BANK OF CANADA
BANQUE DU CANADA

Working Paper/Document de travail
2015-29

Examining Full Collateral Coverage in Canada's Large Value Transfer System

by Lana Embree and Varya Taylor

www.bank-banque-canada.ca

Bank of Canada Working Paper 2015-29

July 2015

Examining Full Collateral Coverage in Canada's Large Value Transfer System

by

Lana Embree and Varya Taylor

Financial Stability Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
Corresponding author: lembree@bankofcanada.ca

ISSN 1701-9397

Acknowledgements

We would like to thank Joey Murray and Gabriel Xerri for their instrumental research assistance. This paper also benefited from the valuable comments and suggestions provided by Nellie Zhang, Paul Miller, Miguel Molico, James Chapman, Hector Perez Saiz, Sean O'Connor, Neville Arjani, Matti Hellqvist and attendees of the 2014 Bank of Finland Simulator Seminar and 2014 Queens University-Bank of Canada Workshop on the Future of Payments.

Abstract

The Large Value Transfer System (LVTS) is Canada's main electronic interbank funds transfer system that financial institutions use daily to transmit thousands of payments worth several billions of dollars. The LVTS is different than real-time gross settlement (RTGS) systems because, while each payment is final and irrevocable, settlement occurs on a multilateral net basis at the end of the day. Furthermore, LVTS payments are secured by a collateral pool that mutualizes losses across participants in the event of a default.

In this paper, we use the Bank of Finland Simulator to examine the implications of fully collateralizing LVTS payments, similar to an RTGS. An important caveat to consider, however, is that the simulations do not take into account the anticipated change in payment behaviour in response to a change in collateral requirements. In this regard, we include a queuing mechanism to at least reflect more efficient use of liquidity. The results indicate that collateral requirements vary by participant and some participants actually require less collateral in the simulation than what is required under the current LVTS design.

JEL classification: E, E4, E47, G, G2, G21
Bank classification: Financial institutions; Payment clearing and settlement systems

Résumé

Le Système de transfert de paiements de grande valeur (STPGV) est le principal système interbancaire de virement électronique de fonds du Canada. Il est utilisé quotidiennement par les institutions financières pour transmettre des milliers de paiements dont la valeur s'élève à plusieurs milliards de dollars. Le STPGV diffère des systèmes à règlement brut en temps réel, car, bien que chaque paiement soit final et irrévocable, le règlement se fait à la fin de la journée par l'inscription des positions nettes multilatérales. De plus, les paiements effectués sont garantis par un portefeuille de sûretés, ce qui permet de répartir les pertes entre les participants en cas de défaillance.

À l'aide du simulateur de la Banque de Finlande, nous étudions les effets qu'entraînerait pour les participants au STPGV le nantissement de la totalité des paiements, une exigence similaire à celle qu'on trouve dans le cas des systèmes à règlement brut en temps réel. Il convient toutefois de souligner que les simulations ne tiennent pas compte du changement anticipé des habitudes de paiement qu'induirait une modification des exigences en matière de sûretés. C'est pourquoi nous intégrons un mécanisme de mise en attente, qui permet de simuler partiellement une utilisation plus efficiente des liquidités. Les résultats montrent que les exigences varient selon les participants et que, pour certains d'entre eux, le montant qui leur est imposé par le simulateur est, en fait, inférieur à celui qu’ils sont tenus d’acquitter dans le cadre du STPGV tel qu’il est conçu actuellement.

Classification JEL : E, E4, E47, G, G2, G21
Classification de la Banque : Institutions financières; Systèmes de compensation et de règlement des paiements

Non-Technical Summary

Many large-value payment systems in the world use real-time gross settlement (RTGS) systems, where each payment is fully collateralized and settled on a payment-by-payment basis. The Large Value Transfer System (LVTS), owned and operated by the Canadian Payments Association, is not an RTGS, because it settles on a multilateral net basis at the end of the day and participants only partially collateralize their credit risk. However, because payments are final and irrevocable in real time, the LVTS is RTGS-equivalent.

