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by H. Evren Damar, Césaire A. Meh and Yaz Terajima

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Abstract

Some evidence points to the procyclicality of leverage among financial institutions leading to aggregate volatility. This procyclicality occurs when financial institutions finance their assets with non-equity funding (i.e., debt financed asset expansions). Wholesale funding is an important source of market-based funding that allows some institutions to quickly adjust their leverage. As such, financial institutions that rely on wholesale funding are expected to have higher degrees of leverage procyclicality. Using high frequency balance sheet data for the universe of banks, this study tries to identify (i) if such a positive link exists between the assets and leverage in Canada, (ii) how wholesale funding plays a role for this link, and (iii) market and macroeconomic factors associated with this link. The findings of the empirical analysis suggest that a strong positive link exists between asset growth and leverage growth, and the use to wholesale funding is an important determinant of this relationship. Furthermore, liquidity of several short-term funding markets matters for procyclicality of leverage.

JEL classification: G21, G28
Bank classification: Financial stability; Financial system regulation and policies; Recent economic and financial developments

Résumé

Certaines données semblent indiquer que la procyclicité du levier des institutions financières contribue à la volatilité globale. Cette procyclicité apparaît lorsque l’expansion des actifs de ces institutions est financée par l’endettement plutôt que par l’émission d’actions. Source importante de mobilisation de fonds sur les marchés, le financement de gros permet à certaines institutions de réajuster rapidement leur levier. En conséquence, on devrait observer plus de procyclicité pour la volatilité des institutions financières qui s’appuient sur ce mode de financement. En utilisant des données à haute fréquence des bilans de l’univers bancaire, les auteurs cherchent à déterminer 1) si cette relation positive entre les actifs et le levier existe au Canada, 2) en quoi le financement de gros joue un rôle dans cette relation, et 3) quels facteurs, macroéconomiques et liés aux marchés, sont associés à cette relation. Il ressort de leur analyse empirique qu’une relation positive étroite unit la croissance des actifs et celle du levier, et que le recours au financement de gros est un déterminant de premier plan de cette relation. En outre, la procyclicité du levier est influencée par le degré de liquidité de plusieurs marchés de financement à court terme.

Classification JEL : G21, G28
Classification de la Banque : Stabilité financière; Réglementation et politiques relatives au système financier; Évolution économique et financière récente

1 Introduction

In the aftermath of the recent financial crisis, the high levels of leverage among financial institutions has widely been identified as one of the major causes of the crisis. This has focused attention on both how financial institutions manage their leverage ratios (defined as assets divided by equity) and on what kind of regulatory actions might be required to prevent the build up of excessive levels of leverage in the financial sector. Given the nature and the severity of the recent financial crisis, leverage has quickly become one of the focal points of both the academic research and policy-oriented discussions related to financial stability.[1]

While the slow build up of leverage over several years among financial institutions is an important issue, some studies also identify the higher frequency movement of leverage as important. In this regard, one major question has been raised: Is leverage procyclical with respect to economic activities? Adrian and Shin (2010) study procyclicality of financial institution leverage in the United States and find evidence that such procyclicality can contribute to aggregate volatility. One channel in which this procyclicality can be observed is when a financial institution actively manages its balance sheet with respect to changes in the value of equity. For example, when the value of equity increases due to a rise in the prices of some marked-to-market assets, the financial institution's leverage ratio decreases. If the financial institution actively manages its balance sheet, it can raise non-equity liabilities and lever back up. In this process, the newly raised liabilities are invested in new assets leading to a positive relationship between changes in leverage and in balance sheet size. As prices of assets tend to increase during booms and decrease during busts, leverage becomes procyclical.

This paper focuses on the interaction of leverage procyclicality with the use of wholesale funding, and how macroeconomic and market environments drive such interactions. The degree of procyclicality is not constant across different types of financial institutions and with respect to the changes in macroeconomic and market environments. Financial institutions that use wholesale funding (e.g., institutional deposits, repos, commercial paper and banker's acceptances) display high degrees of procyclicality as these market-based funds are readily available at short notice for quick adjustments to leverage. However, the crisis disrupted short-term wholesale funding markets, revealing the high funding liquidity risks of these funds. With reduced access to wholesale funding, financial institutions lost the ability to adjust leverage easily and quickly, which dampened the degree of procyclicality.

Specifically, we have two main objectives. First, we show that leverage of Canadian financial institutions is procyclical (i.e., positive correlations between leverage and balance sheet size) and

[1] See Committee on the Global Financial System (2009) for an international policy discussion.

that the degree of procyclicality depends on the usage of wholesale funding. Second, we identify macroeconomic and market variables that are important for the degree of procyclicality. The empirical strategy chosen to achieve these goals is a two-step method, similar to the approach outlined by Kashyap and Stein (2000) in their work on the banking lending channel of monetary policy. The first step cross-sectionally estimates the degree of procyclicality of leverage based on monthly *bank-level* balance sheet data for all federally chartered deposit taking institutions in Canada over the period 1994-2009. The analysis for the first objective is derived from the outcome of this step. Then, the second step tries to determine if and how the degree of procyclicality changes over time following macroeconomic and market-wide changes. The results from this step are used for the discussion of the second objective.

With respect to the first objective, we find strong procyclicality of leverage (i.e., positive relationship between changes in leverage and changes in balance sheet size). In addition, we find significantly higher degrees of procyclicality among financial institutions that use more wholesale funding over those that use less. This confirms the findings by Adrian and Shin (2010) that leverage among U.S. investment banks, who mainly rely on market-based wholesale funding to fund their investment activities, is strongly procyclical. They do not find such leverage procyclicality for commercial banks who rely less on wholesale funding. Secondly, we find that degrees of procyclicality change with liquidity in short-term wholesale funding markets, where market liquidity is measured as either the trading volume or the volume of outstanding instruments. Specifically, for high wholesale funding users, we find that procyclicality is high when the liquidity of the repo and the banker's acceptance markets is also high. As these funding sources are important for high wholesale funding users, when the markets become illiquid, their ability to quickly adjust leverage declines, leading to weaker procyclicality of leverage. This result is also consistent with Brunnermeier and Pedersen (2009) who provide a theory that links market liquidity (i.e., the ease with which an asset is traded) and funding liquidity (i.e., the ease with which funds are obtained) through the margin requirements for financial intermediaries. Since margin requirements for financial institutions to raise funds (e.g., haircuts on collateral and discounts on bank debts) can increase during downturns, available funds for investment decrease, reducing market liquidity. Such market and funding illiquidity would show up as weaker procyclicality of leverage, as the financial institution's ability to adjust leverage and investment declines. We observe weaker procyclicality with illiquid market conditions only for those financial institutions that rely on short-term wholesale funding markets.

Our analysis of the findings leads to several policy discussions. First, Canadian financial institutions we analyze all face a regulatory leverage limit.[2] One may argue that our procyclicality result

[2] The Office of Superintendent of Financial Institutions regulates and supervises federally chartered institutions in Canada.

is an outcome of financial institutions facing the binding leverage limit. When financial institutions attempt to remain at the bound of the leverage limit, any exogenously driven deviation from the limit (e.g., a shock to asset prices or the value of equity) may be met by an endogenous reaction by the financial institutions to return to the pre-shock level, which in the process could enhance procyclical movements. In the first step of the empirical method discussed above, we control for potential effects of the leverage limit on procyclicality. Even after controlling for the regulatory limit, leverage is procyclical. Hence, other regulations may be necessary to control procyclicality. Some of the new regulations under discussion may reduce this procyclicality. For example, in September 2010, the Basel Committee on Banking Supervision (BCBS) has announced a substantial strengthening of existing capital requirements, including potential counter-cyclical capital buffers, where the required capital increases during booms and decreases during busts. Such a regulation would directly reduce leverage procyclicality. In addition, the BCBS has been discussing directly restricting banks' balance-sheet liquidity-risk management. In December 2009, the BCBS has published a consultative report on the framework for liquidity management that can be applied internationally.[3] Moreover, there is a complementary move to build a resilient market infrastructure to stabilize the volatility of these markets.[4] Even in the face of strong procyclicality, if the market is resilient to negative shocks, the severity of market and funding liquidity problems would be reduced.

Secondly, despite the similarity in the procyclicality of leverage between the Canadian financial institutions in the analysis and the U.S. investment banks in Adrian and Shin (2010), most of the Canadian financial institutions in the analysis are *full-service* banks whose business models are quite different from those of the U.S. investment banks. On one hand, it is surprising to find such similarity in procyclicality of leverage between these two different groups of institutions. On the other hand, the severity of this issue may be lower for Canadian banks as they typically hold other less price-sensitive assets and liabilities such as non-securitized loans on the asset side of the balance sheet and retail deposits on the liability side, in contrast to U.S. investment banks that mainly hold securities for trading on the asset side and short-term market-based funding on the liability side. These less price-sensitive instruments could serve as a cushion in downturns.

Our paper is related to several other literatures. Regarding wholesale funding of banks, Haung and Ratnovski (2010) analyze a model with a tradeoff of using wholesale funding vs. retail deposits. On one hand, wholesale funding improves efficiency as wholesale financiers monitor banks. The monitoring incentives of the financiers, however, sensitively depends on the available information set, which could lead to inefficient liquidations. This study is similar to ours in spirit, since it also

[3]See Basel Committee on Banking Supervision (2009).

[4]Such effort is currently underway in Canada. For example, a creation of the central counter party in repo trading is being discussed.

evaluates the decisions and the riskiness of banks under different funding structures (retail deposits vs. wholesale funding). Our study is also related to the literature on the regulation of bank leverage. As mentioned, banks in Canada face regulatory leverage limits; a bank-specific leverage ratio ceiling called the "asset-to-capital multiple" or ACM limit. Blum (2008) provides a theoretical motivation for leverage limits in a world where the supervisor knows that different types of banks (safe vs. risky) exist, but it does not know the actual risk types of banks. In such a setting, asking banks to assess and report their own risks (in a manner similar to Basel II) is not optimal, since risky banks will have an incentive to understate their risks. Blum (2008) shows that having a simple leverage ratio cap along with capital requirements based on banks' internal risk assessments can result in truthful revelations of banks' risk levels. Geanakoplos (2010) theoretically analyzes adverse effects of leverage fluctuations in the environment where leverage is determined in an equilibrium together with interest rates. The paper shows how leverage cycles damage the economy and argues for regulations to control them. Bordeleau, Crawford, and Graham (2009) discuss the historical evolution of regulatory leverage limits in Canada and analyze how large Canadian banks manage leverage with respect to these limits. They find some large banks maintain a buffer between their leverage and the regulatory limit.

The rest of the study is as follows: Section 2 presents some basic balance sheet arithmetic to explain the link between asset growth and leverage growth. Section 3 provides a brief overview of the Canadian banking sector between 1982 and 2009, along with a timeline of regulatory changes, including the introduction and the evolution of the ACM limit. Section 4 presents the data. Section 5 explains the empirical methodology. Section 6 describes the results and Section 7 discusses our robustness checks. Finally, Section 8 concludes.

2 Asset Changes vs. Leverage Changes

Our findings of leverage procyclicality is based on positive correlations between asset changes and leverage changes.[5] In this section, we discuss how such a positive correlation can emerge from a bank actively managing its balance sheet. Furthermore, the basic balance sheet arithmetic below also demonstrates how the strength of leverage procyclicality (i.e. the positive correlation between asset growth and leverage growth) is influenced by the funding sources used by a financial intermediary (wholesale funding vs. retail deposits). Consider the simplified balance sheets for two banks that use different funding sources, where Bank 1 is funded by wholesale funding and Bank 2 by retail deposits:

[5]Bank credits and hence bank's balance sheet sizes tend to increase during booms and decrease during busts.

