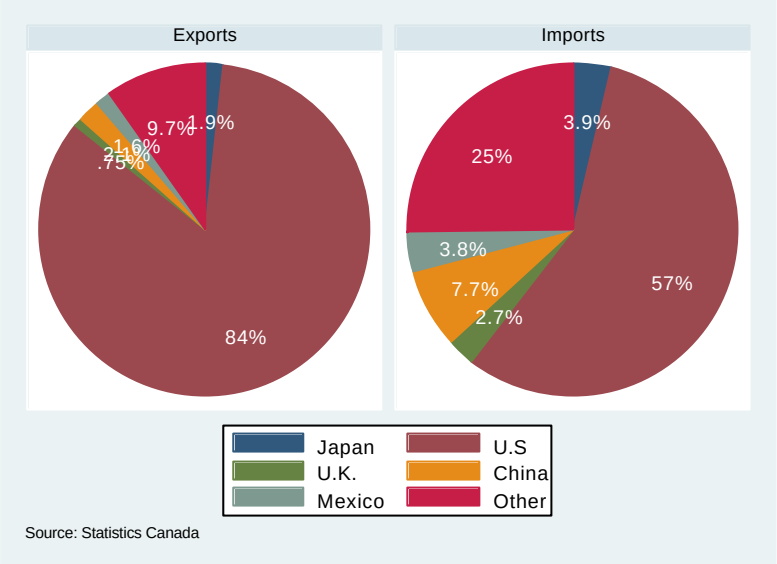
The Canadian economy is relatively open, with export and imports summing to nearly 80% of GDP. Canada is very dependent on the United States, which accounts for the majority of both exports and imports (followed by the Euro Area, Japan, and increasingly China – Figure 2).[10]

[8] Empirical studies include Calvo et al. (2004); Edwards (2001; 2004); Maria Milesi-Ferretti and Razin (1998). A theoretical treatment is given in Krugman (1979).

[9] While the link between the current account and the exchange rate is weak, nevertheless, there is some anecdotal evidence that the ongoing appreciation of the dollar may have lead to a reduction in the goods surplus, as manufacturers could have become less competitive in global markets.

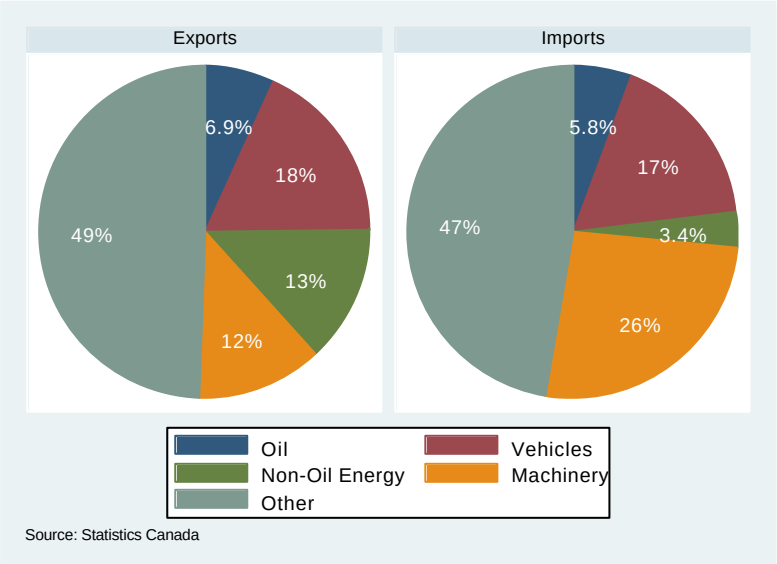
[10] As measured by a Herfindahl index, Canada's exports were the second least diversified in terms of destinations of the OECD countries.

Figure 2: Canada's Export and Import Partners, 2006



The composition of these exports and imports are also important, as energy and commodity exports play an important role in the Canadian economy (Figure 3), relative to the past. Nonetheless, manufactured goods still constitute a significant proportion of Canadian exports and imports.

Figure 3: Composition of Canadian Exports and Imports



The trade account suggests that shocks to the U.S. real economy could affect the demand for Canadian exports, and thus have direct consequences on the Canadian financial system, through the impact on the financial health of firms. But trade links are not the only channels through which real-side shocks could affect the Canadian financial system. Research at the Bank of Canada has found a close and empirically robust relationship between commodity, and recently, energy prices, and the Canadian-US dollar exchange rate (Issa et al., 2006). Consequently, international shocks that affect commodity and

energy prices may have direct effects on the Canadian financial system through the exchange rate.

The Flow of Funds and the IIP

The current account includes the trade balance and the financial account. The financial account shows the flow of funds; the complement to these flows is the stock of Canadian foreign assets and liabilities, as measured by the international investment position. An examination of the flow of funds can help to determine what factors could affect the allocation of assets and liabilities over the short term. Likewise, analysing the IIP, and hence the gross asset and liability positions will allow us to determine if the Canadian economy is vulnerable to financial shocks that might affect the value of foreign assets or the willingness of foreigners to hold Canadian assets.

Table 2 shows the flow assets across the three broad categories: direct investment, portfolio investment, and other flows (mostly loans and deposits). Since 2001, there has been a strong and stable increase in FDI assets, while foreign FDI liabilities increased more slowly, apart from the sharp increase in 2006. This recent increase in FDI liabilities can be attributed to the boom in foreign takeovers in the natural resource sector. Over the same period, portfolio assets have continued to increase, although at a slower rate in 2003 and 2004. Lastly, loans and deposits - essentially the activity of Canadian banks - does not show any clear trend during the period.