In our paper, we examine the implications of fully collateralizing LVTS payments using the Bank of Finland Simulator. We then compare the simulation results to the collateral requirements participants actually face in the LVTS. We find that collateral requirements at a system-wide level increase; however, some participants, typically smaller participants, actually see a decrease in collateral requirements. We also find that the introduction of a bypass queue results in collateral savings at a system-wide level. The results indicate that further work could be done to explore the liquidity efficiencies of the current LVTS design at a participant level.

Indeed, the Canadian Payments Association, owner and operator of the LVTS, is undertaking a multi-year project to review and modernize its payment systems. The results from this paper could provide some insight into the implications of adopting a fully collateralized system, similar to an RTGS. If the LVTS were fully collateralized, those participants that face an increase in collateral requirements may delay their payments to rely on incoming funds rather than collateral. There are several approaches that could be used to reduce payment delay, however, including liquidity-saving mechanisms such as queuing, throughput rules and fee structures.

1. Introduction

The Large Value Transfer System (LVTS) is owned and operated by the Canadian Payments Association (CPA) and is Canada's main interbank system for large-value payments.[1] Financial institutions use the LVTS to process around 30 thousand payments per day, worth $150 billion.[2] Given its critical importance to the Canadian financial system, the LVTS is designated as systemically important under the Payment Clearing and Settlement Act and subject to oversight by the Bank of Canada. The Bank's oversight objective is to ensure that the LVTS has adequate risk controls to operate safely and efficiently.

Most large-value payment systems are real-time gross settlement (RTGS) systems that are settled on a fully collateralized, payment-by-payment basis.[3] The LVTS is different than RTGS for two reasons. First, the LVTS settles at the end of the day on a multilateral net basis; however, each payment is final and irrevocable in real time. For that reason, the LVTS is often described as a "hybrid" between a deferred net settlement system and an RTGS. Second, the LVTS has two payment streams available to participants: Tranche 1 (T1) and Tranche 2 (T2). As described later, participants fully secure intraday credit in T1 by pledging collateral to the Bank. However, in T2, intraday credit is secured by a collateral pool also pledged by participants to the Bank.

In this paper, we use the Bank of Finland Simulator to examine the potential implications of fully collateralizing LVTS payments, similar to an RTGS. Our results indicate that the increase in collateral requirements at a system level is not unreasonable given the total collateral currently available in the system. However, at a participant level, the results indicate that some participants face a greater impact than others, and some even see lower collateral requirements relative to what they currently pledge for the LVTS.

2. Motivation

In April 2012, the Committee on Payment and Settlement Systems[4] and the International Organization of Securities Commissions (CPSS-IOSCO) released a set of risk-management principles that apply to financial market infrastructures, including systemically important payment systems such as the LVTS (CPSS-IOSCO 2012). The principle on credit risk requires a payments system to cover its current and future exposures to each participant fully using collateral and other equivalent financial resources. The LVTS meets the credit-risk principle because:

- the total value of collateral pledged by participants to the Bank is sufficient to cover the single largest potential default, and

[1] For a thorough review of the LVTS, see Arjani and McVanel (2006).
[2] Source: Canadian Payments Association.
[3] An RTGS is a fully collateralized system that facilitates the "continuous (real-time) settlement of funds or securities transfers individually on an order by order basis (without netting)" (CPSS 2003).
[4] This committee was renamed the Committee on Payments and Market Infrastructures (CPMI) in September 2014.

- the Bank provides an explicit guarantee to settle the system if there were multiple defaults on the same day and insufficient collateral.

The Bank's explicit guarantee of settlement, which is enshrined in legislation, constitutes equivalent financial resources under the principles and ensures that intraday credit risk is always fully covered.