Bank 1

Assets		Liabilities	
Total Assets	200	Retail Deposits	0
		Wholesale Funding	190
		Equity	10

Bank 2

Assets		Liabilities	
Total Assets	200	Retail Deposits	190
		Wholesale Funding	0
		Equity	10

The leverage ratio of a bank is $L = A/E$, where L is leverage, A is total assets and E is equity. Given these balance sheets, the leverage ratio for both banks is $200/10 = 20$. Now suppose that both the size of the asset portfolio and the amount of equity rises by $2 for each bank. Such an increase in assets and equity could be caused by the bank issuing new equity in order to purchase more assets, or it can be a result of an increase in the price of marked-to-market securities, which gets reflected in the banks' net worth Adrian and Shin (2010). Under both scenarios, the leverage ratio will become $202/12 = 16.83$ for both banks. The result is the following balance sheets:

Bank 1

Assets		Liabilities	
Total Assets	202	Retail Deposits	0
		Wholesale Funding	190
		Equity	12

Bank 2

Assets		Liabilities	
Total Assets	202	Retail Deposits	190
		Wholesale Funding	0
		Equity	12

It is, however, possible that the banks will not remain passive and they will decide to "actively manage" their balance sheets as shown in Adrian and Shin (2010). The banks could attempt to return their leverage ratios to the previous level of 20, which can be done by raising more funds and using these funds to purchase more assets (e.g., securities). Bank 1, with its access to liquid wholesale funding markets, is likely to be able to raise the required funds ($38). On the other hand, since Bank 2 depends exclusively on retail deposits, it will be less able to quickly raise funds, given the "sluggish" nature of retail deposits. Assuming that Bank 2 is only able to raise half of the required funds ($19) in a given period, the balance sheets of these two institutions become:[6]

Bank 1

Assets		Liabilities	
Total Assets	240	Retail Deposits	0
		Wholesale Funding	228
		Equity	12

Bank 2

Assets		Liabilities	
Total Assets	221	Retail Deposits	209
		Wholesale Funding	0
		Equity	12

[6] This assumption features the key difference between wholesale funding and retail deposits.

Now the leverage ratio of Bank 1 is 240/12 = 20, whereas the leverage ratio of Bank 2 is 221/12 = 18.41. Furthermore, if the initial change in the value of equity is the result of an asset price change with marked-to-market accounting, it would affect all banks with the same marked-to-market security on the balance sheet. This initial increase in the asset price could result in a further increase in the price of this security, and the value of the securities might appreciate further, triggering another round of adjustments as described above. This is the "feedback effect" discussed by Adrian and Shin (2010) (or similarly the "spiral effect" by Brunnermeier and Pedersen (2009)) since the increase in the value of the marked-to-marked assets (and the bank's desire to actively manage its balance sheet) is the cause of the adjustment process and the possible spiral that follows.

This example illustrates two things: leverage is procyclical and leverage procyclicality is stronger for banks that use wholesale funding (Bank 1). In the first stage of the example, the change in assets and leverage is identical for both banks: a relatively small increase in assets (1%) leads to a fairly large drop in leverage (approximately 16%). In the second stage, however, both the balance sheet size and leverage increase at a fast rate for Bank 1, since it is able to raise all of the funds required to restore its old leverage ratio. The growth rates for assets and leverage both equal 19%, approximately. On the other hand, assets and leverage grow at a slower pace for Bank 2, since it is unable to raise as many funds as Bank 1. For Bank 2, the growth rates of assets and leverage both approximately equal 9.4%. Given that the growth rates were identical for the two banks in the first stage, it is clear that the correlation between asset growth and leverage growth will be higher for Bank 1 ([1%, -16%], [19%, 19%]) than for Bank 2 ([1%, -16%], [9.4%, 9.4%]). When extended to additional stages, a feedback effect can generate a series of observations which will confirm positive correlations for both banks (i.e., leverage procyclicality) and a higher correlation for Bank 1, the wholesale funded bank. This is solely due to the fact that Bank 1 is able to quickly raise funds to adjust its leverage.[7]

[INSERT FIGURES 1 AND 2 HERE]

Figure 1 shows the scatter-plots of annual leverage growth rate and asset growth rate for all federally chartered Canadian commercial banks between 1994 and 2007 for the U.S. and between 1994 and 2009 for Canada.[8] In this graph, each point corresponds to a bank-year combination. A positive correlation is observed when the points are aligned along a positively sloped line – assets and leverage change in the same direction. The correlation coefficient is 0.734, a highly positive

[7]Intuitively, the correlations would be positive in this example because the contribution from the initial movements in assets and leverage (i.e., a decrease in leverage and an increase in assets, a potential source of negative correlation) is small as the asset change is very small.

[8]Trust and loan companies and commercial banks that were inactive/closed by the end of 2009 are excluded from this graph. They are, however, included in the empirical analysis discussed below.

relationship between changes in assets and changes in leverage. Our study focuses on Canadian financial institutions, however for a comparison, we plot the same graph for selected U.S. commercial banks and savings & loans (S&L) institutions between 1993 and 2007 in Figure 2.[9] The correlation coefficient is 0.212 in the U.S., a much smaller number than for Canada.[10]

Adrian and Shin (2010) present a similar scatter-plot for the average growth rates of assets and liquidity for all U.S. commercial banks between 1963 to 2006. In their graph, however, there is no positive relationship between asset growth and leverage growth. Furthermore, similar scatter-plots presented by Panetta and Angelini (2009) do not show a positive asset growth-leverage growth relationship in Germany, France, Italy and Japan. Interestingly, Panetta and Angelini (2009) do observe a positive relationship between asset growth and leverage growth in the United Kingdom.

3 Canadian Banking Sector

In this section, we provide an overview of important regulatory developments (particularly the "asset-to-capital multiple" or ACM limit) in Canada.[11][12] Following this overview, the empirical analysis presented in Section 4 below will further examine the positive relationship between asset growth and leverage growth in Canada.

3.1 Important Change in Regulatory Environment

An important feature of the Canadian banking sector is that the Bank Act, the legislation that governs banks, includes a requirement for a periodic and formal review process of the rules and regulations regarding financial institutions. This "sunset provision" has led to a number of important legislative amendments since 1980.[13] We discuss one such regulation that is directly relevant for our analysis. The 1987 Amendments to the Bank Act allowed banks, which already could have subsidiaries in the areas of venture capital and mortgage lending, to invest in or own securities

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[9]We include 24 U.S. depository institutions that form an approximate "peer group" of the Canadian commercial banks in Figure 1. The criteria for the construction of this peer list is explained in Appendix A.

[10]Explaining the possible causes of the much stronger positive relationship between asset and leverage growth in Canada (compared to the U.S., and other countries) are beyond the scope of this study. Given our focus on the role of wholesale funding in determining leverage, however, a comparison between wholesale funding use by Canadian and U.S. banks could be desirable. Unfortunately, constructing an "internationally comparable wholesale funding use" measure is very difficult due to a lack of data. See Haung and Ratnovski (2010) and Hadley and Boecher (2007).

[11]The ACM limit is the regulatory definition of the leverage ratio used by the Office of Superintendent of Financial Institutions.

[12]A more elaborate picture of the Canadian banking sector and its regulatory environment is given in Appendix B.

[13]See Allen and Engert (2007).

dealers, and to invest in corporate securities. All of the large and some of the small chartered banks eventually acquired or founded a securities dealer. As a consequence, no large, independent Canadian securities dealers remained by the mid-1990s. Thus, the financial institutions in our analysis can own investment banking subsidiaries. Our data consist of regulatory reports which give consolidated financial information and do not separately provide activities of different divisions and subsidiaries.[14]

3.2 Leverage Ratio Limits and Their Evolution

Another important feature of the Canadian banking sector is the presence of a regulatory leverage ceiling. As discussed by Bordeleau, Crawford, and Graham (2009), Canada is one of the few countries that has had a long-standing limit on leverage ratios. The leverage ceiling, known as the ACM limit, was introduced in 1982, following a period of high leverage ratios among major Canadian banks. Leverage is measured using the following regulatory definition in Canada:

$$\text{Leverage} = \frac{\text{Total balance sheet assets} + \text{Certain off-balance sheet assets}}{\text{Total regulatory capital}}$$

Based on the overview provided by Bordeleau, Crawford, and Graham (2009), the evolution of the ACM limit between 1994 and 2009 can be divided into two distinct periods:

- **1991 to 1999**: During this period a formal ACM limit of 20 was imposed. While the supervisors used their discretionary powers to impose lower limits on smaller and/or newly founded financial institutions, it appears that the leverage ratio restriction was applied quite uniformly at 20 during this period.

  The supervisory bank data used in this study contains the ACM limits for 26 banks and 22 trust and loan companies for the period between 1997 Q4 and 1999 Q4 (ACM limit data is unavailable for the period 1994Q1-1997Q3). Most of the 26 banks had an ACM limit of 20 during the entire period between 1997 Q4 and 1999 Q4 while some banks reported having an ACM limit below 20. Similarly, most trust and loan companies had an ACM limit at 20, while others reported an ACM limit below 20.

[14] This fact puts some of these financial institutions closer to investment banks analyzed in Adrian and Shin (2010). However, the U.S. banks in Figure 2 are also bank holding companies such that some of them own investment banking subsidiaries. The positive correlation is still stronger among Canadian institutions than the U.S. banks.

- **2000 to Today**: After 2000, banks that satisfy a certain set of criteria have been allowed to increase their ACM limit to as high as 23. The standard ACM limit of 20 is still maintained, although the regulators can (and do) apply a lower ACM limit to certain institutions.

  The available data suggest that there was much less uniformity in the ACM limits set on individual banks during this period. Currently, ACM limit data exists for 23 banks and 29 trust and loan companies for the period 2000 Q1 and 2009 Q4. Of these, the majority of banks reported having an ACM limit of 20 during the entire period. Several banks had a limit above 20 for at least part of the period, while some banks reported a limit below 20 for the entire period. Among the trust and loan companies, about half of them had a limit of 20 during the entire period. Other trust and loan companies reported a limit below 20 at least once and/or a limit above 20 for at least part of the period. Overall, it appears that the ACM limit was more variable during this period compared to 1991-1999, with more financial institutions having a leverage ratio limit either above or below the standard limit of 20.

In their study of regulatory leverage constraints in Canada, Bordeleau, Crawford, and Graham (2009) argue that the major Canadian banks do not like to operate too close to their limit. Instead, these banks tend to keep a "leverage buffer" in order to minimize the risk of balance sheet volatility (such as trading activity) pushing leverage above the limit. The presence of such a buffer between a bank's leverage and its leverage limit can play a role in determining the link between asset growth and leverage growth. This issue will be further discussed below.

4 Data

The bank balance sheet data used in this study comes from the Tri-Agency Database System (TDS) of the Bank of Canada, Office of the Superintendent of Financial Institutions (OSFI) and the Canadian Deposit Insurance Corporation (CDIC). The TDS database contains the monthly balance sheet and off-balance sheet information, along with the quarterly income statement information, reported by financial institutions. Although there exist data going back to January 1981, some series did not begin until after 2000, while other series were terminated and/or replaced to accounting rule changes. As a result, only certain broad measures can be tracked across the entire sample period such as: total assets, total equity, retail deposits, wholesale deposits, total loans and total securities. Most of the subitems under these broad categories become available only much later than 1981. This imposes some constraints on the design of the empirical analysis, which will be discussed below. Nevertheless, TDS is an extensive database and it has the advantage of providing balance sheet data at a higher frequency than the data used in other studies in the literature. This study uses data that covers the period January 1994 to December 2009.

Although TDS provides data on a universe of 224 domestic banks, foreign bank subsidiaries, foreign bank branches and trust and loan companies (active or inactive), some of these institutions had to be eliminated from the study. The foreign bank branches that were established in Canada following the regulatory changes in 1999 had to be eliminated, since they do not report any equity (making it impossible to calculate their leverage ratio). Also, banks and trust and loan companies that are fully owned subsidiaries of a chartered bank or a trust and loan company were also eliminated, since their parent institution already reports a consolidated balance sheet.[15] The remaining 136 Canadian financial institutions form the sample that was used in the study. Overall, the data set contains 12,949 bank-month combinations.

