Collateral Management in the LVTS by Canadian Financial Institutions

Chris D'Souza, Financial Markets Department

- *The demand for collateral in wholesale financial markets has increased along with financial activity worldwide.*
- *Collateral is used to mitigate credit risk between the counterparties involved in a financial transaction by providing insurance that the lender will be repaid.*
- *Secondary-market liquidity has an important effect on the choices of collateral. Relatively less liquid securities that have fewer alternative uses are more likely to be pledged, while assets in which an institution plays a larger market-making role are also typically pledged.*

To mitigate credit risk, collateral is required of financial institutions (FIs) operating in securities trading and derivatives markets, as well as in central bank operations and large-value payment and settlement systems. Assets eligible as collateral are usually liquid, with negligible levels of credit risk, such as government or government-guaranteed securities. As the demand for collateral has increased, the list of securities deemed eligible as collateral has grown to include private sector securities that meet certain credit-rating requirements. Still, there is a concern that new demands will outstrip the growth in the supply of these preferred assets and that the costs to acquire and hold these assets will increase over time (Committee on the Global Financial System 2001).[1]

This article examines the incentives for banks to hold various assets on their balance sheets for use as collateral when the opportunity costs of doing so are high. It focuses on the five-year period between mid-2002 and mid-2007 that preceded the worldwide financial crisis in order to determine a baseline for collateral-management practices, and in particular, the factors affecting the choice of security during relatively normal times. Specifically, the article examines the choices made by FIs among the assets that serve as collateral in Canada's Large Value Transfer System (LVTS). By the end of March 2007, FIs had pledged collateral with a market value of $32 billion. Given the large value of the assets tied up as collateral, it is important that FIs establish robust controls, determine sources of additional collateral, and ensure that the assets are managed effectively with respect to both liquidity and their balance sheets. The adequacy of liquidity management by FIs is also of concern to policy-makers,[2] as illustrated by the fact

1 New demand has come about mostly via increased growth in derivatives markets and in payment and settlement system activity.

2 The risks of a bank becoming insolvent as a result of problems associated with funding illiquidity are explored in Goodhart (2008). See also Armstrong and Caldwell (2008) and Banque de France (2008).

that the financial crisis that began in 2007 has prompted central banks around the world to expand the lists of assets they would accept as collateral to support the efficient functioning of financial markets.[3]

In addition to improving our understanding of collateral and liquidity-risk management practices within and across FIs, this article seeks to contribute to the market-microstructure literature in fixed-income markets. It examines how secondary-market liquidity and the market-making capacity of FIs affect the types of assets pledged as collateral in the LVTS. Many FIs that employ collateral in their wholesale operations are also dealers in fixed-income markets and have a comparative advantage in managing inventories of these assets. These dealers provide liquidity to their customers and other dealers by buying and selling securities at their posted quotes.[4] When collateral is required in a timely manner, market-making institutions can look to their inventories of eligible assets for use as collateral. While there is a significant literature on the market microstructure of securities that are typically used as collateral, few studies have empirically examined the actual cost, or pricing, of financial collateral.

Many FIs that employ collateral in their wholesale operations are also dealers in fixed-income markets and have a comparative advantage in managing inventories of these assets.

The article begins with a brief discussion of recent trends in collateral management and the requirements for collateral in Canada's LVTS. This is followed by a short discussion of the data employed in the study, the factors that affect the cost of collateral, and the methodology used to determine how FIs decide which assets to pledge as collateral, and for how long. The results section provides evidence that the relative scarcity of collateral is important in the decision-making process. The article concludes with a summary of the findings.

Collateral Management and the LVTS

Collateral is used to mitigate credit risk between the counterparties in a financial transaction. In particular, the credit risk of the borrower is offset by the insurance provided by the value of the asset pledged as collateral. Collateralization is a widespread technique which ensures that disparities between market participants, at least in terms of credit risk, effectively cease to exist.[5] From the borrower's perspective, the risk-reducing effect implies more favourable financing conditions and broader or deeper access to markets.

FIs hold liquid assets both to meet their expected business needs for collateral and to mitigate the risk that they may not be able to meet unexpected cash flows without affecting their daily operations. These securities may be easily redeployed across business lines when the need arises. Recent volatility in the wholesale funding markets has highlighted the importance of sound liquidity risk-management practices, since FIs can experience liquidity problems even during good economic times.[6]

While liquid assets are an important resource for banks operating in wholesale financial markets, they have a relatively high opportunity cost, diverting funds from lending operations that generate higher returns. Depending on the nature of the incentives, collateral managers may therefore hold pools of excess collateral against the possibility that collateral will become expensive when it is needed. Overall, to manage liquidity risk efficiently, firms must minimize funding costs, diversify funding, and monitor the operational risks associated with moving funds and collateral.