Nonetheless, the principle also suggests that a payment system achieve settlement finality by employing an RTGS system.[5] Whether or not an RTGS should be adopted in Canada, a review of the LVTS design and risk controls is warranted because the LVTS was introduced more than 15 years ago. Since then, significant advances in payments technology and liquidity-saving mechanisms have been made. With that in mind, the CPA is currently undertaking a multi-year project to review and modernize its clearing and settlement systems (for both its retail and large-value payment systems). This review will involve extensive research on the options available for increasing safety and efficiency. The results from this paper could provide some insight into the implications of adopting an RTGS from a collateral perspective. Further, this paper allows us to consider the implications of removing the Bank's guarantee, since participants in an RTGS system fully cover their own credit exposure.

3. LVTS Collateral Requirements

The T1 and T2 payment streams each have their own collateral requirements and loss-sharing arrangements in case of a default. In the T1 payment stream, the Bank provides participants an intraday line of credit that is fully secured by collateral pledged to the Bank at the start of the payments cycle.[6] The value of collateral that a participant apportions to T1 determines their T1 Net Debit Cap (T1NDC), which provides participants with a set value of intraday credit.[7] If a participant requires additional credit, it can simply pledge more collateral to the Bank.[8] As such, the T1 payment stream is similar to an RTGS system because it is fully collateralized by the sending participant.

In T2, participants grant bilateral credit limits (BCLs) to each other, which determine the maximum negative position that a participant can have vis-à-vis the grantor of the BCL. Each participant determines the value of BCLs to grant to other participants, but in practice BCL

[5] The "Principles for Financial Market Infrastructures" encourage an RTGS design, both in the explanatory notes for the credit-risk principle and in the key considerations of the settlement finality principle (CPSS-IOSCO 2012).
[6] The assets eligible for collateral, as well as corresponding haircuts and other terms and conditions, are determined by the Bank. See http://www.bankofcanada.ca/wp-content/uploads/2014/03/SLF-Policy.pdf.
[7] The T1NDC represents the maximum negative multilateral net position a participant can have in T1. A negative multilateral position means that the total value of payments sent by a participant is greater than the total value of payments received.
[8] While a participant can increase its T1NDC during the payments cycle by apportioning additional collateral, a participant can also reduce its T1NDC, but only to the extent that its multilateral net position is fully covered at the time of reduction.

values tend to be reciprocal.[9] The BCLs also determine a participant's multilateral T2 Net Debit Cap (T2NDC), which limits the total negative position a participant can have vis-à-vis all participants.[10] The T2NDC for each participant is calculated as the sum of BCLs that a participant is granted multiplied by the system-wide percentage.[11]

To secure T2 intraday credit, participants are required to pledge collateral to the Bank equal to the largest BCL it has granted, multiplied by the system-wide percentage. In that sense, the pledged collateral allows participants to more readily receive payments, which in turn provides it with a source of intraday liquidity through incoming funds.

Because participants only partially collateralize their T2 credit-risk exposure, T2 payments are less costly than T1 payments in terms of collateral requirements.[12] Table 1 compares the daily value of payments sent in each payment stream to the value of collateral pledged. On average, 32 cents worth of collateral is pledged for every dollar of T1 payment sent. This is 28 cents more, on average, than a T2 payment. It is not surprising, then, that the vast majority of payments are sent through T2. Indeed, payments sent through T1 are typically those sent to the Bank to settle payment obligations arising from other systems. In such cases, participants are often obliged to use T1 because the Bank provides only a relatively small amount of bilateral credit in T2 to each participant. T1 can also be used when insufficient collateral is available in T2 and the payment is time critical.