The bank-level balance sheet data is also supplemented by macroeconomic and market-wide variables, such as GDP growth rate, and market liquidity measures. These variables were all obtained from the "Bank of Canada Banking and Financial Statistics."[16]

5 Empirical Analysis: Methodology

As discussed above, the goals of this study are (i) to identify the link between leverage growth and asset growth among Canadian financial institutions, (ii) to determine how this link interacts with banks' funding (specifically their use of wholesale funds) and (iii) to examine whether shocks in wholesale funding markets affect the leverage growth-asset growth relationship. The empirical strategy chosen to achieve these goals is a two-step method, similar to the approach outlined by Kashyap and Stein (2000) in their work on the banking lending channel of monetary policy and subsequently used by Campello (2002) and Certorelli and Goldberg (2008).

In broad terms, the outline of the two-step approach is as follows: in the first step, the sensitivity of leverage growth to asset growth, i.e., the *degree* of leverage procyclicality, ($\partial\Delta\text{Leverage}/\partial\Delta\text{Assets}$) is cross-sectionally estimated using *bank-level* balance sheet data only. Then, the second step of the analysis tries to determine if and how these sensitivities change over time following macroeconomic and market-wide liquidity shocks, i.e., *changes* in the degree of procyclicality over time. Therefore, only *macroeconomic and market-wide financial variables* are used in this second step.

[15]However, if a bank or a trust and loan company operated independently any time between 1994 and 2009 before being acquired, then it was included in the sample for the period during which it was an independent entity. There were 13 such cases.

[16]Available at http://www.bankofcanada.ca/en/bfsgen.html.

As discussed above, while identifying the link between leverage growth and asset growth, the degree of heterogeneity among Canadian banks' funding portfolios also needs to be considered.[17] It is possible that banks with access to liquid wholesale funding markets can adjust their leverage ratios more quickly, compared to banks that rely on illiquid funding sources (such as retail deposits) or equity, which can be more costly to raise. Accordingly, Canadian banks were categorized based on how much wholesale funding they use. "Wholesale funding use" of a bank is thereby defined as:

$$\%\text{WSF} = \frac{\text{Non-personal deposits} + \text{Repos} + \text{Banker's Acceptances}}{\text{Total Liabilities} + \text{Equity}}$$

Using this definition, Canadian banks can be divided into three categories: (a) high degree of wholesale funding users–High WSF, (b) low degree of wholesale funding users–Low WSF, and (c) banks that don't use wholesale funds–No WSF. The latter category contains banks that are entirely funded by equity.[18] For banks that do use wholesale funding, the median of the %WSF ratio was calculated for each month, and banks above (below) the median were placed in the High WSF (Low WSF) group. This categorization was individually performed for each of the 192 months in the sample (January 1994 to December 2009).

Such a categorization naturally raises the issue of a bank's "access" to wholesale funding markets vs. its "use" of such funds. Specifically, a bank that chooses not to raise any wholesale funds would be in the No WSF group along with a bank that has no access to wholesale funding markets. The former bank, however, can decide at any time to access wholesale funding markets, switching either to the Low WSF or High WSF group. The patterns in the data, however, suggest that banks do not frequently change their intensity of wholesale funding use. Table 1 presents a simple "transition matrix" showing the probability of a bank remaining in the same category vs. switching to a different category between time t and $t+1$. As seen from this transition matrix, switches between categories is a relatively rare event: out of a total of 12,949 bank-month combinations, there are only 604 cases where a bank switches categories between t and $t+1$. As such, the concerns related to frequent switches between categories appear to be alleviated for the Canadian case.[19]

[INSERT TABLE 1 HERE]

[17] From this point on, the term "bank" will be used to represent both trust and loan companies, and chartered banks.

[18] The sample does contain a few instances where a bank is 100% equity funded.

[19] As the threshold level of wholesale funding use changes over time, this categorization captures the macroeconomic and market-wide movements fairly well. It is this reason that many banks stay in the same category with high probabilities.

Table 2 below presents some summary statistics for the entire sample of banks, along with different groups of banks based on their wholesale funding use. In addition to the number of banks, summary statistics for leverage, leverage growth (ΔLeverage) and asset growth (ΔAssets) are also presented. The variation in the number of banks within the No WSF group during the sample period is due to the nature of the data set. TDS does not contain balance sheet data for trust and loan companies before January 1996. Since most of the No WSF banks are trust and loan companies, their absence from the data set during the January 1994 - December 1995 period causes the No WSF category to have very few observations. Once the trust and loan companies enter the data set in January 1996, most of this variation is eliminated. The summary statistics in Table 2 suggest that "non-user" banks have lower leverage ratios compared to the rest, but the leverage behaviour of the High WSF and Low WSF banks are similar. Although the average monthly rates of change in assets and leverage are smaller than $\pm 1\%$, there is some variation both within and between different groups of banks, which is what we elaborate on below in the empirical analysis.

[INSERT TABLE 2 HERE]

Finally, Table 3 provides an average balance-sheet portfolio of all banks and for each wholesale funding group in December, 2009. The numbers are un-weighted averages as percentage of total assets across banks. The average bank has half of its assets in loans and the rest in cash, securities and others. On the funding side, two-thirds of assets are funded by non-equity funding, retail deposits, wholesale funding and others. Across wholesale funding groups, note that the percentage of wholesale funding increases with its "use" by design. The average bank in the High WSF group funds 57% of assets by wholesale funding. For the Low WSF group, wholesale funding makes up only 9% of total assets. Retail deposits are the important source of funding for the Low WSF group, amounting to 58% of total assets. The No WSF group tends to finance assets mostly by equity, on average 61% of total assets. Loans make up most of the asset side for High and Low WSF banks with 59% and 61% of total assets, respectively. The High WSF group owns a much higher fraction of riskier non-mortgage loans than safer mortgage loans (46% and 17%, respectively) relative to the Low WSF group (26% and 35%, respectively). The average No WSF bank holds relatively more cash and government bonds which are generally the most liquid assets. Among assets that are subject to the market price risk, there are private sector securities and derivative related securities. The High and Low WSF groups have 11% and 7% of their total assets, respectively, in these securities.

[INSERT TABLE 3 HERE]

5.1 Empirical Analysis: First Step

In the *first step* of the empirical analysis, we run two sets of regressions. The procyclicality of leverage is analyzed for all banks together in the first set and for three groups in the second. These two sets of regressions are independently run for *each month* and shown below as Equation 1 for all banks and Equation 2 for analyzing wholesale funding groups, respectively:

$$\begin{aligned} \Delta \ln(\text{Leverage})_{i,t} &= \psi \\ &+ \alpha_1 \cdot \Delta \ln(Assets)_{i,t} \\ &+ \alpha_2 \cdot \ln(ACM\ Limit)_{i,t} \\ &+ \alpha_3 \cdot Liquid_{i,t} \\ &+ \alpha_4 \cdot Merger_{i,t} \\ &+ \alpha_5 \cdot \ln(Leverage)_{i,t-1} + \epsilon_t, \end{aligned} \tag{1}$$

$$\begin{aligned} \Delta \ln(\text{Leverage})_{i,t} &= \psi_1 + \psi_2 \cdot Low_{i,t} + \psi_3 \cdot No_{i,t} \\ &+ \beta_1 \cdot \Delta \ln(Assets)_{i,t} \\ &+ \beta_2 \cdot \Delta \ln(Assets)_{i,t} \cdot Low_{i,t} \\ &+ \beta_3 \cdot \Delta \ln(Assets)_{i,t} \cdot No_{i,t} \\ &+ \beta_4 \cdot \ln(ACM\ Limit)_{i,t} \\ &+ \beta_5 \cdot Liquid_{i,t} \\ &+ \beta_6 \cdot Merger_{i,t} \\ &+ \beta_7 \cdot \ln(Leverage)_{i,t-1} + \epsilon_t, \end{aligned} \tag{2}$$

where $Leverage_{i,t} = (\text{Assets}_{i,t}/\text{Total Regulatory Capital}_{i,t})$ and $Assets_{i,t}$ is the total balance sheet assets of bank i at time t. This *first step* regression is very similar to the regressions run by Adrian and Shin (2010), since the dependent variable is the growth rate of leverage, and both the lagged leverage ratio (in logs) and the growth rate of assets are included as independent variables. However in Equation 2, in order to account for heterogeneity in the link between leverage and asset growth among banks, $\Delta\text{Log}(Assets_{i,t})$ is also interacted with the wholesale-funding-use group dummies, where the High WSF group is the omitted category.[20]

The first step regressions given in Equations 1 and 2 also include a number of control variables.

[20] The presence of the interacted terms in Equation 2 requires the inclusion of the "wholesale funding use category" dummies by themselves in the regression as well.

A bank with a liquid asset portfolio might be more likely to increase its leverage ratio, since it would be able to quickly sell assets if it were unable to refinance some of its debt in the future. Therefore, $Liquid_{i,t} = (\text{Securities owned}_{i,t}/\text{Assets}_{i,t})$ is included in the first step regression as a control variable. $Merger_{i,t}$ is a dummy variable that takes the value one if the bank was involved in a merger or acquisition during the previous six months, since such activity is likely to impact leverage.

The final independent variable is $ACM\ Limit_{i,t}$, which is the leverage ratio ceiling placed on a bank at time t. As discussed above, the data used in this study does not contain information on the ACM limits of individual banks for 1994Q1 - 1997Q3, and for the period between 1997Q4 and 2009Q4, ACM limits are observed only for some banks. In order to include the ACM limit in the first step regression, the missing ACM limit data was generated using a simple regression procedure. This procedure, which is explained in more detail in Appendix B, involves regressing the ACM limits observed in the data set on a number of bank-specific variables and using the regression coefficients to generate fitted values for the missing ACM limits.

The estimation of Equations 1 and 2 separately for each month involves running 192 individual regressions per equation. The estimated coefficients for $\Delta\text{Log}(Assets)_{i,t}$ and its interactions are then used as dependent variables in the second step regression discussed below. In this setting, α_1 from Equation 1 measures the correlation between leverage and asset growth for all banks combined. In addition, β_1 from Equation 2 is the correlation between leverage and asset growth for high wholesale funding users, whereas $(\beta_1 + \beta_2)$ and $(\beta_1 + \beta_3)$ capture this relationship for the low wholesale funding users and no wholesale funding users, respectively. In essence, the first step of the analysis generates the estimates of a separate time series of $(\partial\Delta\text{Leverage}/\partial\Delta\text{Assets})$ for all banks combined and for each wholesale funding group, with 192 observations in each time series.