Table 2: Net Flow of Assets and Liabilities (billions CDN)

	2001	2002	2003	2004	2005	2006
Direct Investment						
Assets	-56	-42	-32	-57	-41	-51
Liabilities	43	35	10	-0	35	78
Portfolio Investment						
Assets	-38	-29	-19	-24	-53	-79
Liabilities	38	19	20	55	10	33
Loans						
Assets	-8	-9	8	4	8	-12
Liabilities	-6	1	2	-2	3	12
Deposits						
Assets	-2	6	-19	-11	-16	-8
Liabilities	24	14	18	-1	29	21

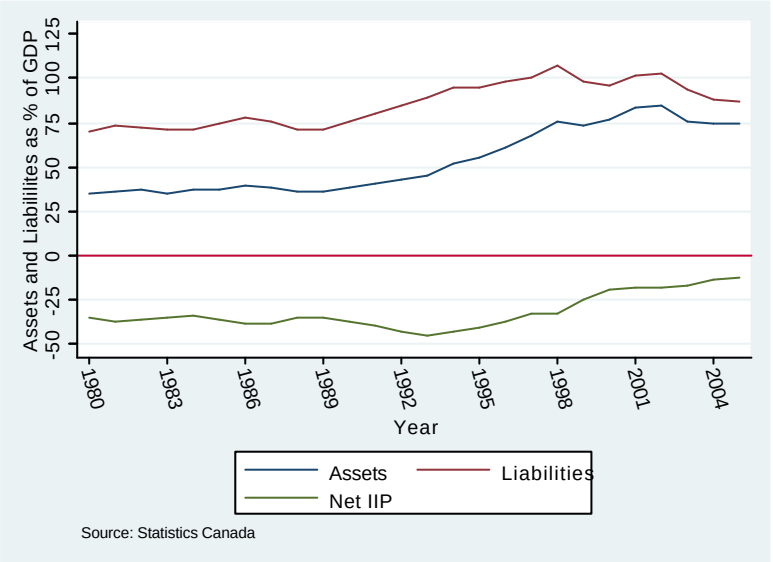
Source: Statistics Canada

The relatively small net capital flows described above do not, however, fully reflect the much larger gross positions. That is, the yearly changes in the financial account simply reflect the long-run evolution in Canada's international investment position (IIP), defined as the difference between Canada's foreign assets and liabilities. Thus, we look both at Canada's net position, and the overall gross position, in order to better understand how

shocks to the international financial system may be transmitted onto the Canadian economy.

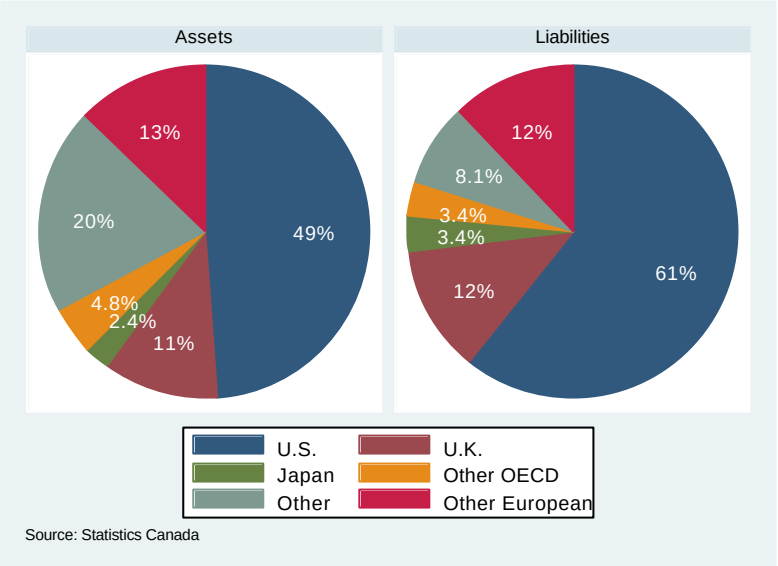
The IIP has been in continuous deficit since 1980, averaging 40 percent of GDP throughout the 1980s and 1990s, hitting a post-1945 low of 45 percent of GDP in 1994. However, sharp improvements in Canada's fiscal performance led to a reduction of the deficit in the IIP. Currently, the deficit is 7.3 percent of GDP, or -106.8 billion dollars (Figure 4). This relatively small net liability position masks larger gross positions. Those grew considerably between 1989 and 1997, when gross liabilities had reached 105 percent of GDP, and gross assets 75 percent of GDP. However, the level of financial openness appears to have stabilized at the current level, and as of 2006, assets were $1192.8 billion and liabilities $1299.6 billion, representing 75 percent and 83 percent of GDP respectively.

Figure 4: Canada's International Investment Position



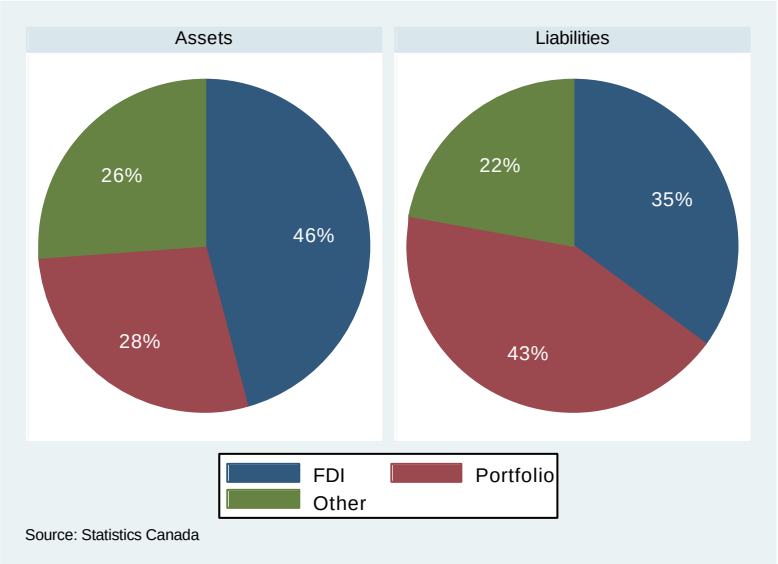
The United States accounts for the majority of foreign assets (49 percent of total assets), followed by the European Union (13 percent), the United Kingdom (11 percent), and the remainder spread amongst Japan (2 percent), other OECD countries (5 percent) and the rest of the world (20 percent) (Figure 5). The majority of Canadian assets are denominated in foreign currencies (mainly U.S. dollars). Canada's liabilities are allocated in a similar fashion to assets, with the United States accounting for nearly 61 percent of all liabilities, with the rest accounted for by the European Union (12 percent), United Kingdom (12 percent), Japan (3 percent), other OECD countries (3 percent), and the rest of the world (8 percent). In terms of net liabilities, Canada is most exposed the United States, with only negligible net liability or asset positions vis-à-vis the U.K. and Japan.