Table 1: Average daily payments sent and collateral pledged

	T1	**T2**	**Total**
Value of payments sent	\$39b	\$115b	\$154b
Volume of payments sent	403	32,797	33,200
Value of collateral pledged	\$12b	\$5b	\$17b
Value of collateral pledged per dollar of payment sent	\$0.32	\$0.04	\$0.11

Sources: Bank of Canada and CPA data for April 2014

In addition to pledging collateral for T1 and T2, participants may, at their discretion, pledge "excess collateral." Excess collateral serves as a buffer when additional collateral is needed on short notice. For example, a participant may need to increase its T1 credit or increase its largest BCL during the payments cycle. Excess collateral may also be used at the end of the day to collateralize an advance from the Bank to settle a final obligation.[13]

---

[9] The Bank also grants a relatively small BCL to each participant equal to 5 per cent of the sum of all BCLs granted to that participant by other participants.

[10] The T2NDC represents the maximum negative multilateral net position a participant can have in T2. A participant can adjust BCLs during the payments cycle so long as the collateral requirement is met. If a participant increases its largest BCL, it is required to apportion additional collateral. However, if a participant decreases its largest BCL intraday, its collateral requirement does not change.

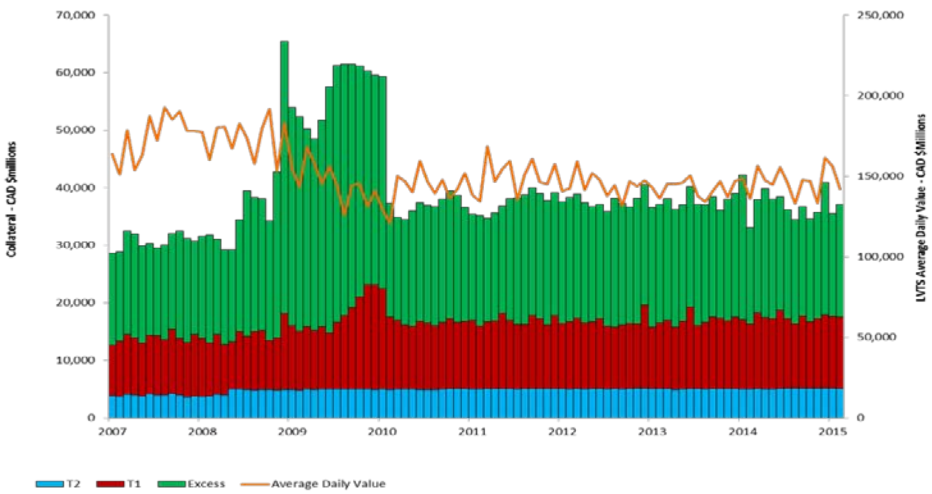
[11] The system-wide percentage is currently set at 30 per cent.

[12] In aggregate, the collateral pledged by all participants is always sufficient to cover the single largest default. This is demonstrated by Engert (1993).

[13] McPhail and Vakos (2003) discuss the motivations for maintaining excess collateral, as well as the factors that influence how much excess collateral a participant chooses to maintain.

During the financial crisis, the Bank temporarily broadened the types of assets eligible as collateral. Figure 1 shows a spike in excess collateral during that period, which reflects its use as a precautionary buffer during a period of financial instability and the greater ease of pledging additional collateral types. The Bank maintained the eligibility of some of the broadened collateral, and since 2010, excess collateral remains fairly stable as is the value of payments sent.

Figure 1: Average Value of Collateral and Daily Payments



In the event a participant defaults on its final LVTS settlement obligation at the end of the day, the Bank will provide the necessary liquidity to settle the system. To secure this advance, the Bank will immediately seize the defaulter's T1 and T2 collateral and call upon other participants (survivors) to pay an additional settlement obligation (ASO) to cover any remaining shortfall. Hence, T2 is a "survivors pay" arrangement where ASOs are determined on a pro rata basis according to the largest credit limit each survivor granted to the defaulter during the payments cycle:[14]

$$ASO_i = Shortfall \cdot \frac{BCL_{ix}}{\sum_{n=1}^{N} BCL_{nx}}, n \neq x,$$

where

- shortfall is the defaulter's remaining settlement obligation following seizure of its collateral,
- BCL_{ix} is the largest BCL granted by participant (*i*) to defaulter (*x*) during the cycle, and
- *N* is the number of LVTS participants.