The LVTS is a real-time, electronic wire transfer system that processes large-value, time-critical payments quickly and continuously throughout the day. Participants in the LVTS use claims on the Bank of Canada to settle net payment obligations. To secure the payments that are sent through the LVTS, collateral is required.[7] While a large buffer of collateral can be held for precautionary reasons, this strategy increases the opportunity cost to FIs that would rather

3 For example, on 12 December 2007, the Bank of Canada expanded the list of eligible securities that could be pledged as collateral in its Standing Liquidity Facility (SLF) to include certain types of asset-backed commercial paper and U.S. Treasuries. Then, on 17 October 2008, the Bank announced the temporary acceptance of non-mortgage loan portfolios. The SLF provides collateralized overnight loans to FIs without sufficient settlement balances at the Bank to permit the settlement of multilateral net positions in the LVTS.

4 Trade in fixed-income markets is organized in a multiple-dealer, over-the-counter market. See Fleming and Remolona (1999) and D'Souza and Gaa (2004).

5 In extreme situations, however, when bankruptcy is perceived to be imminent, there have been examples of institutions not being able to borrow on even a collateralized basis.

6 Decker (2000); Diamond and Rajan (2001); and Strahan, Gatev, and Schuermann (2004) discuss liquidity-risk management, and how banks have evolved new techniques to mitigate credit risk. Brunnermeier and Pedersen (2009) recognize that the balance-sheet liquidity of traders is limited because of such constraints as collateral and margin requirements imposed by counterparties.

7 See Arjani and McVanel (2006) for a complete description of the LVTS.

hold higher-yielding assets.[8] FIs must choose a set of assets that balances the forgone higher returns with the collateral services provided by the assets. The optimal asset portfolio that minimizes the opportunity cost of collateral will depend not only on overall business needs, but also on financial market factors.

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The Bank of Canada has established a list of securities for the pledging of collateral within the LVTS (see below for the detailed list of collateral groupings used in this study). In general, collateral must be liquid, of acceptable credit quality, and have a transparent market for valuation.[9] The Bank originally accepted only Government of Canada (GoC) securities as collateral, but since it expanded the list in November 2001 to include a larger variety of securities (e.g., municipal securities and commercial paper), pools of collateral pledged by individual FIs to the LVTS have diversified significantly. Thus, while GoC-issued securities constituted about 55 per cent of the discounted value of securities pledged in 2002, they made up less than 30 per cent in early 2007 (Table 1). The value of private sector securities plus provincial and municipal securities jumped from about 12 per cent to more than 40 per cent over the same period.

These statistics suggest that FIs are clearly finding alternative securities to pledge as collateral in the LVTS and are selling or reallocating expensive and scarce government-issued securities. Other factors specific to financial markets and institutions (e.g., market interest rates, capital-asset ratios, and payment flows) also drive the choice of newly pledged collateral, as well as the average length of time before that asset is removed from the LVTS pool.

Collateral in the LVTS

Information about the movement of assets into and out of LVTS collateral pools is derived from daily snapshots. The following information was collected for each security pledged as collateral on each day over the sample period (28 March 2002 to 30 March 2007):[10] the LVTS participant, security identifier, issuer name, par value, discounted value, coupon, and maturity date.[11] In total, 14 FIs act as participants in the LVTS and pledge collateral for the purpose of making payments. For this study, securities are grouped in five general categories: longer-term GoC bonds, short-term GoC treasury bills, GoC guaranteed securities, provincial and municipal securities, and private sector securities (such as bankers' acceptances, promissory notes, commercial paper, and corporate bonds).

Table 1 provides statistics on the pool of securities pledged in the LVTS at the beginning and end of the sample period. The number of securities and the value of collateral across all FIs in each asset class are presented in columns 2 and 6, and columns 3 and 7, respectively. The total discounted value of collateral increased from about $20 billion to $32 billion between 2002 and 2007. This is consistent with the overall increase in payment flows over the same period. It also illustrates the need for FIs to manage their collateral more effectively.

Columns 4 and 8 in Table 1 indicate the percentage of collateral associated with each asset class. While the total discounted value (columns 3 and 7) of GoC bonds and treasury bills is similar at the beginning and end of the sample period, the share of treasury bills within that total has increased substantially. Note that FIs are pledging more and more securities from assets that were made eligible in November 2001 (such as provincial/municipal and private sector securities). Lastly, average maturities (in months), shown in columns 5 and 9, have increased significantly for GoC-guaranteed, provincial, municipal, and private sector securities, while the overall average has declined, largely because of the increasing reliance on treasury bills.

As noted above, there has been an overall increase in payment flows during the sample period. Chart 1 illustrates the large increase in quarterly payment

8 Payments sent and received by each institution can vary significantly within and across days, depending on customer needs. McPhail and Vakos (2003) illustrate how a buffer of collateral is typically employed to accommodate unexpected incoming and outgoing flows of funds.

9 Bindseil and Papadia (2006) discuss the acceptable risk characteristics of collateral. Securities currently eligible as collateral and their margin are available at <http://www.bankofcanada.ca/en/financial/securities.pdf>.

10 These dates were chosen to control for seasonal factors and to provide enough time for FIs to adjust to changes in collateral policies introduced in November 2001.