5.2 Empirical Analysis: Second Step

This second step involves the estimation of the following time series regression, separately, *for all banks combined and for each WSF group*:

$$\begin{aligned}
\xi_{j,t} = \eta \quad &+ \quad \sum_{q=0}^{1} \theta_{1q} \cdot \Delta \ln(Repo)_{t-q} + \sum_{q=0}^{1} \theta_{2q} \cdot \Delta \ln(BA)_{t-q} + \sum_{q=0}^{1} \theta_{2q} \cdot \Delta \ln(CP)_{t-q} \\
&+ \quad \sum_{q=0}^{1} \theta_{3q} \cdot \Delta Default_{t-q} + \sum_{q=0}^{1} \theta_{4q} \cdot \Delta Term_{t-q} \\
&+ \quad \sum_{q=0}^{1} \theta_{5q} \cdot \Delta \ln(\mathit{TSX\ Fin}_{t-q}) + \sum_{q=0}^{1} \theta_{6q} \cdot \Delta \ln(GDP)_{t-q} \\
&+ \quad \theta_7 \cdot \mathit{Overnight\ Rate}_t + \theta_8 \cdot \mathit{Year\ End}_t + \epsilon_{j,t},
\end{aligned} \tag{3}$$

where j represents the different groupings of Canadian banks: $j = 1$ for all banks and $j = 2,\ 3$ and 4 based on their wholesale funding use, high, low and non, respectively. $\xi_{j,t}$ is constructed from the estimates in the first step such that $\xi_{1,t} = \alpha_{1,t}$, $\xi_{2,t} = \beta_{1,t}$, $\xi_{3,t} = \beta_{1,t} + \beta_{1,t}$, and $\xi_{4,t} = \beta_{1,t} + \beta_{1,t}$. As discussed above, the second step of the empirical analysis only uses macroeconomic and market-wide financial variables in order to estimate the relationships between these variables and the *changes in the degree* of leverage procyclicality. Some of these variables contain information on market and funding liquidity, which could play an important role in determining the asset growth - leverage growth relationship. As shown in the balance sheet examples above, the procyclicality of leverage is influenced by how easily a bank can raise funds (funding liquidity) and how easily assets can be purchased or sold (market liquidity). The log change in the total volume of transactions in the repo market ($\Delta \ln(Repo)$) and the log change in the amount of outstanding banker's acceptances ($\Delta \ln(BA)$) control changes in funding liquidity. Meanwhile, the log change in the total amount of outstanding corporate short-term paper ($\Delta \ln(CP)$) captures changes in market liquidity.[21] All three of these variables are normalized by the money supply (M2), in order to capture relative changes in the size of repos, banker's acceptances (BA) and commercial paper (CP) markets relative to the more "traditional" source of funding, namely money. If the BA, CP and repo markets are growing faster than the money supply, this can be a signal of "market-based financial intermediaries" playing a larger role in financial intermediation.[22] As such, these variables are of particular interest in the second step of the analysis.[23] A final measure of liquidity is the change in the spread between the 3

[21] Separating outstanding commercial paper volumes into asset-backed vs. not asset-backed commercial paper can be illustrative; unfortunately, such disaggregated data is not available.

[22] Adrian, Moench, and Shin (2010) find that the security broker-dealer (who relies on market-based funding) leverage growth is one of the important variables in predicting excess returns and that balance sheet variables of these institutions also provide information about future real economic activities.

[23] Liquidity in BA and CP markets can be also be measured by their bid-ask spreads, since a liquid (illiquid) market will be more likely to have smaller (larger) bid-ask spreads. Although bid-ask spread data is available for Canadian BA and CP markets, including these variables along with, or instead of, the volume-based measures discussed above does not yield major changes in the findings.

to 5 year Canadian Treasury rate and the 3 to 5 year corporate bond rate ($\Delta Default_t$). An increase in this "default spread" might indicate a flight to quality and lower liquidity in the corporate bond markets.

The liquidity risk faced by Canadian banks is partially captured by the change in the slope of the yield curve. $\Delta Term$ is change in the spread between the Canadian government bonds with a maturity of 10 years or more and the 3-month Canadian Treasury Bill. Given that inflation expectations are anchored at 2% by the inflation targeting monetary policy in Canada, a steepening of the yield curve will create opportunities for banks to borrow short-term funds and invest in long-term assets. Banks that follow this strategy can be expected to have a large and positive asset growth-leverage growth sensitivity, since the new assets would be purchased by debt. Furthermore, if many banks choose to pursue this strategy, this could result in the value of long-term securities to increase, which could potentially be a trigger for the "feedback effect" discussed by Adrian and Shin (2010). The obvious downside of this balance-sheet management approach is the liquidity risk that the bank may not be able to rollover its short-term debt before the returns on the long-term assets are realized. In addition, in order to capture the cost of raising equity, log changes in the Toronto Stock Exchange Financial Index ($\Delta \ln(\textit{TSX Fin})$) are included. If the financial stocks are on an upward trend, then the cost of raising equity may be lower, compared to debt, weakening the link between leverage and asset growth.

Furthermore, the monthly growth rate of GDP ($\Delta \ln(GDP)$) is included in the second step, since higher growth rates could reduce the costs of rolling over short-term debt, resulting in more assets being purchased by debt. Under this scenario, higher rates of GDP growth will strengthen the asset growth-leverage growth relationship in the Canadian banking sector. The status of monetary policy is captured by *Overnight Rate*, which is the overnight rate targeted by the Bank of Canada. Finally, *Year End* is a dummy variable that takes the value of one for the months of October and December. October marks the end of the fiscal year for some Canadian banks while other banks use December. It is possible that banks may choose to de-lever before the end of the fiscal year, independent of their asset portfolio. If so, then leverage growth can be less sensitive to asset growth towards the end of the fiscal year.[24]

Before we present the results, it is necessary to discuss why this particular method was chosen. The obvious alternative to the two-step procedure is to nest Equation 3 into Equation 2 (or

[24] As seen in Equation 3 , the first lag of all independent variables (except *Year End* and *Overnight Rate*) are included in the analysis as well. Studies such as Campello (2002) tend to include longer lags, but unfortunately since some of the data is unavailable for before January 1994, including additional lags places a burden on both the number of observations and degrees of freedom.

Equation 1) and run a panel regression. Kashyap and Stein (2000) and Campello (2002) discuss the benefits of the two-step methodology that allows for a different shock to have an impact on leverage in each month. Therefore, it becomes less likely that the results of the first step (coefficients of $\Delta \text{Log}(Assets)_{i,t}$ and its interactions) are influenced by unobserved factors. For example, the two-step procedure is able to account for a shock that leads to an increase in the leverage ratios of all banks in a given month. Furthermore, if Equation 3 is nested into Equation 2, then this would force the variables in Equation 3 to effect leverage growth in a linear fashion, creating a more restricted structure. Finally, the two-step approach allows for the link between asset growth and leverage growth (i.e., the degree of procyclicality) to vary across time. Given the relatively long time-span of this study, it is reasonable to assume that the relationship between leverage and asset growth have changed over time. Some evidence of the coefficients of $\Delta \text{Log}(Assets)_{i,t}$ and its interactions varying across time will be presented below, further validating the two-step approach. However, the two-step approach has its disadvantages. As discussed by Kashyap and Stein (2000), a two-step specification tends have lower statistical power compared to a one-step method. Therefore, results of a one-step, panel data specification that nests Equation 3 into Equation 2 will also be discussed below as a robustness check.

6 Results

6.1 First Step Results

As discussed above, the first step of the analysis involves the estimation of Equations 1 and 2 for each month.[25] During the estimation, in a manner similar to Campello (2002), observations where $|\Delta \ln(Leverage_{i,t})| \geq 66\%$ and/or $|\Delta \ln(Assets_{i,t})| \geq 66\%$ were eliminated. This ensures that the results are not driven by outliers. Furthermore, the first six months of observations after an entry and the last six months of observations before an exit were eliminated, since the periods immediately following an entry or immediately preceding can involve large swings in assets and equity. The number of observations in each regression varied between 54 and 75 banks, as shown in Table 2.

While analyzing the first step results, three important questions need to be answered: (i) What is the relationship between leverage growth and asset growth in the Canadian banking sector (or is there procyclicality of leverage)? (ii) Does the relationship differ by the wholesale funding use of a bank (or does the degree of procyclicality differ by groups)? (iii) Does the relationship between leverage growth and asset growth evolve over time (or does the degree of procyclicality change over

[25] We correct for heteroscedasticity in these estimations.)

time)?[26]

[INSERT TABLE 4 HERE]

Table 4 summarizes the results of the coefficient estimates. The table shows the mean and the variance of 192 sets of the estimated coefficients in Equations 1 and 2 for all banks and wholesale funding groups, respectively. As discussed above, we focus on the estimates of α_1, β_1, $\beta_1 + \beta_2$, and $\beta_1 + \beta_3$, and hence we mainly discuss these results. We interpret the estimated results of α_1, β_1, $\beta_1 + \beta_2$, and $\beta_1 + \beta_3$ in Table 4 as follows. For all banks, when assets change by 1%, leverage changes by 0.833% in the same direction on average across time. Among High WSF banks, leverage changes by 0.933% with the asset change of 1%, whereas leverage of Low WSF and No WSF banks change by 0.786% (= 0.933 − 0.146) and 0.661% (= 0.933 − 0.272), respectively. As these are all positive numbers, leverage and assets move together, i.e., leverage is procyclical. Furthermore, as the wholesale funding use increases, leverage and assets move more closely to each other (i.e., the number becomes closer to 1), implying that the *degree* of procyclicality increases with the wholesale funding use.[27]

[INSERT FIGURE 3 HERE]

The variance column for wholesale funding groups in Table 4 shows that the variance of these 192 estimated parameters decrease with the wholesale funding use. Figure 3 visually shows this. The figure contains kernel density estimates based on 192 estimates of α_1 on the left panel, and β_1, $\beta_1+\beta_2$, and $\beta_1+\beta_3$ on the right panel. We observe a long left tail in all figures, implying that in some months assets and leverage moved in opposite directions. As seen in Section 2, this happens through passive balance sheet management or alternatively when asset purchases are funded by equity. On the right panel in Figure 3, we also observe that the estimates of β_1 (i.e., for High WSF banks) show less variation than those of $\beta_1 + \beta_2$ (i.e., for Low WSF banks), and the estimates of $\beta_1 + \beta_3$ (i.e., for No WSF banks) show the most variation among three groups.

[26] The answer to this question would justify the two-step approach, which allows for the coefficients of $\Delta \ln(Assets)_{i,t}$ and its interactions to vary across time.

[27] Another potentially important determinant of leverage growth in the Canadian banking sector is the ACM limit. The mean of the coefficient estimate on $\ln(ACM\ Limit)$ in Table 4 suggest that the ACM limit seems to have some positive impact on how banks adjust their leverage. When $\ln(ACM\ Limit)$ increases by one unit, the average increase in leverage is about 0.015% under both Equations 1 and 2. The "buffer" that some banks keep between their actual leverage ratios and the leverage ceiling (as discussed by Bordeleau, Crawford, and Graham (2009)) is a possible explanation for this finding. If most banks keep such a buffer, then they would be able to increase their leverage with their balance sheet size without worrying about violating their ceiling. In times of decreasing leverage in the banking sector, it is natural that the ceiling has no impact on the (negative) rate of leverage growth. This may be a reason that the 192 estimates of the coefficient of $\ln(ACM\ Limit)$ display high volatility over time in both equations, i.e., the high variances relative to the means in Table 4.

Tables 5 and 6 further summarize the main findings of the first-step regressions and provide some answers to the evolution of leverage growth-asset growth sensitivities over time. Table 5 presents the mean of the estimated leverage growth-asset growth sensitivities (i.e., the degree of leverage procyclicality) for all banks and each wholesale funding group, during the entire sample period, as well as during two sub-sample periods (the 1990s and 2000s). Also presented are statistical tests comparing the means and variances of the estimated sensitivities for the *same* category across *different* time-periods.[28]

[INSERT TABLE 5 HERE]

The analysis of the two sub-periods in Table 5 suggests the asset growth-leverage growth link weakened over time, especially, for banks that use little or no wholesale funding. This observation is confirmed by the tests comparing the mean sensitivities across different time periods. The null hypothesis of equal means across different sub-periods is rejected for these banks. Furthermore, for the Low WSF group, the null hypothesis of the estimated coefficients $(\beta_1 + \beta_2)$ having equal variance across time is also rejected. This time-variation in the means and the variances of the estimated coefficients across time for all three categories confirms the benefits of the two-step approach over the one-step approach.