[14] Since the T2 loss-allocation formula is based on the relative value of BCLs granted to the defaulter, participants have incentive to monitor other participants' creditworthiness. A participant may lower a BCL to minimize credit-risk exposure (by reducing the negative position the counterparty can incur); however, a participant is still liable for the largest BCL granted to the defaulter at any time during the payments cycle.

The maximum ASO a participant would be required to pay is equal to the T2 collateral it is already required to pledge. This is also known as a participant's MaxASO.

In the event that more than one participant defaults and the collateral pool is insufficient to cover the final net debit positions of the defaulters, the Bank will advance funds to guarantee settlement. In providing this residual guarantee, the Bank becomes an unsecured creditor for the residual amount.

Several research papers by the Bank demonstrate that a defaulter's own collateral is generally sufficient to settle the LVTS and ASOs are typically small if needed. Further, in simulated multiple-default scenarios, the Bank's residual guarantee is not frequently invoked.[15]

4. LVTS Payment Queues

The LVTS has separate queues for T1 and T2 payments. A payment will enter the T1 or T2 queue if it does not pass the applicable risk control tests (i.e., if the payment results in a net debit position that exceeds the participant's credit limit within the payment tranche) *and* the payment is above a minimum threshold value of $100 million.[16] Queued payments are resubmitted on a first-in-first-out basis when a participant's available credit increases or when they can be netted against other payments in batches as part of an algorithm that runs every 15 minutes. Unsettled payments remaining in the queue for more than 35 minutes expire and must be resent by the sending participant.

Under CPA rules, participants are encouraged to manage their liquidity and discouraged from excessive use of the payment queues. The queues are therefore used infrequently. Nonetheless, these queues are collateral savings mechanisms that serve to mitigate potential gridlock for relatively large payments.

5. Methodology

We use the Bank of Finland Simulator (modified to replicate the unique design of the LVTS) to estimate the additional collateral requirements participants could face if they were to fully collateralize all LVTS payments, similar to an RTGS. Using historical data as our base case, we estimate the collateral required for each participant by simulating T2 payments as if they were fully collateralized T1 payments. The data used in the simulations include LVTS payments and pledged collateral for each participant over the period July to December 2013 (a total of 125 business days). As shown in Figure 1, the sample period, while only six months, is fairly representative of a stable period since 2010.

---

[15] See Ball and Engert (2007) and Zhang and Hossfeld (2010).

[16] The threshold value is determined by each participant, but must be equal to or greater than $100 million – so-called "jumbo payments." Participants can also set the threshold to zero, which means no payments will be sent through the queue.

We examine two different simulation cases and compare them to the actual collateral requirements (the base case):[17]

Case 1: Full collateral coverage with unlimited credit

In Case 1, we simulate all T1 and T2 payments through the fully collateralized T1 payment stream and assume unlimited credit for each participant. Since no payments are rejected or queued, this allows us to observe the collateral that would be required to send all payments at the exact time they were actually submitted in the base case.

For each participant, we then calculate the difference between the value of collateral required in the base case (determined by a participant's maximum intraday net debit position in T1 plus its MaxASO) and the value of collateral required to cover the largest net debit position the participant experiences in the simulation.

Case 2: Full collateral coverage with credit limits and queuing

In Case 2, we simulate all T1 and T2 payments sent through the T1 payment stream, but we set credit limits for each participant. In this case, credit limits, which must be fully collateralized, are assumed to be equal to the value of T1 and T2 collateral a participant is required to pledge in the base case.