11 There were more than 100 different issuers of securities over the sample period.

Table 1: LVTS collateral holdings by asset class

Asset class	28 March 2002				30 March 2007			
	Assets (#)	Total discounted value ($ billions)	Total discounted value (%)	Average maturity (months)	Assets (#)	Total discounted value ($ billions)	Total discounted value (%)	Average maturity (months)
GoC bonds	27	9.55	47.64	83.07	24	2.45	7.67	100.50
GoC treasury bills	22	1.63	8.11	6.82	27	6.72	20.99	4.78
GoC-guaranteed securities	54	6.48	32.34	23.06	60	9.31	29.09	33.28
Provincial/municipal securities	11	0.42	2.10	42.73	102	7.63	23.84	68.83
Private sector securities	79	1.96	9.79	4.01	177	5.89	18.40	11.03
Total/average	**193**	**20.03**	**100.00**	**48.88**	**390**	**32.00**	**100.0**	**36.83**

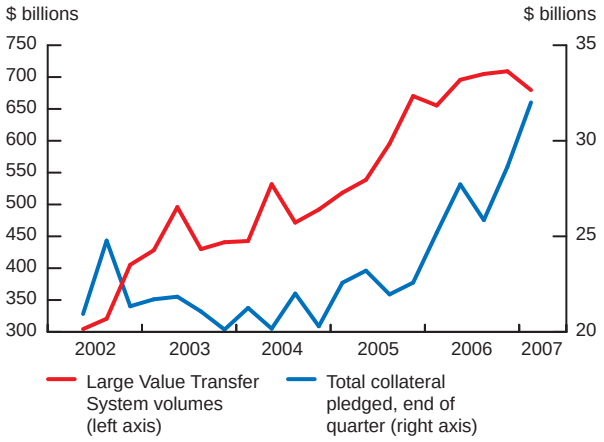
Note: Government of Canada (GoC) bonds include all securities with maturities greater than one year. National Housing Act (NHA) Mortgage-Backed Securities are included with GoC-guaranteed securities. Private sector securities include bankers' acceptances, promissory notes, commercial paper, and corporate bonds.

volumes sent by all direct participants in the LVTS.[12] Only Tranche 1 payment volumes are shown because, despite being a small portion of overall volumes, most of the collateral pledged is actually in support of this type of payment.[13] Also shown is total collateral pledged, which illustrates strong growth, especially since mid-2005.

Table 2 is organized much like Table 1 and provides information about the movements of collateral—securities pledged and released from the LVTS—over the sample period. Column 2 indicates the average holding period (i.e., the number of business days a security is pledged) for assets in each class. Lower-risk securities (GoC bonds and guaranteed securities) are held as collateral in the LVTS for six days or less, while private sector securities are kept in the pool for more than 26 business days, on average. This may reflect the value that FIs place on GoC (issued and guaranteed) bonds for other uses and the fact that private sector securities are less liquid and tend to be held longer in inventory.

In columns 3 and 6, the number of securities either newly pledged to, or newly released from, the LVTS is documented across the five asset classes. Columns 4 and 7 reflect the average value (in millions of dollars) of the transferred securities, while columns 5 and 8

Chart 1: LVTS quarterly volumes, 2002Q2–07Q1[a]



a. Aggregate Tranche 1 payments sent by all direct participants in the Large Value Transfer System (LVTS)

Sources: Bank of Canada and the Canadian Payments Association

indicate the average maturity (in months) of the moved securities. Columns 3 and 6 are surprisingly similar and may suggest that FIs typically pledge and then release, or release and then pledge, very similar securities. Over the five-year period, almost two-thirds of the discounted value related to movements in collateral was associated with GoC bonds and bills. These securities are typically involved in repo market operations, have low credit risk, and are very liquid. While GoC securities are highly mobile in the LVTS, it is important to note that other security classes are also pledged and released on a frequent basis.

Several factors are hypothesized as to which assets are pledged as collateral. While various aspects are common across FIs, such as market liquidity in each asset class, others are specific to the business

12 The overall change across the sample period reflects an increase in the size of the economy, the migration of payments from the Automated Clearing Settlement System to the LVTS, payments settled through the Continuous Linked Settlement system and CDSX (operated by the Canadian Depository for Securities Limited), and increased GoC transactions. Figures on aggregate payment flows and flows disaggregated by participant are obtained from the Canadian Payments Association.

13 Tranche 1 payments that are sent can be no greater than the amount of collateral that the institution has pledged to the Bank of Canada. Under Tranche 2, each FI pledges to the Bank of Canada collateral equal to the largest bilateral line of credit it has extended to any other institution multiplied by a specified percentage. Tranche 2 payments constitute most of the volume and value of payment transfers in the LVTS, principally because of savings in collateral relative to Tranche 1 operations.