Figure 5:Regional Composition of Foreign Assets and Liabilities



The composition of Canada's foreign assets and liabilities can be broken into foreign direct investment (FDI), portfolio investment and other investment. This latter category includes bank activity, and other miscellaneous items (such as the government's foreign reserves). In 2005, 46% of assets were FDI, 28% was portfolio investment and 26% was other investment (Figure 5). Liabilities differ in that FDI accounts for only 35% of total liabilities, with a greater share of 42% in portfolio liabilities. Interestingly, the proportion of portfolio liabilities has fallen since 1994 from a high of 55% of total liabilities, reflecting improvement in the fiscal position of the Canadian government.

Figure 6: Investment Composition of Assets and Liabilities

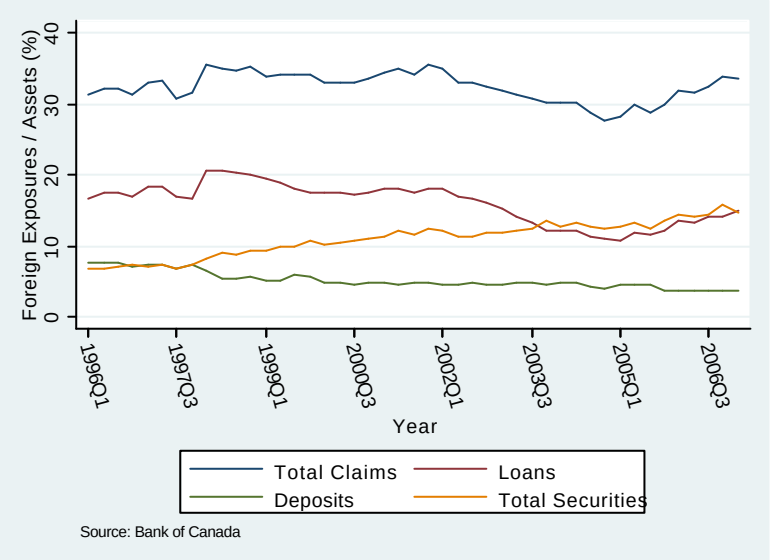


The aggregate data reveals that the Canadian economy has significant gross asset and liability positions and is suggestive of the potential channels through which shocks could be propagated directly or indirectly onto the Canadian financial system. In order to obtain a clearer picture of the potential channels, further dis-aggregation is necessary. For instance, a breakdown of the elements of portfolio assets into equities, sovereign debt, and so on, would help to develop a better understanding of the potential means through which financial stability could be threatened. Likewise, a better understanding of the foreign activity of particular sectors of the Canadian financial sector would be crucial for understanding the channels by which shocks affect the Canadian financial system. To this end, we briefly describe the foreign exposures of Canadian banks, and other elements of the Canadian financial system.

Canadian banks' foreign activities

Canadian banks have always maintained significant foreign exposures: from 1995 to 2005, the foreign assets of Canadian banks have remained relatively stable at 27%–35% of total assets (Figure 7).[11] The absolute level of foreign assets rose from $280 billion in 1995 to $570 billion in 2001, and was $510 billion in 2005Q4.[12] The composition of foreign assets, however, has changed over time, as banks hold proportionately more foreign securities, but fewer foreign loans to private sector corporate entities.

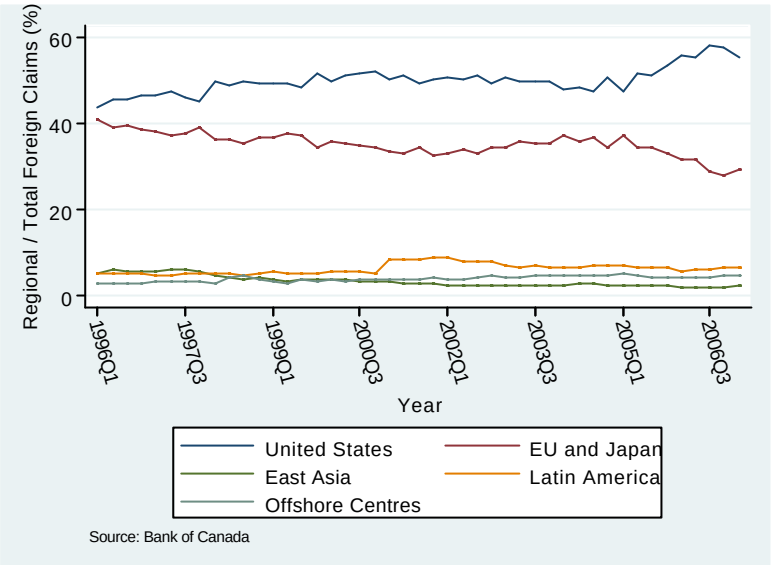
Figure 7: Banks' Foreign Exposures by Type, 1996-2006



The majority of foreign exposures are to the United States, which accounts for 58% ($273 billion) of foreign exposures, followed by Europe with (25%) $115 billion, Latin America with (11%) $53 billion, Japan and Emerging Asia with 3% ($16 billion), and the remainder spread among offshore banking centres, Africa and the Middle East (Figure 8).

[11] The proportion of foreign claims to assets peaked in the early 1980s at over 45%.
[12] All dollar amounts are in constant 1997 dollars.