In this scenario, payments may initially be rejected because they fail to pass the risk control test (i.e., the payment causes the participant's net debit position to exceed its limit). Payments initially rejected are sent to a centralized queue. Unlike the current LVTS queue, the queue in the simulation does not require payments to be greater than a threshold value. It also incorporates a first-in-first-out bypass algorithm that will resubmit queued payments once a participant's credit increases through incoming payments or additional collateral that was pledged in the base case.[18] If the first payment in the queue is too large to be resubmitted, the algorithm will attempt to resubmit the next payment in the queue, and so on.[19] However, if a payment stays in the queue for more than 30 minutes, it will expire and finally be rejected. The queue can be considered as a centralized liquidity-saving mechanism and the likely desire by participants to reorder their payments to make better use of liquidity.

In Case 2, we account for the collateral required to cover the largest negative position the participant incurred (which is less than or equal to the credit limit) and the payments that were ultimately rejected by the queue.[20] To estimate the collateral required to cover these rejected payments, we examine the credit the participant has available at the end of the day (EOD). EOD credit is simply a participant's credit limit net its EOD position, which may be positive or negative. If the total value of rejected payments exceeds EOD credit, the participant would have to pledge additional collateral to cover the remaining rejected payments. However, if the value of

[17] The base case consists of the actual payment flows made through T1 and T2 and the associated collateral requirements.

[18] The simulation includes additional collateral a participant may have pledged intraday in the base case.

[19] The existing LVTS queue does not have a bypass feature, so if a queued payment cannot settle upon retesting, no further payments are retested.

[20] By accounting for the collateral required to cover rejected payments in Case 2, we can compare the results to Case 1, since the same number of payments are settled in both cases.

rejected payments could be covered by the EOD credit available, no additional collateral is required.[21]

6. Change in Payment Behaviour

The simulations are based on historical data and do not take into account the change in payment behaviour that would be expected if new collateral requirements were introduced. Presumably, participants would manage their liquidity differently and may, for example, wait to receive payments before sending them. As such, the results only serve to provide some insight into the potential implications of fully collateralizing existing LVTS payments. To a limited extent, however, the use of a first-in-first-out bypass queue in the simulations partially reflects a participant's decision to reorder payments according to available liquidity.

7. Simulation Results

Simulation results are provided for the system as a whole, and for large (6) and small participants (9), as determined by payments value.

Case 1

Recall that in Case 1, all payments are sent through T1 at the same time they were submitted in the base case and participants have unlimited credit. This provides a simulation of the amount of collateral participants would need to send all payments through T1 at the original submission times. Compared to the base case, the results indicate that the average daily value of collateral increased by $396 million for the system as a whole (Table 2).

Table 2: Change in daily collateral requirements

	Average daily ($ million)	Minimum ($ billion)	Maximum ($ billion)	St. dev. ($)
System-wide	+ 396.2	- 7.6	+ 4.1	+ 893.3m
Large (6)	+ 758.5	- 7.6	+ 4.1	+ 1.2b
Small (9)	+ 154.8	- 1.3	+ 2.2	+ 503.1m

The results in Table 2 also show that, on certain days, some participants actually see a decrease in the amount of collateral required. While this may seem counterintuitive, a reduction in collateral can occur if there is increased netting when the T1 and T2 payment streams are

[21] This approach leads to an overestimation of collateral because it does not account for the fact that if a participant pledges additional collateral to cover their rejected payments, the recipients of those payments would benefit from an increase in their own net position. These recipients would therefore require less collateral if they needed to cover any of their own rejected payments.

combined and/or when a participant pledges collateral in the base case that is higher than what the actual payment flows would demand. Recall that in T2, participants essentially collateralize the credit they extend to other participants, which in turn can be a source of liquidity through incoming payments.[22] The simulation, however, reveals that for some participants, providing this credit to other participants is less optimal than collateralizing their own individual payments. In other words, providing credit in the base case can be more of a cost than benefit for some participants.