Table 2: Pledges and releases: collateral movements by asset class between 28 March 2002 and 30 March 2007

Asset class	Pledges				Releases		
	Average holding period (business days)	Pledges (#)	Average discounted value ($ millions)	Average maturity (months)	Releases (#)	Average discounted value ($ millions)	Average maturity (months)
GoC bonds	6.0	4,190	228	123.5	4,096	196	120.5
GoC treasury bills	14.3	2,410	239	5.2	2,173	193	4.6
GoC-guaranteed securities	4.8	9,403	125	26.4	8,533	113	26.4
Provincial/municipal securities	14.7	3,547	91	92.8	3,223	80	91.3
Private sector securities	26.4	4,168	29	5.8	4,093	28	5.5
Total/average	**11.2**	**23,718**	**133**	**47.7**	**22,118**	**116**	**47.3**

Note: Government of Canada (GoC) bonds include all securities with maturities greater than one year. National Housing Act (NHA) Mortgage-Backed Securities are included with GoC guaranteed securities. Private sector securities include bankers' acceptances, promissory notes, commercial paper, and corporate bonds. The Total/average row includes the sum of the pledges/releases for each asset type (columns 3 and 6) and the weighted average for the holding period, discounted value, and maturity columns.

operations of the individual firm. The factors considered include asset market turnover, market-making capacity, payment flows, capital-asset ratio, and the collateralized overnight lending rate. We consider each in turn.

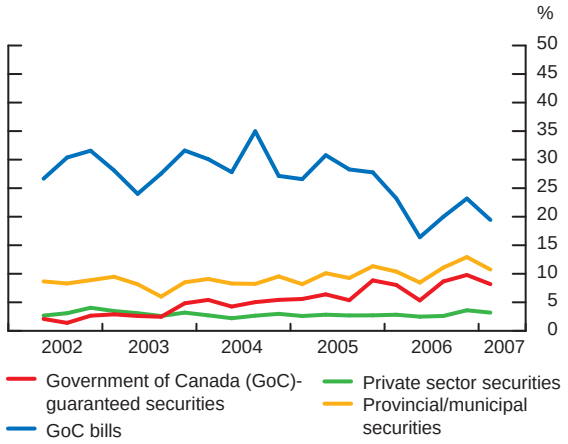
Turnover, a broad measure of market liquidity, is often associated with greater market depth. Eligible securities that are also liquid provide additional value to collateral managers, since such securities are relatively easy to acquire or sell, with minimal impact on prices. For regular collateral requirements in the LVTS, managers will look first to less-liquid assets and attempt to preserve any valuable collateral for other uses (e.g., trading in repo or derivatives markets). Turnover in each asset class, which provides an overall daily measure of the relative scarcity of a security, is calculated by dividing the volume of securities traded over a given period by the average amount of securities outstanding over the same period.[14]

Chart 2 illustrates aggregate trading for all dealers in each asset class relative to trading in GoC bonds. The normalization is introduced to control for the overall increase in trading across markets and also to effectively illustrate the size of the GoC bond market. While ratios are relatively stable across time in most asset classes, there has been a considerable increase in relative market activity in GoC-guaranteed securities.

The market-making capacity of each FI in each asset class may also affect which securities an institution pledges in the LVTS, since banks may not want to use

Chart 2: Aggregate trading as a share of GoC bond trading, 2002Q2–07Q1

Quarterly



Sources: Bank of Canada and the Investment Industry Regulatory Organization of Canada

assets whose inventory risk they have a comparative advantage in managing. A proxy for relative market-making capacity in each asset class is calculated as the ratio of trading relative to total trading by each institution.

Payment flows, and their volatility, will effectively determine the total size of every collateral pool pledged by each participant in the LVTS. For firms that manage their LVTS payments intensively, the more payments that are received relative to those that must be sent, the less collateral will be required. When payment flows are large or volatile, FIs may need to purchase and pledge increasingly costly securities. Furthermore, since time-sensitive payments can be significant, FIs may hold or borrow securities that are

14 Outstanding amounts in each security class are collected from the Bank of Canada's *Banking and Financial Statistics*. Data on each FI's share of trading in each asset class were obtained from the Investment Dealers Association of Canada.

available in large amounts, such as government securities.

Liquid assets have a lower credit risk and are readily redeployable across business lines if the need arises. Banks that hold large pools of eligible and liquid assets on their balance sheets may pledge these assets to the LVTS. The percentage of liquid assets relative to total assets is a proxy for the relative size of an FI's portfolio of liquid assets, as well as the scarcity of available liquid assets on its balance sheet. The capital-to-asset ratio of each FI, which measures the overall risk of a bank's asset portfolio, may also affect which assets are pledged to the LVTS. A bank with a lower capital-asset ratio, for example, may have higher insolvency risks and find it difficult to borrow from other banks on an uncollateralized basis.[15] Such an FI will preserve its most liquid assets in case of a funding shock.