Figure 8: Banks' Foreign Exposures by Region, 1996-2006

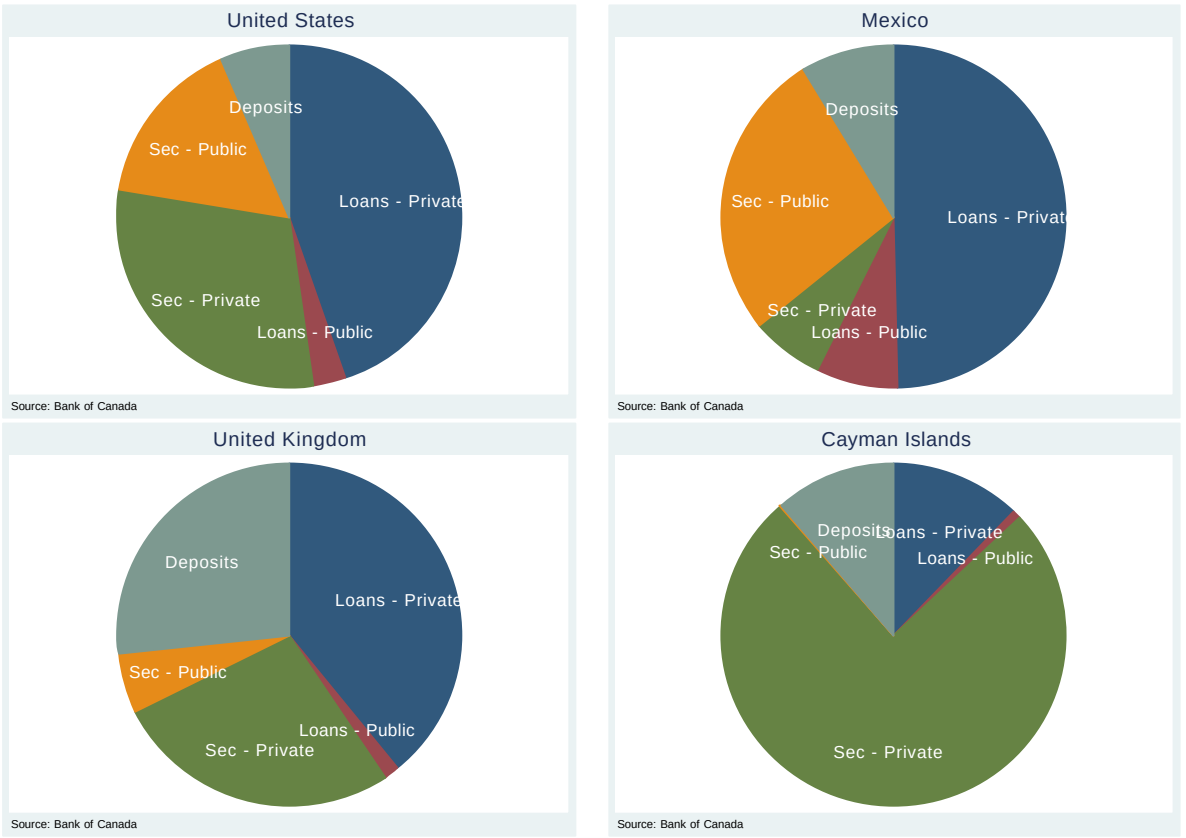


Further dis-aggregation can help identify the channels through which shocks can affect the Canadian banking system. Figure 9 breaks down Canadian banks' exposures to the U.S., U.K., Mexico, and the Cayman Islands. Exposures to both countries are dominated by private securities, loans to private firms, and bank deposits, although this latter category is more important for U.K. exposures. The exposures to Mexico, however, differ from the U.S., in that banks have substantial exposures to private loans and public securities, while exposures to the Cayman Islands are dominated by securities to firms.. While the banking statistics provide a useful first cut at the data, it is clear that future research needs to address deeper issues with respect to the behaviour of Canadian banks. Specifically, the nature of their capital market activity, and their subsequent exposures to global credit market conditions.[13]

The foreign activities of other elements of the Canadian financial system are, unlike banks, less well-documented. Nevertheless, recent financial market innovation and regulatory change has led to an environment where non-bank Canadian financial entities are more likely to be exposed to foreign economic developments. For instance, foreign assets constitute nearly 30% of the total assets of Canadian pension and mutual funds.

[13] The recent turmoil in global credit markets, and its impact on the Canadian non-bank Asset Backed Commercial Paper, highlights the need to better understand the nature of financial market linkages, both domestically and globally.

Figure 9: Banks' Foreign Assets by Country, 1996-2006



Moreover, research suggests that Canadian and U.S. equity markets are well-integrated. Flood and Rose (2005) shows that equities in the TSX and the NYSE have the same stochastic discount factor, suggesting that they are priced similarly in both markets. This is seen in the high correlation of the TSX300 and the SP500 (Figure 10). Similarly, recent regulatory reform raised the allowable foreign content limit of tax-deferred pension plans from 30% to 100%. Consequently, pension funds and mutual funds are likely to become increasingly global in their portfolio allocation decisions. In either case, it is clear that shocks to foreign equity markets can quickly spread to the Canadian financial system.[14] Lastly, household and corporate balance sheets could also be a potential transmission channel. A key part of our future research agenda is to fully examine the extent and importance of these channels.

The channels listed above are by no means exhaustive – rather, they are described in order to highlight the fact that any successful framework for identifying and assessing risks will need to consider such channels thoroughly. Before turning to the framework, a brief description of the Canadian financial system follows.

[14] The recent episode where a sharp correction to Chinese equities spread to other markets is a good example of the degree of integration of global capital markets

Figure 10: TSX 300 and SP500, 1996-2007

The Canadian financial system

Box 1 has not just shown considerable heterogeneity in terms of the risks analyzed, but also in terms of institutions examined. While some central banks focus on the banking system, others include pension funds or insurance companies. Nevertheless, most central banks naturally focus financial stability analysis on the banking system. While this focus is largely justified, we intend to take a more comprehensive approach, and will include analysis on the following elements of the Canadian financial system:

- banks
- insurance companies
- pension funds
- hedge funds, private equity firms, and other pooled financial investment vehicles
- equity markets
- bond markets

We believe that for Canada a comprehensive approach has merits. In the last decades, equity markets have become more important for Canadian firm financing. Likewise, while hedge funds and private equity funds have grown dramatically, relatively little is known of their activity and subsequent importance to financial stability. And lastly, demographic and structural changes have highlighted the need to account for pension funds and insurance companies in any assessment of financial stability. It is within this broad definition of the Canadian financial system that our framework will seek to identify and assess international risks.

4. A framework for identifying and assessing international risks

Diagram 1 provides a highly stylized overview of the risk identification and analysis framework. We discuss each step in turn.

Step 1: Identifying International Risks

The starting point of any framework to identify and assess international risk is a mechanism to spot country-specific or regional vulnerabilities or unsustainable developments at an early stage (particularly in financial markets). The Bank of Canada's identification of international risk starts with three main sources of information: country monitoring, information acquired in international meetings, and research.