Table 6 presents comparisons of mean leverage growth-asset growth sensitivities across different wholesale funding use categories for different periods. The comparisons confirm differences in the leverage growth-asset growth link across the different groups over the entire sample period, and especially during the 2000s. As seen on Panel B of Table 6, the differences between the mean sensitivities of the three groups were not as significant during the 1990s, suggesting that most of the divergence occurred sometime during the 2000s. Whether these changes were due to macroeconomic or financial shocks will be the focus of the second step of the empirical analysis. Nevertheless, the big differences between the High WSF group and the other two groups are not very surprising. Based on the balance sheet examples discussed above, the link between asset growth and leverage growth is likely to be stronger for banks that are able to change their leverage ratio quickly. Banks that access wholesale funding markets can raise or retire debt more quickly, since the wholesale funding markets tend to be more liquid compared to retail deposit markets in normal times.[29]

[28] Since the number of no wholesale funding user banks is very small during January 1994 and December 1995, the estimated coefficients for these 24 months are mostly driven by movements in the leverage ratios of one or two banks. As a result, the asset growth-leverage growth sensitivities for this group are not taken into consideration in Tables 5 and 6.

[29] The significant variations across these different groups of Canadian banks also validate the inclusion of the wholesale funding use interactions in the first step of the analysis.

[INSERT TABLE 6 HERE]

In summary, the first step of the analysis suggests that the relationship between leverage growth and asset growth in the Canadian banking sector (a) is positive, i.e., leverage is procyclical, (b) is dependent on wholesale funding use of banks, i.e., the degree of procyclicality increases with wholesale funding use, and (c) has evolved over time. Specifically, during the 1990s, changes in leverage ratios of all Canadian banks were relatively more procyclical and sensitive to changes in balance sheet size (as seen in Table 5, mean sensitivities are higher than 0.85 for all three categories during this sub-period). There was a divergence in the 2000s, caused by the weakening of the asset growth-leverage growth relationship among banks that use little or no wholesale funding. Changes in leverage ratios of banks that use high levels of wholesale funding, however, continued to be very sensitive to changes in balance sheet size. It is possible that the asset growth-leverage growth correlations have a negative time trend, due to the expansion of non-intermediated funding markets reducing the traditional growth opportunities of banks (such as commercial loans) and limiting balance sheet growth rates. However, for the high wholesale funding banks, the development of wholesale funding markets and the use of these funds may have given them new growth opportunities and kept them from lowering the sensitivities relative to other banks. In the second step, we analyze these possibilities.

6.2 Second Step Results

The second step of the empirical analysis investigates the macroeconomic and market-wide variables associated with the change in the degree of leverage procyclicality of Canadian banks over time. This involves the time-series estimation of Equation 3 separately for each bank group: All, High WSF, Low WSF and No WSF banks.

The results of the second step analysis are given in Table 7 below. These result strongly suggest that both funding and market liquidity matter for the change in the degree of leverage procyclicality in the Canadian banking sector. For example with all banks, the degree of leverage procyclicality increases when the liquidity of both the repo and the BA markets contemporaneously increases (i.e., the positive and significant coefficient of $\Delta \ln(Repo)$ and $\Delta \ln(BA)$). Specifically, as the repo market transaction volume increases by 1%, the co-movement of leverage and assets (measured by the estimated coefficients of $\Delta \ln(Assets)$ in Equation 1) increase by 0.0019, and similarly by 0.0197 for an 1% increase in the outstanding BA. In addition, the default and term spreads seem to be important for the degree of leverage procyclicality (i.e., the significant coefficient of $\Delta Default$ and $\Delta Term_{-1}$). With an increase in default risks, the degree of leverage procyclicality decreases, weakening the link between leverage and assets. This can be intuitive if the observed leverage-assets link arises out of the greater risk-taking behaviour by banks. A lagged term spread increase tends to occur with an increase in the leverage procyclicality. A higher term spread may create an increased incentive to hold greater maturity mismatches by purchasing long-term assets with short-term debts, leading to a stronger positive link between leverage and assets. Finally, an increase in the overnight rate coincides with a higher degree of procyclicality. As discussed below, No WSF banks appear to drive this result.

Regarding the results on different wholesale funding groups, changes in liquidity in the repo market (as measured by turnover) have positive and significant coefficients for both high and low WSF banks. This finding confirms Adrian and Shin (2010), who argue that the active management of a financial institution's balance sheet requires frequent access to repo markets. This is especially true for U.S. investment banks, whose asset growth-leverage growth relationship is highly positive. The positive and significant coefficient of $\Delta \ln(Repo)$ suggests that more liquid repo markets make it easier for wholesale funding users to take positions in financial markets, perhaps fueling the "feedback effect" of Adrian and Shin (2010) to take place in some parts of the Canadian banking sector.

For the High WSF group, the asset growth-leverage growth relationship is also stronger (more positive) when the BA market is more liquid, due to an increase in the amount of outstanding BA. In Canada, large and established banks use BA as an important source of funding. As most of such banks likely belong to the high wholesale funding group, the result is reasonable. Meanwhile, the growth rate of outstanding CP has a positive and significant coefficient for the Low WSF group. Increased liquidity in CP or BA markets can signal easier access to asset and funding markets for these institutions, which can then be used to purchase assets, leading to higher procyclicality. Alternatively, higher turnover can also cause an appreciation in the value of the CP held by Low WSF banks, which can trigger the "feedback effect" discussed by Adrian and Shin (2010). Taken together, the coefficients for $\Delta \ln(Repo)$, $\Delta \ln(BA)$, and $\Delta \ln(CP)$ point to easier access to wholesale funds (i.e. when the markets are more liquid) resulting in more assets being financed with debt and a higher correlation between asset growth and leverage growth.

[INSERT TABLE 7 HERE]

The impact of macroeconomic factors on the asset growth-leverage growth relationship is limited among the No WSF group. The asset growth-leverage growth relationship is positive with respect to GDP for this group. Additionally, the overnight rate has a positive and significant coefficient. The positive coefficients of $\Delta \ln(GDP)$ and *Overnight Rate* could both be capturing easier access to retail deposits and an abundance of growth opportunities during a booming economy. Finally, the

No WSF banks tend to reduce their leverage procyclicality (and liquidity risk) towards the end of the fiscal year.

Overall, the second step of the analysis suggests that the degree of leverage procyclicality among Canadian banks is significantly impacted by liquidity-related macroeconomic and market-wide variables. Liquidity in the repo, BA and CP markets plays at least some role in determining the magnitude of this relationship, depending on the degree of wholesale funding use. For both High WSF and Low WSF banks, the repo market matters. Since these banks might be pursuing active trading strategies, their ability to use repo markets to take trading positions can have an impact on their leverage behaviours. The CP and BA markets also may determine the asset growth-leverage growth relationship, since borrowing funds for asset purchases are more likely to take place in these markets.

7 Robustness Checks

7.1 Noise and outliers in "first step" results

One concern related to the "two-step" methodology is that the dependent variables used in the second-step may contain noise (or sampling variation). Given that our sample is smaller than of Kashyap and Stein (2000) or Campello (2002), it is possible that some of the coefficients estimated in the first-step (i.e. degrees of procyclicality) contain noise, which in turn, reduces the significance of the second-step regressions.

This concern is addressed by transforming the outliers among the first-step coefficients, which can reduce the degree of variability and limit the presence of noise in the second-step. As seen in the distributions of these estimated coefficients in Figure 3, such extreme values are almost always on the left-side of the distribution. Accordingly, the transformation of the outliers is achieved by a one-sided "winsorising", where all the observations below the 5^{th} percentile is set at the 5^{th} percentile. Then the second-step regressions are re-estimated using these transformed dependent variables. The results are given in Table 8 below.

[INSERT TABLE 8 HERE]

The findings in Table 8 are quite similar to those in Table 7, which suggests that the results are not driven by outliers or noise.[30] The significance levels of the regressions somewhat improve with the transformation of the outliers, although it is clear that winsorising the dependent variable does not eliminate all of the noise associated with the first-step regressions.

7.2 Panel regression for the "first step"

Another way of dealing with the issue of potential noise in the first-step coefficients would be to take advantage of the panel nature of our data. A comparison of the coefficients obtained from a single panel regression to the mean of the first-step coefficients given in Table 4 can help determine whether the findings of the two-step methodology are driven by noise/outliers or not.

Accordingly, the first-step equations given in Equations 1 and 2 were estimated using bank-level fixed effects. Similar to the criteria used in the initial first step regressions, outliers with $|\Delta \ln(Leverage_{i,t})| \geq 66\%$ and/or $|\Delta \ln(Assets_{i,t})| \geq 66\%$, and banks with fewer than 40 observations were eliminated. The results of these fixed-effects regressions are given in Table 9 below.

[INSERT TABLE 9 HERE]

The results of the first-step panel regressions are broadly in line with the earlier findings discussed above. High wholesale funding using banks have a significantly higher degree of procyclicality compared to the other two groups. The coefficient estimates are also close to the mean regression coefficients reported in Table 4 as well, especially for the high- and low-wholesale funding use groups. Overall, these panel regressions seem to confirm the findings of our two-step methodology.

7.3 A "One-Step" Panel Data Approach

As discussed above, an alternative approach to the "two-step" methodology of Kashyap and Stein (2000) is to nest the second step equation (Equation 3) into the first step (Equation 2).[31] This "one-step" approach will take advantage of the panel nature of the data and may have more statistical power. Therefore, this specification can serve as a useful robustness check.

[30]One notable exception is the result regarding the overnight rate. The sign of the coefficient changes for No WSF banks from positive in Table 7 to negative in Table 8.

[31]Alternatively, we could nest Equation 3 into Equation 1, however we focus on the analysis of wholesale funding groups in our robustness checks.

In specifying the one-step model, attention needs to be paid to the nature of the dependent variable. As discussed above, the main goals of this study are to determine the correlation between asset growth and leverage growth in Canadian banking sector, and to examine whether this correlation depends on banks' funding portfolios. Accordingly, the dependent variable for the one-step specification needs to reflect the correlation between asset growth and leverage growth for each bank at each time period. Based on this need, the dependent variable was specified as:

$$y_{i,t} = \frac{(\Delta \ln(\text{Assets})_{i,t} - \mu_{\Delta A}) * (\Delta \ln(\text{Leverage})_{i,t} - \mu_{\Delta L})}{SD_{\Delta A} * SD_{\Delta L}}$$

where $\mu_{\Delta A}$ is the mean asset growth rate and $\mu_{\Delta L}$ is the mean leverage growth rate. Similarly, $SD_{\Delta A}$ and $SD_{\Delta L}$ represent the standard deviations of the asset growth rate and leverage growth rate, respectively. These means and standard deviations can be calculated either (i) across banks for each time period (for time t across all i), or (ii) across time periods for each bank (for bank i across all t).[32]

Using this dependent variable, the following equation can be estimated, where the main variables of interest are interacted with wholesale funding use dummies:

[32]This specification of the dependent variable is intuitively motivated from the formula for sample correlations: $\frac{\sum_{i=1}^{n}(a_i-\bar{a})(b_i-\bar{b})}{(n-1)SD_a SD_b}$ for two random variables, a and b, where n is the sample size. The dependent variable is one element of the summation in this formula. Hence, this specification would allow us to interpret how the right-hand-side variables effect the correlation between changes in leverage and assets.