Lastly, the overnight collateralized lending rate will also affect which assets are pledged in the LVTS. When collateral is scarce, the Canadian Overnight Repo Rate Average (CORRA) may fall relative to the Bank of Canada's target for the overnight rate.[16] The CORRA is limited to repo transactions that involve general collateral and provides a transparent daily measure of the level of the overnight rate. Since the repo market is a very liquid market for the purchase and resale of GoC securities, FIs may tap this market for short-term collateral demands. When scarcity is an issue, however, FIs will economize on their collateral demands.

Methodology

Standard regression models are not appropriate when examining the choice of collateral made by banks. This choice is discrete, taking on only one of a number of values. Binary dependent models (such as logit and probit models), where the choice variable takes on only one of two values, are also not appropriate when firms are given many different choices. In the case of collateral choice, no natural ordering of assets exists across time and institutions. Instead, the ordering of securities will depend on each FI's needs for payment services, its market-making capacity, conditions in the marketplace, and the state of the FI's balance sheet at the moment a decision must be made. Each of these elements may affect the opportunity cost of every security that is eligible as collateral in the LVTS. An unordered conditional logit model is appropriate under these circumstances.[17]

The data set collected and analyzed for this study is atypical, since it includes mixtures of both individual and choice-specific attributes. These data are used to estimate a model of how FIs choose which security to pledge as collateral in the LVTS. The outcome is an estimate of the probability of pledging a particular type of asset given a set of control variables for individual firm characteristics as well as market-wide factors. The dependent variable in the model assumes a value of one when that asset is pledged, and zero otherwise. Each observation is actually a set of data consisting of explanatory variables for the securities that were chosen as well as for those that were not chosen. To observe how individual firm characteristics (i.e., size, composition of assets, funding choices, regional diversification, etc.) influence the choice of security, a dummy variable for each type of security is multiplied by each of the firm-level control variables: daily payments sent by the firm; the realized volatility of the FI's payments over the past month; the liquid-asset-to-total-asset ratio and the capital-to-asset ratio in the most recent quarter; and the overnight rate. Because a dummy is not included for GoC bonds, the resulting coefficients are interpreted as the effect of the control variable on the probability of pledging the particular asset relative to GoC bonds. Variables are also included to control for general market liquidity and the market-making efforts of individual firms.

We also perform an analysis of pledging duration by estimating an accelerated failure-time model (estimating the probability that a certain security will be removed from the pool of pledged collateral) to determine whether the factors that drive choice also affect the length of time that an asset is pledged. Consider the following model of an accelerated "release" time:

$$\ln(t_j) = x_j \beta_j + \tau_j, \qquad (1)$$

where the release time of collateral is t_j, and τ_j is an error term. The values of the explanatory variables, x_j, are chosen at the time the collateral is first pledged to the LVTS.

15 Liquid assets relative to total assets and the capital relative to risk-weighted asset ratios are obtained from quarterly balance sheet data from the Office of the Superintendent of Financial Institutions. Liquid assets include bank notes, deposits with the Bank of Canada, securities issued or guaranteed by the Government of Canada, and securities issued or guaranteed by provinces or municipalities.

16 See Reid (2007). The Bank of Canada publishes the CORRA, which consists of a weighted average of rates on repo transactions conducted onscreen between 06:00 and 16:00 hours and subsequently reported by interdealer brokers.

17 Estimation of a conditional logit model (clogit) is discussed in the box on page 14. See McFadden (1974) or, for a brief introduction, Greene (2008). A model specification similar to that of Hensher (1986) is used in this article.

Findings

Only data corresponding to the largest financial institutions in Canada are employed in the analysis. This reflects our focus on market liquidity and market-making, as well as the availability of trading data for a select number of firms. (The big six banks examined are the Bank of Montreal, the Canadian Imperial Bank of Commerce, the Banque Nationale, the Royal Bank of Canada, Scotiabank, and the Toronto-Dominion Bank.) Furthermore, to simplify the model and preserve the confidentiality of the data, we assume that the effects of all independent variables are the same for each FI. The data are thus entered individually for each FI, but are pooled into one model.[18] Table 3 presents coefficient estimates, and their associated *p*-values, for all variables. Pseudo R^2 values indicate that the model provides a reasonably good fit for the data.

Dummy variables for GoC treasury bills, GoC-guaranteed securities, provincial and municipal securities, and private sector securities are included in the analysis, with GoC bonds treated as the control asset class. Positive (or negative) estimates indicate a greater (or smaller) likelihood that a security in a certain asset class will be pledged relative to a GoC bond. These dummies give an indication of any unobserved factors driving pledges unrelated to the control variables. Judging by the signs of the estimates, GoC-guaranteed securities are more likely, on average, to be pledged than GoC bonds, while GoC bills and private sector and provincial securities are less likely to be pledged.