1. Country monitoring: Country monitoring is central in spotting unsustainable developments or potential crises. Currently, the International Department monitors developments in North and South America, in Europe, and in Asia. To detect a crisis, monitoring can focus on economic and political developments, or indicators such as currency or debt mismatches. Determination of the most useful indicators is determined by ongoing Bank of Canada research, as well as external studies on currency or banking crises (see, for instance, Calvo and Reinhart, 2002), or credit market disruptions.
2. Information acquired in international meetings and reports (see Box 2): Bank of Canada officials participate in various international fora, such as meetings at the BIS (CGFS, BCBS), FSF, G7, G20, IMFC, etc. Also, international organizations such as the IMF (GFSR, WEO, FSAPs), BIS, OECD, etc. provide regular reports about international economic developments. Information acquired from these meetings and reports can provide input to understanding country, regional and/or global vulnerabilities.
3. Research: Economic and financial system research can provide insights whether changes in relationships between economic variables reflect structural changes, or could signal the potential for abrupt corrections. Research can also contribute to our understanding of linkages between financial markets, behaviour of Canadian banks, etc.

To make the best use of such information, it needs to be extracted in an efficient way. There are various ways to do this. For instance, with respect to information from international meetings, one could include a 'check list' in briefing books, focusing on whether certain risks are discussed during the meeting, and providing room to list other international issues evaluated during the discussion. An important part of step 1 is better organization of information. To avoid duplication of work, it is important to have a structure enabling common better access of information.

Note that this process focuses primarily on the detection of risk, rather than on vulnerabilities. However, there might be instances where knowledge regarding vulnerabilities from existing research and analysis may assist the process. For example, information on vulnerabilities could come from financial institutions' balance sheets, stress tests, or analysis of financial infrastructure. Also, the Financial Market Department might detect abnormal behaviour in financial markets (e.g. spreads not responding to

negative information, which could indicate that risk is mispriced). As indicated by the box "vulnerabilities" in Step 1 of Diagram 1, the framework will utilize such information to complement the risk identification process.

Step 2: Global Financial System and Model Based Analysis for Drafting Scenarios

Based on the identification of risks as outlined in Step 1, risk scenarios can be developed. Broadly speaking, the Bank of Canada employs three methods to evaluate the nature of the risks:

- Financial system analysis (models of asset market transmission, contagion, systemic risk, etc.);
- real economic models such as *BoC-GEM* (see below);
- monitoring and current analysis.

Where possible, we envisage the use of economic models. The main advantage of using models is that it adds rigor to the analysis. Ideally, models of the global real economy or the global financial system provide insights how a particular risk could develop and be propagated through the global economy. For instance, risks emanating from the adjustment to global imbalances could be assessed by their impact on financial markets, or by their impact on the real economy. Such assessments could be used to draw up specific scenarios. This parallels the risk assessment process done for monetary policy analysis at the Bank of Canada, and in many other central banks.

Various models still need to be developed, notably for financial system analysis (Christensen et al., 2006). These could include models of the interbank market, market liquidity, informational contagion, and so on. We are, however, relatively far advanced in terms of real economic models: The Bank of Canada is currently adapting the Global Economy Model *GEM*, developed by the International Monetary Fund, to the Bank's needs. For many international risks, this model will be the starting point of the analysis.

The Bank of Canada's Global Economic Model (*BOC-GEM)*

BOC-GEM is a dynamic stochastic general-equilibrium (DSGE) model that has highly developed theoretical and microeconomic foundations, modelled on the principles of supply and demand. The model contains five-country blocks and four-sectors. The "country blocks" are namely Canada, the United States, emerging Asian countries that import raw materials (primarily China and India), commodity-exporting countries (including members of the Organization of Petroleum-Exporting Countries), and the rest of the world (notably Europe and Japan).

In each region, there are three main types of agents: firms, households, and government. A continuum of firms that combine capital and labour to produce raw materials, intermediate, and final goods, and are typically characterised by monopolistic competition and CES production functions. Given the importance of natural resources for Canada, *BoC-GEM* features tradable and nontradable goods sectors, the oil and gas sector, and other commodities.[15] The tradable goods, nontradable goods, and gasoline,

[15] See the forthcoming *TECHNICAL REPORT* for details on BoC-GEM.

Box 2: Leveraging external information on risks to financial stability

An effective process to identify and prioritize global financial risks will draw upon the wide range of external information available from official and private sources. This includes participation in international organizations and meetings, exchanges with public and private sector officials, as well as external publications and research.

The IMF and the BIS are the two leading organizations for international financial stability. The IMF produces the semi-annual *Global Financial Stability Report* and the *Financial Market Update*, regional and country reports, and FSAP documents. The semi-annual meetings of the IMFC also provide a forum in which global financial issues are discussed. The BIS, in addition to the Governors, CGFS and BCBS meetings, acts as the secretariat for the Financial Stability Forum and Joint Forum, perhaps the groups most focused on evaluating the risks that are at the core of our proposal. Specific financial system developments are also analyzed by the OECD, with relevant issues discussed at meetings of the EPC and WP3, or appearing in the publication *Financial Market Trends*. All three organizations undertake related research to which Bank staff often has good access.

Discussion of current financial stability issues also occur in international fora such as the G-7 and G-20, and in more ad hoc groups such as the Bellagio meeting. Other international joint bodies or organizations may be relevant to specific issues, including the International Organization of Securities Commissions (IOSCO), the International Association of Insurance Supervisors (IAIS), or the World Bank and regional developments banks. In addition, foreign central banks and other financial authorities (e.g. the U.K. FSA or U.S. FDIC) publish financial stability related work.

Private sector sources are also important. These include organizations such as the Institute of International Finance, credit rating agencies, banks, and other financial institutions, which often publish extensive analyses related to the financial system (e.g. on credit quality, new financial instruments, or risk management practices). Academic research and conferences may also be relevant, although they are often less focused on near-term risk assessment.

To make effective use of these resources, a methodology is required for extracting and organizing information in a timely manner. This process will include senior management. Moreover, these sources of information can also be used to check our own assessments.

are combined to produce a final consumption good, while tradable and nontradable goods are required for the investment good. The key frictions for firms are the existence of adjustment costs for capital, investment, the share of imported goods, and the production and use of oil. Firms typically set prices a la Rotemberg pricing.