$$
\begin{aligned}
y_{i,t} &= \psi_i + \psi_1 \cdot Low_{i,t} + \psi_2 \cdot No_{i,t} \qquad (4)\\
&+ \gamma_{11} \cdot \Delta \ln(Repo)_t + \gamma_{12} \Delta \ln(Repo)_t \cdot Low_{i,t} + \gamma_{13} \Delta \ln(Repo)_t \cdot No_{i,t}\\
&+ \gamma_{21} \cdot \Delta \ln(BA)_t + \gamma_{22} \Delta \ln(BA)_t \cdot Low_{i,t} + \gamma_{23} \Delta \ln(BA)_t \cdot No_{i,t}\\
&+ \gamma_{31} \cdot \Delta \ln(CP)_t + \gamma_{32} \Delta \ln(CP)_t \cdot Low_{i,t} + \gamma_{33} \Delta \ln(CP)_t \cdot No_{i,t}\\
&+ \gamma_{41} \cdot \Delta Default_t + \gamma_{42} \Delta Default_t \cdot Low_{i,t} + \gamma_{43} \Delta Default_t \cdot No_{i,t}\\
&+ \gamma_6 \cdot \Delta Term_t + \gamma_7 \cdot \Delta \ln(TSX\ Fin)_t\\
&+ \gamma_{71} \cdot \Delta \ln(GDP)_t + \gamma_{72} \Delta \ln(GDP)_t \cdot Low_{i,t} + \gamma_{73} \Delta \ln(GDP)_t \cdot No_{i,t}\\
&+ \gamma_{81} \cdot \Delta Overnight\ Rate_t + \gamma_{82} \cdot \Delta Overnight\ Rate_t \cdot Low_{i,t} + \gamma_{83} \cdot \Delta Overnight\ Rate_t \cdot No_{i,t}\\
&+ \gamma_{91} \cdot Year\ End_{i,t} + \gamma_{92} \cdot Year\ End_{i,t} \cdot Low_{i,t} + \gamma_{93} \cdot Year\ End_{i,t} \cdot No_{i,t}\\
&+ \omega_1 \cdot \Delta \ln(Leverage)_{i,t-1} + \omega_2 \cdot \Delta \ln(ACMLimit)_{i,t} + \omega_3 \cdot Merger_{i,t} + \epsilon_{i,t}
\end{aligned}
$$

In Equation 4, the variables with the γ coefficients are for the macroeconomic/market-wide variables, whereas the ω coefficients are for the bank-level variables. ψ_i is a bank-specific effect. As the dependent variable can be calculated in two ways, this equation was estimated under two methodologies. First, the means and standard deviations of ln(Leverage) and ln(Assets) were calculated for each bank across time and Equation 4 was estimated using a random-effects specification. Then, the means and standard deviations were calculated for each time period, across all banks and Equation 4 was estimated using a fixed-effects specification (both of these choices were confirmed by Hausman tests). Banks with less than 40 observations were dropped from the sample in each case. To ensure that the findings are not driven by outliers, dependent variable observations in the 1st and 99th percentiles of the two distributions were winsorised.

[INSERT TABLE 10 HERE]

The results of the two different one-step specifications, which are presented in Table 10, are broadly in line with the findings of the two-step analysis discussed above. The asset growth-leverage growth correlations are higher for High WSF banks, since $Low_{i,t}$ and $No_{i,t}$ have negative coefficients (except for $No_{i,t}$ in (ii)). Furthermore, liquidity in funding markets still matters for the asset growth-leverage growth link, since liquidity, especially, in the BA market has significant coefficients for High and Low WSF groups in both specifications. Although the findings in Table 7 and 10 do not exactly match, the general conclusions of the two-step analysis concerning the impact of wholesale funding use and liquidity on Canadian banks' leverage behaviour are confirmed.[33]

8 Conclusion

We study the extent of procyclicality of leverage in the Canadian banking sector. The study is motivated by the theory developed by Brunnermeier and Pedersen (2009) and empirically studied in Adrian and Shin (2010) that a link exists between funding liquidity and market liquidity through financial institutions' balance-sheet management. Our analysis utilizes a variation of the two-step empirical estimation method first proposed by Kashyap and Stein (2000). We use monthly balance sheet data covering almost two decades and we establish that leverage is highly procyclical among Canadian financial institutions. This link depends on banks' use of wholesale funding markets and it has evolved over time. The degree of procyclicality among banks that are more dependent on wholesale funding is higher, e.g., leverage rises more rapidly as assets increase. Furthermore, the gap in the degree of procyclicality between high wholesale funding users and the rest of the banking sector has grown larger during the 2000s. We then investigate macroeconomic and market-wide variables associated with leverage procyclicality and its divergence between different wholesale funding groups. This "second step" of the empirical analysis suggests that leverage becomes more procyclical during times of increased liquidity in repo, BA and CP markets.

The current regulation in Canada places a limit on the leverage ratio. This regulation is designed to prevent excessively high leverage but does not directly control the change in leverage. Given that procyclicality of leverage could lead to aggregate volatility, our findings imply that this current leverage regulation may not adequately address potential consequences of market and funding liquidity risks. Other regulations, such as those being discussed in the Basel Committee on Banking Supervision, that enforce counter-cyclical capital holdings and directly restrict banks' balance-sheet liquidity-risk management may have a potential in addressing this issue. However, the consideration of the potential costs of such regulations needs to be taken into account.

In this study, we document and highlight an important issue (i.e., procyclicality of leverage) in the Canadian financial sector. Important questions still remain. Why do Canadian banks behave similarly to U.S. investment banks even though their business models are very different? The search for potential causes of this observation is left for future research. Insights into this question would contribute in the designing of new financial sector regulations. This line of research would also help

[33]The only major differences between the findings of the two-step vs. the one-step analysis are that $\Delta \ln(Repo)_t$ does not have a positive and significant coefficient (for the High WSF group) and that none of the CP market-related coefficients are statistically significant.

to further our understanding of the behaviour of complex financial institutions that are the focus of recent regulatory reforms.

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Figure 1: Annual change in assets and leverage in Canada (1994-2009).

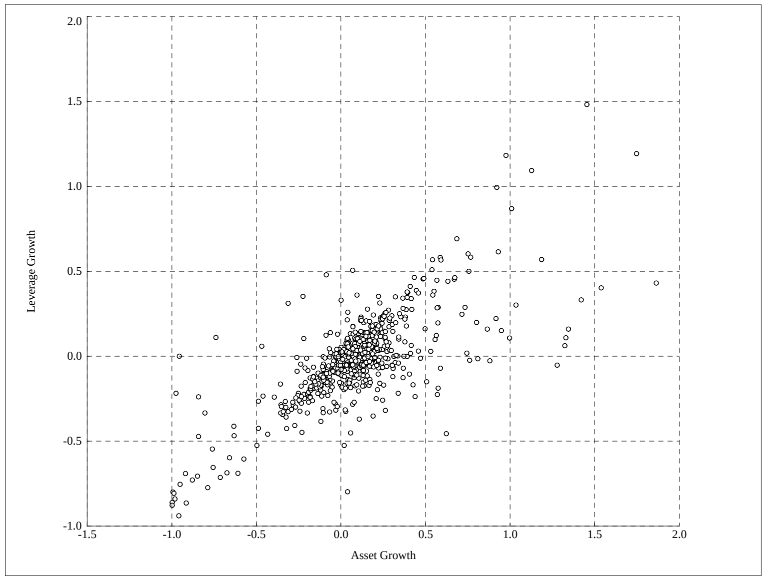

Figure 2: Annual change in assets and leverage in the U.S. (1994-2007).

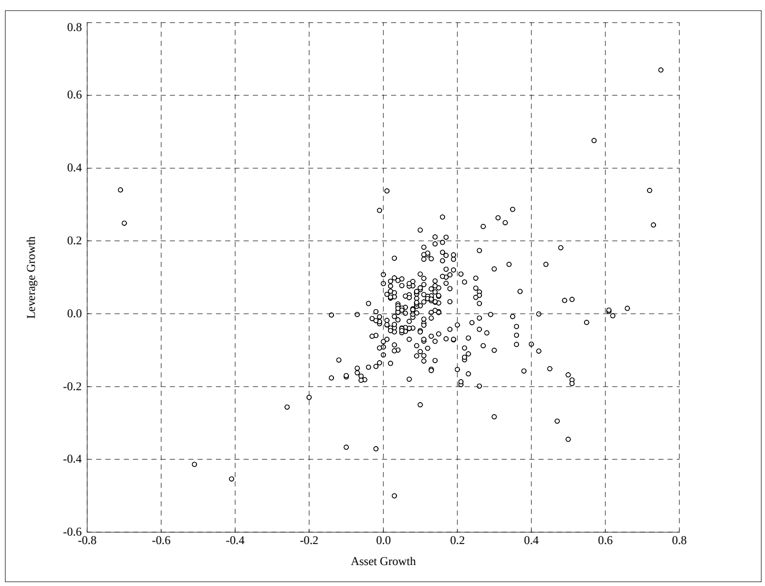

Figure 3: Kernel Density Estimates of α_1 from the regression model (1) on the left panel; and β_1 (High WSF), $\beta_1 + \beta_2$ (Low WSF) and $\beta_1 + \beta_3$ (No WSF) from the regression model (2) on the right panel.

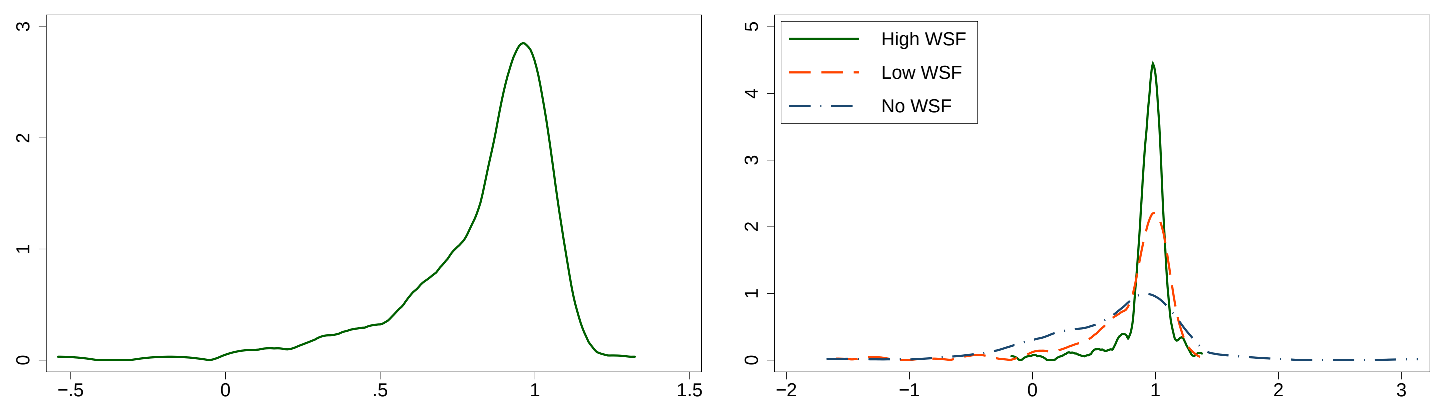

Table 1: "Transition matrix" showing switching patterns of banks among the different wholesale funding use categories.

	Group at $t+1$		
Group at t	High WSF	Low WSF	No WSF
High WSF	96.29%	3.51%	0.2%
Low WSF	3.56%	94.22%	2.22%
No WSF	0.05%	3.84%	96.11%

Table 2: Summary statistics for all banks in the sample and each individual group of banks.

	Mean	Median	Std. Dev.	Min	Max
All Banks					
# of banks	67.44	69	4.04	54	75
Leverage	9.33	9.40	5.38	0.96	24.15
ΔLeverage	-0.001	0.00	0.09	-0.66	0.63
ΔAssets	0.006	0.004	0.08	-0.63	0.65
High WSF					
# of banks	26.59	26	3.69	20	33
Leverage	10.56	9.93	4.47	1.58	24.15
ΔLeverage	-0.003	0.002	0.10	-0.62	0.63
ΔAssets	0.004	0.006	0.09	-0.62	0.64
Low WSF					
# of banks	26.06	25.5	3.65	19	32
Leverage	10.749	11.57	4.71	1.00	23.75
ΔLeverage	0.0004	0.001	0.08	-0.64	0.63
ΔAssets	0.009	0.007	0.07	0.63	0.65
No WSF					
# of banks	14.79	13	7.97	1	30
Leverage	4.57	1.30	5.30	0.96	22.92
ΔLeverage	-0.0004	0.00	0.07	-0.66	0.60
ΔAssets	0.004	0.002	0.07	-0.60	0.59

Table 3: Average balance-sheet portfolios for each individual group of banks in percentage of total assets, December 2009.