Control variables are included to reflect factors that are thought to affect the management of collateral but are unrelated to financial market liquidity and market-making capacity. These controls are multiplied by the four dummy variables representing the individual asset classes. A positive estimate indicates an increased likelihood that a specific security type will be pledged relative to a GoC bond when that control variable increases. For example, when the value of payments sent increases on a particular day, GoC bonds are preferred to all other security classes (that is, all coefficients are negative) to satisfy the increased collateral requirement. Intuitively, when collateral is needed for a short time, an FI can either expend effort looking for cheap securities, or (although this is

Table 3: Conditional logit estimation of pledges[a]

Explanatory variables	Coefficient
GoC bills	-1.011 *(0.000)*
GoC-guaranteed securities	0.807 *(0.000)*
Provincial/municipal securities	-1.200 *(0.000)*
Private sector securities	-0.955 *(0.000)*
Payments sent x	
GoC bills	-0.395 *(0.086)*
GoC-guaranteed	-6.306 *(0.000)*
Provincial/municipal	-1.536 *(0.000)*
Private sector	-1.980 *(0.000)*
Payments volatility x	
GoC bills	-2.933 *(0.064)*
GoC-guaranteed	6.915 *(0.000)*
Provincial/municipal	3.246 *(0.015)*
Private sector	16.855 *(0.000)*
Liquid-asset ratio x	
GoC bills	11.673 *(0.000)*
GoC-guaranteed	30.463 *(0.000)*
Provincial/municipal	8.798 *(0.000)*
Private sector	-1.281 *(0.559)*
Capital-asset ratio x	
GoC bills	-0.989 *(0.000)*
GoC-guaranteed	-1.941 *(0.000)*
Provincial/municipal	-0.716 *(0.000)*
Private sector	-0.292 *(0.009)*
Overnight spread x	
GoC bills	3.674 *(0.062)*
GoC-guaranteed	7.084 *(0.000)*
Provincial/municipal	-1.453 *(0.358)*
Private sector	1.746 *(0.272)*
Market liquidity	-3.571 *(0.000)*
Market-making	1.201 *(0.000)*
Observations	11189
Pseudo R^2	0.392
Wald statistic *p*-value	0.000

a. Estimates of coefficients are based on the estimation of a conditional logit model. The sample period is 28 March 2002 to 30 March 2007. Probability values are presented in parentheses. The dependent variable is equal to one for the asset class chosen and zero otherwise. Independent variables include dummy variables for GoC treasury bills, GoC-guaranteed securities, provincial/municipal securities, and private sector securities. These dummy variables are also multiplied by the value of payments sent on the day of the pledge, payment volatility (equal to the standard deviation of payments sent over the past 20 business days), the ratio of liquid to total assets in the most recent quarter, the ratio of capital to risk-weighted asset in the most recent quarter, and the spread between the CORRA and the Bank of Canada's target overnight rate. Coefficient estimates associated with payments sent and payment volatilities are multiplied by 10^{-4}. The following are also included as explanatory variables: market liquidity, calculated by dividing the volume of securities traded over the most recent quarter by the average amount of securities outstanding in that quarter; and market-making, the fraction of trading in each asset class by each financial institution.

18 While seasonal (e.g., quarterly) dummies may be warranted, only variables that differ across choices, or that differ across firm characteristics, can be included in the analysis. It is therefore not possible to control for changes in the behaviour of FIs across time.

generally more costly) it can pledge an easily found GoC bond, recognizing that the bond will also be easier to sell once the collateral is no longer needed.

In contrast, when the recent volatility of payments increases, all asset classes except GoC bills are more likely to be pledged relative to GoC bonds. This is especially true for private sector securities. This increased likelihood may reflect the precautionary motive for holding collateral and the conservative nature of collateral managers. When volatility is high and persistent, they increase the buffer of cheap collateral pledged in the LVTS.

Comparing liquid assets with total assets gives some indication of the relative scarcity of liquid assets in each institution. Results suggest that a larger liquid-asset ratio increases the probability that, relative to GoC bonds, an FI will pledge treasury bills, GoC-guaranteed securities, or provincial and municipal bonds. The use of other liquid assets may be relatively high because FIs are employing GoC bonds elsewhere.

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The estimates also indicate that when the total capital-to-asset ratio decreases, banks are less likely to pledge GoC bonds relative to all other asset classes (similar results were found using the Basel Tier 1 capital-to-asset ratio). A reduction in the capital-asset ratio may indicate an increased risk of insolvency. FIs in this position will conserve their most-liquid assets (e.g., GoC bonds), which are acceptable as collateral by a wider range of parties in the marketplace if additional funding is required.

A decrease in the overnight rate relative to the Bank of Canada's overnight target might suggest that high-quality collateral has become scarcer (e.g., securities in high demand will trade at a lower rate in the repo market. Participants who own such securities can lend them in the repo market in return for cash, at a lower interest rate.) Statistically significant results in Table 3 suggest that, in this event, banks prefer to pledge GoC bonds relative to GoC-guaranteed securities. This result is less intuitive and could be biased, since the quantity of high-quality pledged collateral and the "price" of collateral are determined endogenously.

Our main interest is the effect of market liquidity and a bank's market-making capacity on the choice of assets pledged as collateral. Results presented in Table 3 are statistically significant for both variables. Increased market liquidity in an asset class (which is measured by turnover) reduces the likelihood that a security from that sector of the fixed-income market will be pledged. Intuitively, highly liquid securities are too valuable to serve as collateral from the perspective of a bank's trading desk. While liquid assets could be released from the LVTS if the need arose, the operational costs of doing so may not be justified.