Households consist of two classes of consumers, those who own all the firms and have access to capital markets, and those who can only consume out of their labour income. Households have habit persistence in consumption and labour, and there are nominal

rigidities in wages. They can hold two types of bonds, a domestic bond, and an internationally traded bond.

The government in each region consumes nontradables that are financed through taxes or borrowing. Government consumption does not enter the utility function of households. There are seven sources of taxes, including taxes on capital, labour, tariffs, oil royalties and gasoline, and fiscal policy follows a rule that targets a stable long-run debt-to-GDP ratio. The monetary authority defines the objective for monetary policy, and controls a short-term interest rate to achieve this goal. For most of the country blocks, the monetary authority follows an inflation-forecast based rule that targets core or total inflation. For Emerging Asia, however, the rule is adapted to reflect the fact that the nominal exchange rate is fixed to the U.S. dollar.

There is international trade in oil, commodities, and tradable goods for consumption and investment. There is also trade in an international bond, and positions in this bond determine the net foreign asset position of each region. Importantly, the net foreign asset position is maintained through a financial friction, an exogenously determined NFA-to-GDP ratio, and a risk-adjusted uncovered interest rate parity condition defined in terms of the bilateral exchange rate with the U.S.

The model's parameters are calibrated using data, the results from previous microeconomic studies, and other DSGE models. The Bank of Canada uses this model to study issues requiring a global perspective, such as global imbalances, low risk premia, the causes and effects of the rise in commodity prices, and the benefits of price-level targeting relative to inflation-targeting. Many of these issues could potentially have important financial stability implications. As it currently stands, *BoC-GEM* can be primarily used to evaluate the real consequences of a shock. An important weakness of the Bank's current risk analysis is that we lack good models for financial sector analysis. This implies that at the current stage, risks such as a reversal of low risk premia need to be calibrated, rather than simulated or estimated. However, *GEM* has a modular structure, so it will be possible to integrate a financial sector into the model. Such work is currently under way at the IMF and the Bank of Canada.

Despite the apparent benefits of being able to use *BoC-GEM* to analyze economic developments, economic models are not developed enough to be relied upon exclusively. Consequently, in the short run, an important element of the analysis will be based on monitoring, current analysis, and judgement. However, given the Bank of Canada's comparative advantage in the use of models for policy analysis, we expect that the use of judgement can diminish over time, as we continue to conduct research on financial stability issues. Finally, given that we have a set of risk scenarios, we can the rank the scenarios on the basis of probability.

Step 3: Transmission Channels and Evaluating Impacts

The output of step 2 does not only include drafting risk scenarios, but it also provides a basis for thinking about transmission channels. Transmission channels are mechanisms through which shocks are internationally propagated (asset markets are an example).[16]

[16] See also Bank of England (2006).

Note that the transmission channels depend on the set of risks being considered: e.g., a currency crisis in an emerging market affects Canada differently than an increase in oil demand due to higher global growth. Given the importance of propagation mechanisms, the relevant transmission channels for each shock are jointly assessed by all relevant Bank departments. Given this broad involvement, transmission channels can be considered for all the elements of the Canadian financial system, including banks, equity markets, bond markets, hedge funds, insurance companies, and pension funds.

Also, understanding the transmission channels will help to better inform the process of identifying risks. In this way, the framework, in steady-state, is an inherently iterative process that will evolve over time as we better understand the linkages and transmission channels between the global and Canadian financial systems.

The ultimate aim of the analysis is to deliver quantitative and qualitative estimates of the potential effects of global shocks on the Canadian financial system. Having determined the risk scenarios and appropriate set of transmission channels, departments can jointly assess the implications of international shocks in a variety of ways. Examples include:

- evaluating the potential effects of the scenario on the financial system vis-à-vis reduced form models (i.e. distance to default, the effect on non-performing loans, bank income from fees, etc)
- macro stress-testing.

Given the different focus and expertise of the different departments, close collaboration among them in quantifying the potential impact of risks is an important element in this step.

5 Example: Analysis of the "global liquidity overhang"

To demonstrate how this framework facilitates risk identification and assessment in practice, we apply our methodology to examine a recent event: the reversal of historically low levels of risk premia. In brief, over the past few years, some policymakers were concerned about high levels of global funding liquidity (also called "global liquidity overhang"), which may have been encouraging, or at least facilitating, unduly high levels of financial risk taking.[17] For example, in 2006, the IMF observed that "the long period of ample liquidity in the business cycle has encouraged the search for yield and high risk appetite" (International Monetary Fund, 2006). Thus, if there were a sudden and broad-based reversal in risk premia (as witnessed during the recent turbulence in credit markets) which led to large swings in asset prices and substantial capital losses, there may be risks to the Canadian financial system.

In what follows, we describe how this framework contributes to identifying the risk at an early stage and evaluating its implications. Given that there is little consensus surrounding the issue of "abundant excess liquidity" and its implications for global

[17] We do not offer a precise definition of global liquidity, but it is used here to represent a potential explanation for the existence of historically low risk premia, the ease of funding, and/or high risk appetite on the part of investors.

financial stability, this examples also illustrates the challenges inherent to identification and assessment of international risks.

Step 1: Identifying International Risks

The initial identification of the global liquidity issue arises from several sources. For example, country monitoring noted unusually low spreads and compressed risk premia for many months. Concerns surrounding global liquidity have been noted in several international fora, such as the BIS, G-7, or the IMFC, and global liquidity has been the subject of numerous reports (OECD, BIS, and even private sector institutions such as UBS). And lastly, ongoing economic research into the determinants of capital flows, savings and investment (Desroches and Francis, 2007; Caballero et al., 2006) have identified very high levels of global liquidity. Taken together, all three elements of the identification process have detected signs of possible excess global liquidity, and have pointed to potentially negative consequences of a sharp reversal in risk premia, if the supply of liquidity were to suddenly dry up.

Step 2: Global Financial System and Model Based Analysis for Drafting Scenarios

The risk analysis can be model-based, or vis-à-vis current analysis assessments. Ideally, the risks associated with a reversal of global liquidity would be assessed through a model of the international financial system. In this setup, the model would examine the consequences of reduced liquidity on asset prices and interest rates, and the liquidity of global capital markets. At the current stage, however, the Bank of Canada does not have sufficiently well-developed models of the financial sector to undertake this step.