	All Banks	High WSF	Low WSF	No WSF
Total Assets	100	100	100	100
Cash	24	19	19	33
Loans	47	59	61	25
Mortgage	21	17	35	14
Non-mortgage	25	42	26	11
Securities	19	18	15	24
Public Sector	12	7	7	20
Private Sector	5	6	5	4
Derivative Related	2	5	2	0
Other Assets	10	4	6	17
Total Liabilities	67	89	80	39
Retail Deposit	35	21	58	28
Wholesale Funding	19	57	9	0
Other Debts	13	11	13	12
Equity	33	11	20	61

Table 4: Summary of the 192 individual first-step regression results. Means and variances for all coefficients except "$\Delta(Assets) \cdot No$" are calculated across the 192 individual regressions. The mean and variance of "$\Delta(Assets) \cdot No$" does not include the 24 estimated coefficients for the years 1994 and 1995, since this group had very few banks during this period.

	All Banks		WSF Groups	
Variable	Mean	Variance	Mean	Variance
$\Delta \ln(Assets)$	0.833	0.062	0.933	0.039
$\Delta(Assets) \cdot Low$			-0.146	0.205
$\Delta(Assets) \cdot No$			-0.272	0.335
$\ln(Leverage)_{-1}$	-0.005	0.0001	-0.006	0.0001
$\ln(ACM\ Limit)$	0.014	0.021	0.015	0.028
$Liquid$	0.005	0.003	0.008	0.004
$Merger$	-0.003	0.0004	-0.002	0.0003
Low			-0.0004	0.0002
No			-0.010	0.005

Table 5: Summary of first step regression results, continued. Mean (μ) and variance (σ^2) for the estimated leverage growth-asset growth sensitivities are reported for the entire sample period and two sub-periods. The last two rows present tests for the equivalence of the means (μ) and variances (σ^2) of the estimated coefficients for the same category but across different subperiods. $H_0 : \sigma^2_{90} = \sigma^2_{00}$ reports the chi-squared test statistic for a Bartlett's test for equal variance across the two sub-periods. $H_0 : \mu_{90} = \mu_{00}$ reports the results of a F* test for the equality of the sub-sample means (robust to $\sigma^2_{90} \neq \sigma^2_{00}$). The mean leverage growth-asset growth sensitivities for the No WSF group do not include the estimated coefficients for 1994 and 1995, since this group had very few banks in it during this period. *** is significant at 1% and ** represents significance at 5%.

	All	High WSF	Low WSF	No WSF
Mean (μ)				
Whole Sample (μ_{whole})	0.833	0.933	0.786	0.654
1990s (μ_{90})	0.930	0.952	0.872	0.915
2000s (μ_{00})	0.774	0.921	0.735	0.550
Variance (σ^2)				
Whole Sample (σ^2_{whole})	0.062	0.039	0.193	0.319
1990s (σ^2_{90})	0.023	0.029	0.078	0.257
2000s (σ^2_{00})	0.076	0.045	0.256	0.309
$H_0 : \sigma^2_{90} = \sigma^2_{00}$	13.79***	4.41**	26.84***	0.549
$H_0 : \mu_{90} = \mu_{00}$	25.36***	1.23	5.90**	16.74***

Table 6: Comparison of mean leverage growth-asset growth sensitivities across different size categories for (i) the entire sample and (ii) two sub-sample periods. The differences in the mean sensitivities are calculated as "Column i - Row j" and a Welch's t-test is performed with the null hypothesis of "Mean difference = 0" (robust to unequal sample variances). The mean difference tests involving the No WSF group only include observations from January 1996 and onwards, since this group had too few banks in it prior to January 1996. *** is significant at 1% and ** is significant at 5%.

Panel A: Entire Sample	Low WSF	No WSF
High WSF	0.146***	0.272***
Low WSF		0.117**
Panel B: The 1990s		
High WSF	0.080**	0.028
Low WSF		-0.053
Panel C: The 2000s		
High WSF	0.186***	0.370***
Low WSF		0.184***

Table 7: Second-step regression results. Heteroscedasticity and autocorrelation corrected Newey-West (one lag) standard errors. The regression for the No WSF group includes estimated asset growth-leverage growth sensitivities from January 1996 and onwards only. *** is significant at 1%, ** and * are significant at 5% and 10% respectively.

	All Banks		High WSF		Low WSF		No WSF	
Variable	Coef	S. E.	Coef	S. E.	Coef	S. E.	Coef	S. E.
$\Delta \ln(Repo)$	0.190**	0.085	0.173**	0.077	0.331**	0.144	0.004	0.227
$\Delta \ln(Repo)_{-1}$	0.104	0.064	-0.050	0.066	0.025	0.122	0.192	0.139
$\Delta \ln(BA)$	1.197**	0.562	0.183	0.414	0.585	1.226	0.116	1.338
$\Delta \ln(BA)_{-1}$	0.363	0.517	0.662*	0.381	0.637	1.025	-1.695	1.081
$\Delta \ln(CP)$	0.0911	0.624	-0.262	0.439	-0.678	1.165	1.260	1.586
$\Delta \ln(CP)_{-1}$	0.656	0.529	-0.263	0.345	3.118*	1.654	-1.418	1.155
$\Delta Default$	-0.137*	0.0707	-0.0509	0.059	-0.290**	0.130	-0.060	0.191
$\Delta Default_{-1}$	-0.019	0.059	-0.020	0.058	-0.058	0.111	-0.006	0.204
$\Delta Term$	-0.075	0.049	-0.085	0.057	-0.135	0.089	-0.151	0.157
$\Delta Term_{-1}$	0.085**	0.042	0.039	0.032	0.154*	0.081	-0.023	0.190
$\Delta \ln(TSX\ Fin)$	-0.545	0.350	-0.221	0.229	-0.800	0.608	-0.367	0.799
$\Delta \ln(TSX\ Fin)_{-1}$	0.0709	0.366	-0.140	0.258	-0.042	0.644	0.519	0.892
$\Delta \ln(GDP)$	0.043	0.038	0.033	0.032	-0.049	0.067	0.069	0.100
$\Delta \ln(GDP)_{-1}$	0.027	0.043	-0.053	0.036	-0.056	0.077	0.249**	0.099
Overnight Rate	0.026**	0.010	0.012	0.009	0.014	0.020	0.058*	0.035
Year End	-0.025	0.061	0.060	0.050	0.013	0.105	-0.549***	0.174
No. of obs.	190		190		190		168	
F-Stat	2.53***		1.56*		1.62*		2.50***	

Table 8: Second-step regression results with the dependent variables winsorised at the 5th percentile (one-sided). Heteroscedasticity and autocorrelation corrected Newey-West (one lag) standard errors. *** is significant at 1%, ** and * are significant at 5% and 10% respectively.

	All Banks		High WSF		Low WSF		No WSF	
Variable	Coef	S. E.	Coef	S. E.	Coef	S. E.	Coef	S. E.
$\Delta \ln(Repo)$	0.142**	0.069	0.128**	0.055	0.240**	0.102	0.075	0.194
$\Delta \ln(Repo)_{-1}$	0.083	0.056	-0.067	0.052	0.019	0.104	0.224*	0.129
$\Delta \ln(BA)$	0.695*	0.421	-0.154	0.329	0.257	0.723	-0.043	1.154
$\Delta \ln(BA)_{-1}$	0.253	0.436	0.576*	0.330	0.474	0.707	-1.471	0.968
$\Delta \ln(CP)$	0.293	0.499	-0.123	0.391	-0.314	0.939	1.856	1.530
$\Delta \ln(CP)_{-1}$	0.670	0.462	-0.121	0.286	1.962	1.209	-0.342	1.071
$\Delta Default$	-0.130**	0.064	-0.024	0.046	-0.263**	0.106	0.144	0.148
$\Delta Default_{-1}$	-0.013	0.052	0.017	0.042	-0.047	0.091	0.223	0.160
$\Delta Term$	-0.064	0.045	-0.061	0.038	-0.103	0.072	-0.044	0.123
$\Delta Term_{-1}$	0.074*	0.038	0.029	0.029	0.108*	0.065	0.133	0.121
$\Delta \ln(TSX\ Fin)$	-0.563*	0.291	-0.178	0.180	-0.640	0.454	0.0003	0.806
$\Delta \ln(TSX\ Fin)_{-1}$	0.153	0.318	-0.021	0.191	-0.053	0.469	0.990	0.919
$\Delta \ln(GDP)$	0.036	0.033	0.038	0.026	-0.015	0.051	0.081	0.032
$\Delta \ln(GDP)_{-1}$	0.025	0.042	-0.042	0.028	-0.012	0.065	0.233***	0.082
Overnight Rate	0.023**	0.009	0.005	0.007	0.006	0.014	-0.048*	0.028
Year End	-0.005	0.051	0.049	0.039	0.016	0.078	-0.408***	0.118
Observations	190		190		190		190	
F-stat	2.76***		1.66*		1.93**		2.68***	

Table 9: Fixed-effects panel regression for the first-step (all banks and banks grouped according to wholesale funding use). Arbitrary serial correlation and heteroscedasticity-robust standard errors are reported. *** is significant at 1%, ** and * are significant at 5% and 10% respectively.

	All Banks		WSF Groups	
Variable	Coef.	S. E.	Coef.	S. E.
$\Delta \ln(Assets)$	0.816***	0.046	0.928***	0.014
$\Delta \ln(Assets) \cdot Low$			-0.113**	0.047
$\Delta \ln(Assets) \cdot No$			-0.493***	0.157
$ACM\ Limit$	-0.006	0.009	-0.003	0.009
$Liquid$	-0.004	0.009	-0.002	0.011
$Merger$	-0.014**	0.006	-0.015**	0.007
$\ln(Leverage_{-1})$	-0.014***	0.003	-0.016***	0.004
Low			-0.005**	0.002
No			-0.011**	0.005
Bank-specific Effects	Fixed		Fixed	
No. of observations	12,293		12,293	
No. of banks	103		103	

Table 10: One-step panel regression results, using the wholesale funding grouping for banks. Arbitrary serial correlation and heteroscedasticity-robust standard errors are reported. Dependent variable for (i) uses means and standard deviations across all banks for each time t. Dependent variable for (ii) uses means and standard deviations across all time for each bank i. *** is significant at 1%, ** and * are significant at 5% and 10% respectively.