Alternatively, FIs are more likely to choose assets in which they have a greater market-making capacity (represented by relative trading activity). Banks that deal actively in a certain segment of the fixed-income market have more expertise in managing inventories in that market. While institutions may be reluctant to pledge as collateral securities from their market-making portfolio of assets, they may be able to do this more efficiently in a market in which they are better aware of the trading activity over time.

The results of the duration analysis (where the model looks at the amount of time a security remains pledged) performed with the same set of data are consistent with the results of the unordered conditional logit model. Models are estimated separately for each asset class.[19] Instead of examining the choice of security made by an FI pledging collateral to the LVTS, coefficient estimates in Table 4 show whether the length of time a security stays in the LVTS collateral pool increases or decreases when the independent variables increase in magnitude.

Results in Table 4 suggest that, across most asset classes, market liquidity reduces the time before a security is released from the LVTS, while market-making capacity increases the length of time a security stays in the LVTS collateral pool. The only exception is GoC-guaranteed securities, where the results are reversed. Market liquidity increases the length of time that the security is pledged to the LVTS, while market-making intensity reduces the duration of the security's stay in the LVTS. An interesting line of future research will be to investigate what aspect of GoC-guaranteed securities drives this result.

19 The random variable (τ_j) in equation 1 is assumed to follow a Weibull distribution, although results are robust to alternative probability distributions.

Table 4: Duration analysis of accelerated failure time[a]

Pledges	Security				
	GoC bonds	GoC bills	GoC guaranteed	Provincial/municipal	Private sector
Payments sent x 10^{-4}	-2.687 *(0.000)*	-2.443 *(0.000)*	0.851 *(0.111)*	-1.954 *(0.000)*	-0.438 *(0.111)*
Payment volatility x 10^{-4}	5.753 *(0.000)*	1.571 *(0.389)*	11.902 *(0.000)*	7.590 *(0.000)*	5.093 *(0.000)*
Liquid-asset ratio	10.651 *(0.000)*	20.859 *(0.000)*	-0.659 *(0.258)*	7.605 *(0.000)*	27.968 *(0.000)*
Capital-asset ratio	0.390 *(0.001)*	-1.333 *(0.000)*	0.536 *(0.000)*	-0.377 *(0.027)*	0.292 *(0.044)*
Overnight spread	6.341 *(0.000)*	2.994 *(0.079)*	-1.558 *(0.189)*	-3.162 *(0.074)*	-1.846 *(0.188)*
Market liquidity	-9.031 *(0.000)*	-56.406 *(0.001)*	20.076 *(0.001)*	-7.936 *(0.056)*	-13.593 *(0.001)*
Market-making	5.231 *(0.017)*	2.658 *(0.005)*	-1.423 *(0.000)*	4.508 *(0.022)*	12.093 *(0.017)*
Constant	1.615 *(0.000)*	2.691 *(0.000)*	0.605 *(0.000)*	1.749 *(0.000)*	-2.861 *(0.000)*
Observations	1188	857	6922	1068	1154
Log likelihood	-2019.4	-1377.3	-8458.2	-1755.8	-1929.9
LR *p*-value	0.000	0.000	0.000	0.000	0.000

a. Estimates of coefficients are based on the estimation of an accelerated failure-time model (see equation 1) for each asset class. The error term is assumed to follow a Weibull distribution. The sample period is 28 March 2002 to 30 March 2007. The dependent variable, $\ln(t_j)$, is the log of the number of days that a security is pledged as collateral. Probability values are presented in parentheses. Independent variables include dummy variables for GoC treasury bills, GoC-guaranteed securities, provincial/municipal securities, and private sector securities. These dummy variables are also multiplied by the value of the payments sent on the day of the pledge, payment volatility equal to standard deviation of payments sent over the past 20 business days, the ratio of liquid to total assets in the most recent quarter, the ratio of capital to risk-weighted assets in the most recent quarter, and the spread between the CORRA and the Bank of Canada's target overnight rate. The following are also included as explanatory variables: market liquidity, calculated by dividing the volume of securities traded over the most recent quarter by the average amount of securities outstanding in that quarter; and market-making, the fraction of trading in each asset class by each FI.

The control variables from the duration analysis are consistent with the conditional unordered logit estimates. For example, an increase in the value of payments sent reduces the length of time before a security is released from the LVTS, suggesting that the variables for payments sent may be more related to short-term needs for collateral. In contrast, when realized volatility is elevated over the previous month, all securities are kept in the LVTS for longer periods before being released.

Summary and Conclusions

It is important to monitor how participants in the LVTS make use of the assets available to them in their collateral decisions. This is especially vital in an environment where the use of collateral has expanded and where certain securities are thought to be scarce. The empirical analysis presented in this article provides an extensive list of factors that affect the choice of collateral in wholesale markets. While many of the factors affecting the demand for collateral were already well known (e.g., the dynamics of payment flow, balance-sheet factors, and market interest rates), this analysis presents new evidence on how market liquidity and trading in fixed-income markets can affect the choice of collateral.