However, the risk can be assessed through *BoC-GEM* by examining the effects of a change to interest rates and/or risk premia on real variables. As mentioned above, given our lack of financial sector models, it is not clear how large the shock on global risk premia is likely to be if global funding liquidity were to dry up. In order to replicate the effects of a sharp reduction in global liquidity, we introduce a temporary shock to the risky asset by increasing the yield spread between the two bonds by 100 and 300 basis points for the whole world (we also run separate scenarios for each country block).

The effect of the shock to the risk premia in BoC-GEM is propagated in the following manner.[18] In the country block for Canada, as the interest rate increases, and hence the cost of borrowing, investment falls. At the same time, higher interest rates induce consumers to increase savings and reduce consumption. Lower consumption and investment leads to lower demand, and in response, firms reduce production. This leads to lower demand for inputs (namely labour and commodities), a fall in marginal cost, and hence a drop in prices.[19]

[18] It is important to note that agents, both firms and consumers, know the magnitude and persistence of the shock, and optimize accordingly.

[19] The price channel in GEM is marginal cost – i.e. the price level is evaluated in terms of the supply-side. Therefore, a decrease demand does not directly lower prices, but prompts decreases in production, leading to lower marginal cost and hence lower inflation.

The central bank targets core inflation at three quarters in the future. The central bank is credible and fully understands the nature and the persistence of the shocks, and so adjusts the policy rate to bring inflation back to target. This leads to a reduction in the central bank policy rate (monetary policy does not react to the output gap). As inflation returns to target, the policy rate returns to "neutral."

Under this shock, the policy response in Canada is weaker than in the U.S., and thus the UIP condition requires an appreciation of the Canadian dollar vis-à-vis the U.S. dollar (this compares to the fixed exchange rate regime of Emerging Asia, which limits real exchange rate movements). Eventually, when the long-run steady state is reached as a result of policy reaction, the real exchange rate returns to its equilibrium level.

The propagation of the shock in the other country blocks is broadly similar, with investment and consumption, and hence GDP, falling. The notable difference, though, is the impact on Emerging Asia. Due to its exchange rate regime of pegging its currency to the U.S. dollar in the model (and the effective importation of U.S. monetary policy) and falling oil and commodity prices, the impact is more limited. The impact of the fall of world GDP affects Canada through lower commodity and oil prices. Combined with the appreciation of Canada's real exchange rate, this leads to a fall in exports and a deterioration in the trade account, and ultimately lower Canadian real GDP.

The effects of a 100 and 300 basis point increase in the spread between the risk-free and risky asset are presented in Table 3. The impact of the 300 basis point shock on Canada is dramatic, with large decreases in investment, consumption and real GDP. The effect on the U.S. is more muted, but nonetheless significant, with real GDP falling 1% and real interest rates rising 3.6%. In comparison, the impact on emerging Asia is limited.

BOC-GEM provides a rigorous means to assess the impact of a reduction of global liquidity on real side macroeconomic variables. However, the lack of a financial sector in GEM prevents a more detailed analysis of how financial markets might evolve.[20] Nevertheless, the issue could be examined on a more ad hoc basis, with various scenarios of how capital market conditions (quantities and prices) would evolve if the risk materialized. In any case, judgement plays a key role in the process of drafting a risk scenario. This is where additional information from international meetings is helpful, as our own judgment can be contrasted with external views.

Step 3: Transmission Channels and Evaluating Outcomes

Given the risk scenarios, the next step is to explore how the risk is propagated to the Canadian financial system. This analysis of "transmission channels" builds upon our existing understanding of such linkages. Once an understanding has been reached on how the shock is transmitted, the effects can be quantified, or a qualitative assessment can be given. In the context of this example, the GEM simulation allows one to assess the impact on the Canadian financial system of the change in risk premia, vis-à-vis the

[20] To this end, the International Department has initiated research into incorporating a financial sector in to *B0C-GEM.*

shock's impact on Canadian and U.S. real GDP growth, commodity prices, and the change in long-term real interest rates.

Table 3: BOC-GEM simulation results of 100 and 300 basis point interest rate shock
First year average percentage change deviation from control

Country Block	Real Interest Rate	Investment	Consumption	Real Effective Exchange Rate**	Net Foreign Assets	Real GDP
100 basis point shock						
Canada	1.36	-1.40	-0.80	-0.72	-0.25	-0.99
United States	1.25	-0.87	-0.58		-0.48	-0.35
Commodity Exporter	1.25	-1.30	-0.76	-0.58	0.07	-1.12
Emerging Asia	1.00	-0.40	-0.27	-0.04	0.43	-0.06
Remaining Countries	1.40	-0.95	-0.82	-2.09	-0.16	-0.75
300 basis point shock						
Canada	3.96	-4.27	-2.61	-2.37	-0.76	-3.12
United States	3.63	-2.42	-1.71		-1.45	-1.02
Commodity Exporter	3.58	-3.76	-2.56	-1.21	0.42	-3.38
Emerging Asia	2.81	-0.26	-0.79	-0.16	1.26	-0.14
Remaining Countries	4.03	-0.16	-2.63	-6.15	-0.44	-2.33

* All figures are the first year average in percentage deviation from control. **Real effective exchange rate relative to the U.S. dollar.

Having identified the risks and transmission channels, different scenarios (e.g. benign adjustment versus sharp correction) can be assigned probabilities. In this case, one could assign probabilities to different levels of possible interest rate shocks. Then, having assigned probabilities, the assessment of the realized shock on the Canadian financial system can be conducted.

Assessing the Impact of the Shock

There are numerous ways to evaluate the impact of macroeconomic shocks on the Canadian financial system, including stress-testing, reduced form models, scenario

analysis, and distance-to-default models. For example, Misina, Tessier and Dey (2006) stress test the corporate loans portfolio of the Canadian banking sector in relation to a number of macroeconomic shocks (such as changes in U.S. real GDP, real interest rates, and commodity prices). Alternatively, one could utilize a distance-to-default model to assess the impact directly on Canadian banks.[21] One of the difficulties is that the reduced form models may be estimated over benign periods, and thus may not be particularly useful for forecasting stressful periods. Nevertheless, it does provide a template for how this framework could work in practice, and more sophisticated models of the financial sector could be considered.