	(i) Across Banks		(ii) Across Time	
Variable	Coef	S. E.	Coef	S. E.
$\Delta \ln(Repo)$	-0.086	0.101	-0.055	0.093
$\Delta \ln(Repo) \cdot Low$	0.230 *	0.128	0.217 *	0.112
$\Delta \ln(Repo) \cdot No$	0.140	0.182	0.136	0.154
$\Delta \ln(BA)$	2.438 **	1.108	1.714 ***	0.628
$\Delta \ln(BA) \cdot Low$	-3.837 ***	1.148	-2.190 **	0.852
$\Delta \ln(BA) \cdot No$	-2.645 **	1.247	-1.509	1.000
$\Delta \ln(CP)$	0.267	2.139	-0.417	1.167
$\Delta \ln(CP) \cdot Low$	1.273	2.317	0.883	1.406
$\Delta \ln(CP) \cdot No$	0.747	2.245	-0.255	1.380
$\Delta Default$	0.135	0.129	0.004	0.067
$\Delta Default \cdot Low$	-0.137	0.161	-0.055	0.102
$\Delta Default \cdot No$	-0.228	0.165	-0.235 **	0.105
$\Delta Term$	0.011	0.061	-0.113 ***	0.039
$\Delta \ln(\textit{TSX Fin})$	0.151	0.300	-0.110	0.245
$\Delta \ln(GDP)$	-0.019	0.092	-0.035	0.062
$\Delta \ln(GDP) \cdot Low$	0.116	0.114	0.121	0.090
$\Delta \ln(GDP) \cdot No$	0.008	0.124	0.131	0.092
Year End	-0.069	0.105	0.273 ***	0.093
Year End $\cdot$ *Low*	0.014	0.125	0.039	0.126
Year End $\cdot$ No	-0.067	0.194	-0.152	0.200
Overnight Rate	-0.123 ***	0.033	-0.034 **	0.016
Overnight Rate $\cdot$ *Low*	0.185 ***	0.046	0.070 ***	0.026
Overnight Rate $\cdot$ No	0.109 **	0.052	0.028	0.039
$\ln(Leverage_{-1})$	0.274 *	0.152	0.025	0.047
Liquid	-0.044	0.278	0.003	0.120
$\ln(\textit{ACM Limit})$	0.107	0.382	0.086	0.174
$Merger$	0.163	0.270	0.076	0.183
Low	-0.814 ***	0.212	-0.355 ***	0.121
No	-0.862 ***	0.320	-0.255	0.176
Bank-specific Effects	Fixed		Random	
No. of observations	12,457		12,457	
No. of banks	103		103	

Appendix

A Details of the "Peer List" of U.S. Financial Institutions

In order to construct the peer list, the Canadian commercial banks that were active as of 2009 Q2 were divided into separate categories based on (a) ownership criteria (domestic vs. foreign), (b) business lines (retail, wholesale, investment banking, etc.) and (c) geographic scope (nationwide, regional, online only, etc.). It should be stressed here that this peer list should not be considered an exhaustive or comprehensive list of U.S. peers of Canadian banks. The goal of this exercise was to make very basic comparisons of the asset growth-leverage growth relationship in the U.S. vs. Canadian banking sectors.

While constructing these categories, the six major Canadian banks (the "Big Six") were considered to be in a category by themselves. Furthermore, a list of U.S. bank holding companies (BHCs) that are the likeliest U.S. peers for the Big Six has already been constructed by Allen, Engert, and Liu (2006). This list of 11 U.S. BHCs was supplemented by the addition of Citigroup.

The peers of non-U.S. foreign banks subsidiaries operating in Canada are represented by the subsidiaries of the same banks operating in the U.S. The peer for the small, specialized subsidiaries of U.S. banks operating in Canada is the U.S. subsidiary of Caisses Desjardins, which is the largest cooperative credit institution in Canada.[34]

The peers of domestically-owned Canadian regional banks were determined by a criteria of geographical concentration, as opposed to assets or number of branches. Peers of the remaining variety of Canadian banks that operate primarily through online banking and ABM networks, and credit cards-only banks were determined solely according to their specialized lines of business. The complete list of the U.S institutions chosen and the categories they represent are given below. Balance sheet data for these peer institutions were obtained from BankScope and the Financial Institutions Examination Council's (FFIEC) Uniform Bank Performance Reports (UBPR).

[34] Although Caisses Desjardins is not included in this study as a Canadian financial institution, its subsidiary in the U.S. is a good example of a small (three branch) foreign bank subsidiary concentrating on a niche business (financial needs of Canadian retirees in the state of Florida). In this sense, it is more representative of the small, niche U.S. bank subsidiaries in Canada than the large Canadian bank subsidiaries in the U.S., such as TD Banknorth or Harris Bank. Of course, since the U.S. subsidiaries in Canada concentrate on investment (and not retail) banking, Desjardins Bank should not be considered as a perfect substitute.

Table 11: List of U.S. peer institutions and their corresponding categories.

Category	Canadian Example(s)	U.S. Peer(s)
Big Six	BMO; CIBC; National Bank; RBC; ScotiaBank; TD-Canada Trust	Bank of America; Citigroup; U.S. Bankcorp.; FifthThird Bancorp.; JP Morgan Chase; National City Corp.; Wachovia Corp.; Wells Fargo & Co.; PNC Financial Services Group; Keycorp.; SunTrust Banks Inc.; BB&T Corp.
Domestic-owned Regional Banks	Canadian Western; Laurentian Bank	M&T Bank Corporation; Sterling Savings Bank
Non-U.S. Foreign Subsidiaries	HSBC Canada; ING Direct; Bank of East Asia; Bank of Tokyo-Mitsubishi UBS Bank Canada	HSBC USA, NA; ING Bank; Bank of East Asia, USA, NA; Bank of Tokyo-Mitsubishi; UBS Bank (USA)
U.S Foreign Subsidiaries	JP Morgan (Canada); Citibank Canada	Desjardins Bank NA
Domestic-owned Retail Banks	Citizens Bank of Canada; President's Choice Bank; Manulife Bank of Canada;	First Internet Bank of Indiana; Bank of Internet; E*TRADE Bank
Credit Card Only Banks	Canadian Tire Bank	Target National Bank

B Regulatory Environment of Canadian Financial Sector

It can be argued that the Canadian banking sector has always had a relatively stable structure. Historically (prior to 1980), the financial system had five pillars: chartered banks, trust and loan companies, securities dealers, co-operative credit institutions, and life insurance companies. Of these, federally chartered banks were historically involved in commercial lending, whereas trust and loan companies specialized in collecting term deposits and making residential mortgage loans. Co-operative credit institutions, which are chartered and regulated by the provinces, have traditionally concentrated on retail deposits, residential mortgages and personal loans (Freedman, 1998).

Due to nationwide branch banking arrangements, the sector has always been dominated by a few very large banks. Currently, around 88.5% of all banking sector assets are held by six large banks, known as the "Big Six."[35] A number of smaller foreign or domestically-owned banks provide competition to these six very large banks in certain geographic areas or lines of business. For example, a few smaller regional banks are very active in Western Canada and Quebec, while a few internet-only banks provide competition for small retail deposits. Finally, according to Hardy (2009), foreign owned banks compete with the Big Six in investment banking. Therefore, the Canadian banking sector can be characterized as having a dominant core and a competitive fringe.

Another important feature of the Canadian banking sector is that the "Bank Act", which is the legislation that governs banks, includes a requirement for a periodic and formal review process of the rules and regulations regarding financial institutions. This "sunset provision" has led to a number of important legislative amendments since 1980 (Allen and Engert, 2007). The regulatory changes that are of particular interest to this study, are briefly highlighted below.[36]

- **1987 Amendments:** These amendments allowed banks, which already could have subsidiaries in the areas of venture capital and mortgage lending, to invest in (or own) securities dealers and to invest in corporate securities. All of the very large and some of the smaller chartered banks eventually either acquired or founded a securities dealer. As a consequence, no large, independent Canadian securities dealers remained by the mid-1990s.
- **1992 Amendments:** Chartered banks were allowed to own trust companies and enter the insurance business. These amendments and the weak financial condition of the trust industry,

[35] They are: Bank of Montreal (BMO), Canadian Imperial Bank of Commerce (CIBC), National Bank, Royal Bank of Canada (RBC), ScotiaBank, TD-Canada Trust.

[36] It should be stressed here that the following is not an exhaustive list of bank regulation changes, but only those that are relevant to this study. This discussion draws heavily from Freedman (1998) and Allen and Engert (2007).

caused an wave of acquisitions, where most trust companies were purchased by chartered banks. Despite the 1987 and 1992 amendments, Canadian banks did not become fully universal banks, since investments in non-financial businesses continued to be restricted.

- **1999:** Although not mandated by the "sunset clause", these regulatory changes allowed foreign banks to open branches in Canada without having to establish a subsidiary. Foreign branches, however, were strictly limited in raising retail deposits.

- **2002 Amendments:** Chartered banks were allowed to own finance companies.

- **2005**: New accounting rules concerning marked-to-market accounting were introduced. Banks were required to recognize securities held for trading or available for sale at fair value. Securities being held to maturity were required to be valued at cost.

C Estimation of the "Missing" ACM Limit Data

As discussed above, the supervisory data used in this study only contains partial information on the official leverage ratio requirements (the Asset-Capital Multiple, or ACM, limit). There is no ACM limit information available for any bank for the period January 1994 - September 1997, while ACM limit data exists for only some banks for the period October 1997 - December 2009. Overall, ACM limit data is available for 2,903 out of the total 12,984 bank-month observations used in the study. In order to generate the "missing" ACM limit data, a simple regression-based procedure was used. First, the existing ACM limits (for the period Oct. 1997 - Dec. 2009) were regressed on a number of bank-specific factors, which are likely to influence the regulators' decisions:

$$ACM\ Limit_i = \psi + \beta_1 Assets_i + \beta_2 Liquid_i + \beta_3 Big\ Six_i + \beta_4 Foreign_i + \beta_5 T\&L_i + \beta_6 Sub_i + \epsilon_j \quad (5)$$

The size of the bank ($Assets_i$) has been identified in Bordeleau, Crawford, and Graham (2009) as one of the factors that determine whether the regulators set an ACM limit below the "standard" limit of 20. In addition, the level of liquid assets ($Liquid_i$) that are held by the bank can influence its ACM limit, since a more liquid portfolio can allow a bank to have a higher level of leverage without being exposed to excessive liquidity risk. Dummy variables that capture whether the bank is one of the dominant six banks ($Big\ Six_i$), a foreign bank ($Foreign_i$) or a trust and loan company ($T\&L_i$) are also included, since they can explain the age, reputation and the business model of different types of banks that contribute to the regulators' decision on the appropriate ACM limit. Finally, Sub_i is a dummy variable that captures whether bank i is a fully-owned subsidiary of another bank or not.[37]

The estimation of (5) involves running two cross-sectional regressions: one for the period January 1994 - December 1999 (when a relatively strict ACM limit of 20 was imposed on almost all banks) and another for January 2000 - December 2009 (when ACM limits could go as high as 23). As such, all of the variables in (5) are period averages.[38] Since the ACM limit has both a (theoretical) lower bound of one and an (actual) upper bound of 20 or 23, depending on the period, a Tobit approach is more appropriate. The results of these two Tobit regressions are given in Table 12 below.

[37] In Canada, it is common for fully-owned subsidiaries to have a different ACM limit than their parents. Although these subsidiaries are left out of the main empirical analysis discussed above, we opted to include them in the estimation of ACM limit data, in an attempt to increase the number of available ACM limit observations.

[38] A panel data specification with bank-specific fixed effects and period dummies yield similar results).

After the estimation of (5) for the two different subperiods, the missing ACM limits can now be estimated by generating fitted values using the coefficients in Table 12. Since most of the available ACM limits are integers, the fitted values were rounded to the nearest integer. These "generated" ACM limits were then combined with the "actual" ACM limit data to be used as an explanatory variable in the main empirical analysis.

It should be noted here that this approach has some obvious drawbacks, mainly because it leads to measurement error. However, the generated ACM limits appear to match quite well with the existing data, as shown by a comparison of the "generated" and "actual" ACM limits for banks for whom actual ACM limit data is available. The mean difference between the generated and actual ACM limits for such banks is 0.003 and -0.233 for the periods October 1997 - December 1999 and January 2000 - December 2009, respectively. Furthermore, 69.01% of the actual ACM limits and 66.53% of the generated ACM limits fall within [19, 21], although the generated ACM limits are slightly more skewed away from 20. Nevertheless, these observations suggest that the generated ACM limits are a reasonable proxy for the (unobserved) actual ACM limits.

Table 12: Results of Tobit regressions used to generate the missing ACM limit data. Dependent variable: the ACM limit for each bank, averaged over the entire period.

	Oct. 1997 - Dec. 1999		Jan. 2000 - Dec. 2009	
	Coef	S. E.	Coef	S. E.
Assets	0.003	0.011	0.006	0.007
Liquid	-4.836	5.537	-7.174	2.443
Big Six	-0.258	2.901	3.554	2.545
Foreign	-0.417	1.452	2.641	1.130
T&L	-1.868	1.620	0.948	1.216
Sub	0.928	0.913	1.851	0.836
Constant	20.453	1.484	17.907	1.047
No. of obs.	48		52	
Pseudo R^2	0.019		0.103	