The results find strong evidence to suggest that relative market liquidity and market-making capacity are important factors in the choice of securities pledged as collateral in the LVTS. Since market-making activities can be a profitable business line, it is expected that FIs will first look for assets held in their inventories that are not required immediately for other purposes; that is, assets that are relatively less active or liquid.[20] Furthermore, FIs will look to the inventories of assets in which they have more management expertise. Their knowledge of the inventory risk associated with these securities can minimize their temporary funding costs in the long run.

The results find strong evidence to suggest that relative market liquidity and market-making capacity are important factors in the choice of securities pledged as collateral in the LVTS.

There is an implicit opportunity cost associated with holding securities that are eligible as collateral in wholesale financial markets. In particular, certain assets that serve as collateral in the LVTS can also be redeployed to other profitable uses. These assets (e.g., liquid Government of Canada bonds and bills) are highly sought after and have been used less extensively in the LVTS since the list of eligible securities was expanded. Such securities are still pledged for short-term needs, however. In contrast, less-liquid inventories of securities that have a higher yield and that an FI has a comparative advantage in managing are more cost-effective when pledged as collateral.

20 Liquid and/or redeployable collateral is valuable in FIs with many business lines that may require temporary funding. The literature on benchmark, or on-the-run, securities suggests that assets with similar cash flows can differ substantially in their liquidity and price.

On the whole, there is significant evidence that collateral is cautiously managed. FIs must balance risk and return by minimizing funding costs, diversifying funding, and monitoring the operational costs of pledging and releasing collateral.

The results of this study are important for policy-makers such as the Bank of Canada, which is concerned both about the efficient functioning of fixed-income markets and about the credit risk it ultimately bears in insuring LVTS settlement. Given these new insights into the behaviour of FIs, future changes in collateral policies, in particular those regarding the eligibility of assets as collateral, can be designed more effectively.

Ongoing monitoring of and research into collateral-management practices is required to keep abreast of the changing behaviours at financial institutions and within an evolving financial environment. Future research will examine collateral management in more detail, with a particular focus on changes resulting from the recent financial crisis and the ensuing increase in Government of Canada debt issuance.

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Empirical Methodology

In McFadden's (1974) choice model, there is a set of unordered choices, say, *1,2,....,J*. Let y_{jt} be an indicator variable for the actual choice of collateral made by a financial institution (FI). In particular, $y_{jt} = 1$ if the institution chooses asset j on day t, and $y_{jt} = 0$ for $j' \neq j$. The independent variables in the model, $z_{jt} = [x_{jt}, w_t]$, can be broken down into attributes of the choices on day t, x_{jt}, and individual characteristics of the firm on day t, w_t.[1]

Unordered-choice models are motivated by a random-utility model. FIs maximize utility (accounting for both profits and the risk management of assets across its balance sheet). For a firm faced with J choices, the utility of choice j on day t is

$$U_{jt} = \beta' z_{jt} + \varepsilon_{jt}.$$

If the bank makes choice j, it is assumed that U_{jt} is the maximum among the J utilities. The statistical model is driven by the probability that choice j is made, which is

$$\Pr(U_{jt} > U_{jt})$$

for all other $j' \neq j$. If, and only if, the J disturbances are independent and identically distributed with Weibull distribution,

$$F(\varepsilon_{jt}) = exp(e^{-\varepsilon_{jt}}),$$

then

$$\Pr(y_{jt} = j) = ((e^{\beta' z_{jt}})/(\sum_j e^{\beta' z_{jt}})) = ((e^{\delta' x_{jt} + a' w_t})/(\sum_j e^{\delta' x_{jt} + a' w_t})).$$

The conditional logit model is intended for problems where choices are made based at least partly on observable attributes of each alternative. For the current model to allow for individual specific effects, dummy variables for the choices have to be created. These are then multiplied by the *w*'s. In this way, the coefficients can vary across the choices instead of the characteristics, and not drop out of the probabilities. Estimation of the model by maximum likelihood methods is straightforward, where the dependent variable is coded as either 0 or 1. The log-likelihood function is

$$\log L = \sum^T t = 1 \sum^J j = 1 \; d_{jt} \; \log \Pr(y_{jt} = j),$$

where d_{jt} is one when alternative j is chosen at time t and zero otherwise. The model is slightly different from a regular logistic regression in that the data are grouped and the likelihood is calculated relative to all other possible choices that the institution could have made.[2] In a model that is estimated for multiple FIs, the above equations are replicated for each FI and the log-likelihood function includes an additional summation across the FIs.

1 A multinomial logit model can be utilized when only individual attributes are observed.

2 Conditional and multinominal logit models are convenient but assume independence from irrelevant alternatives. Specifically, a third alternative does not affect the relative odds between alternatives *i* and *j*.