6 Limitations

We believe that the use of models in the assessment of international risk yields important benefits, as they provide not just an overview of the qualitative impact, but also allow quantification of effects, were the risks to materialize. However, experience with the recent Financial Sector Assessment Program, conducted together with the IMF, has also highlighted a number of limitations. Current DSGE models such as *BoC-GEM* are micro-founded, and assume that individuals and policymakers are forward-looking and behave optimally. This implies that agents adjust their behaviour optimally in response to a shock.

Consequently, when risks are simulated in the models, various channels exist to mitigate adverse economic effects. The fact that the central bank employs a Taylor rule and therefore lowers interest rates in the face of a severe drop of economic output is probably the most obvious example. While we believe that the assumption of optimizing agents is the best way to model individual behaviour, this also implies that modelling a very severe adverse economic shock is not straightforward. This can become an issue when conducting stress tests, as the effects generated by DSGE simulations might not be large enough to severely harm the financial system, making it more difficult to detect potential vulnerabilities.

Put differently, when evaluating the potential effects of a shock, it is important to correctly anticipate the reaction of policymakers. This is how current DSGE models operate. Therefore, when simulating a risk, DSGE models can accurately predict possible consequences, taking into account that agents adjust their behaviour in the face of a shock. At the same time, such re-optimization mitigates the negative consequences of adverse shocks. Macroeconomic stress-testing, however, often relies on simulations of extreme scenarios. Generating such scenarios can require either very strong assumptions about the possible consequences of an adverse economic development, or shutting down policy reactions (such as keeping interest rates fixed, despite the economy going into recession).

[21] Typically, this measure has been applied to non-financial corporates by Moody's[21], but has recently received attention in the context of many central banks' work on financial stability (Cihak 2005). Gropp, Vesala and Vulpes also provide a good description and application of the distance-to-default approach for banks.

7 Conclusion and next steps

This note proposes a framework for identifying and assessing international risks to the Canadian financial system. Often, identification of shocks and risk analysis is not guided by a well-defined, structured process. Instead, risks are analyzed as they arise. This reactive approach does not always make full use of state-of-the-art models to analyze risks, and is not forward-looking. As such, monitoring might not always detect underlying adverse economic developments at an early stage. This is all the more apparent, given that the Bank of Canada has a very rigorous process in place for evaluating risks to the macroeconomic outlook for purposes of monetary policy.

In this study, we have proposed a framework that parallels the monetary policy process. We have outlined the elements of this framework, and illustrated the merits of this approach using the example of the "global liquidity overhang". This specific risk has been discussed in various international fora for several years; yet a comprehensive assessment of how the Canadian financial system could be affected in both a gradual adjustment scenario and in a disruptive scenario is still missing.

It should be emphasized that the framework outlined above is not final; rather, we hope to set out a template for future work. There are many future steps to consider, including:

- Empirical research to determine the relative importance of different channels in assessing the impact of international shocks to the Canadian financial system;
- Development of global financial system models (such as models of contagion, etc.);
- The utilization of real-side models in the evaluation of risk scenarios;
- Development of reduced form models to quantify the impact of realized risk events on the entire financial sector;

As indicated above, our framework yields multiple benefits: first, its structure, and the use of models, adds considerable rigour to our analysis of international risk. Second, it provides a key component for organizing the Bank of Canada's work on financial stability. And lastly, by utilizing the same processes and resources as the monetary policy function, it will ultimately provide a better link between financial system analysis, and monetary policy analysis.

References

Bank of England (2006). Prospects for the UK financial system. *Bank of England Financial Stability Review* 20.

Caballero, R. J., Farhi, E. and Gourinchas, P.-O. (2006). An equilibrium model of `global imbalances' and `low interest rates'. *American Economic Review* forthcoming.

Calvo, G. A. and Reinhart, C. M. (2002). Fear of floating. *Quarterly Journal of Economics* CXVII, 379-408.

Christensen, I., Fung, B. and Meh, C. (2006). Modelling financial channels for monetary policy analysis. *Bank of Canada Review* Autumn, 33-40.

Cihak, M. (2006). How do central banks write on financial stability? *IMF Working Paper* WP/06/163.

Desroches, B. and Francis, M. (2007). World Real Interest Rates: A Global Savings and Investment Perspective. *Bank of Canada Working Paper* 2007-16.

Edwards, S. (2001). Exchange Rate Regimes, Capital Flows and Crisis Prevention. *NBER Working Paper* 8529.

Edwards, S. (2004). Thirty Years of Current Account Imbalances, Current Account Reversals and Sudden Stops. *NBER Working Paper* 10276.

Flood, R. and Rose, A. K. (2005). Estimating the expected marginal rate of substitution: A systematic exploitation of idiosyncratic risk. *Journal of Monetary Economics* 52, 951-969.

Gauthier, C. and St-Amand, P. (2006). Analyzing the Evolution of Financial Instability Risk. *Bank of Canada Financial Sector Review*.

Guillermo A. Calvo, Alejandro Izquierdo and Luis-Fernando Mejia (2004). On the Empirics of Sudden Stops: The Relevance of Balance-Sheet Effects. *NBER Working Paper* 10520.

International Monetary Fund (2006). Financial Market Update.

Issa, R., Lafrance, R. and Murray, J. (2006). The turning black tide: Energy prices and the Canadian dollar. *Bank of Canada Working Paper* 2006-29.

Krugman, P. R. (1979). A Model of Balance-of-Payments Crises. *Journal of Money, Credit & Banking* 11, 311-325.

Macklem, T. (2002). Information and Analysis for Monetary Policy: Coming to a Decision. *Bank of Canada Review* 127, 11-18.

Maria Milesi-Ferretti, G. and Razin, A. (1998). Sharp reductions in current account deficits An empirical analysis. *European Economic Review* 42, 897-908.

Meyer Aaron, Tamara Gomes, Philipp Maier, Eric Santor and Garima Vasishtha (2008). The Foreign Exposures of the Canadian Economy. *Bank of Canada Discussion Paper* forthcoming.

Diagram 1: A process to identify and assess international risk to the financial system