On average, large participants experience an increase in collateral on 82 per cent of the days in the sample, while small participants do so on 46 per cent of the days (Table 3). The average value of an increase (given an increase has occurred) is higher for large participants ($1.1 billion) compared to small participants ($478 million). This result indicates that the large participants are making more efficient use of the current LVTS collateral design by sending a greater value on credit.

Table 3: Increases in collateral requirements

	% of days increased	Average daily Increase ($)	Median daily increase ($)	Minimum Increase ($)	Maximum Increase ($)	St. dev. ($)
Large (6)	82	1.1b	1.0b	7.1m	4.1b	733.7m
Small (9)	46	478.3m	159.3m	300.8k	2.2b	559.3m

The results indicate a fair amount of variation between participants in the sample, reflecting differences in their liquidity management. Similarly, some participants experience high daily variation, reflecting variation in their own daily liquidity management.

To gauge whether participants could manage the simulated collateral requirements, we compare Case 1 results to the collateral pledged in the base case (Table 4). For small participants, Case 1 collateral required represents, on average, 93 per cent of the collateral pledged to T1 and T2 in the base case and is sufficient on 72 per cent of the days in the sample. However, for large participants, the amount of collateral required in Case 1 represents, on average, 152 per cent of the collateral pledged to T1 and T2 in the base case and is sufficient on only 35 per cent of the days. When Case 1 collateral requirements are compared to total collateral pledged in the base case including excess collateral, both large and small participants can meet the Case 1 collateral requirements for the majority of the days in the sample (84 per cent and 86 per cent of the days, respectively).

[22] The decision to grant a BCL is not only influenced by expected payment flows but also other factors including the creditworthiness of the counterparty. In addition, participants pledge collateral to T1 at the beginning of the payments cycle according to how much T1 credit they *expect* to use during the day. It is possible that not all of this credit is always fully utilized.

Table 4: Case 1 collateral requirements relative to the base case

	% of base case collateral	% of days base case collateral sufficient	% of base case collateral including excess	% of days base case collateral including excess sufficient
Large (6)	152	35	60	84
Small (9)	93	72	45	86

Another way to observe the effect of full collateralization across participants is to examine the collateral required for every dollar of payment sent. When compared to the base case, some participants face a relatively large increase (Table 5). For example, Participants A, B and C pay approximately 20 cents more per dollar than in the base case. On the other hand, participant N saves 45 cents for every dollar sent and participants G and H face no change, on average. Indeed, most of the large participants (denoted in blue) face an increase, while most of the small banks actually see a decrease. We note, however, that the results are not perfectly correlated with participant size, since participants can vary by how efficiently they manage their liquidity in the base case. For the system as a whole, there is an overall increase of 5 cents for every dollar sent.

Table 5: Collateral required per dollar of payment sent

Participant*	Case 1	Base case	Case 1 – Base case
A	$0.34	$0.12	$0.22
B	$0.33	$0.13	$0.20
C	$0.38	$0.20	$0.18
D	$0.15	$0.08	$0.08
E	$0.12	$0.07	$0.04
F	$0.09	$0.06	$0.03
G	$0.20	$0.21	$0.00
H	$0.08	$0.08	$0.00
I	$0.19	$0.21	-$0.02
J	$0.16	$0.17	-$0.01
K	$0.11	$0.19	-$0.09
L	$0.20	$0.30	-$0.10
M	$0.20	$0.36	-$0.17
N	$0.08	$0.53	-$0.45
System-wide	$0.13	$0.08	+$0.05

*Large participants are denoted in blue.

Case 2

In Case 2, participants are assigned a credit limit equal to the T1 and T2 collateral they were required to pledge in the base case. If a payment is submitted when there is insufficient credit available, it will enter the queue. A queued payment will either pass the risk control when more credit is available, or it will be rejected if it cannot pass within 30 minutes.

In general, large participants have a higher value of rejected payments than small participants (Table 6), which is understandable since large participants tend to send more payments and may require more credit. The value of rejected payments for each participant is compared to the credit they have at the EOD. When EOD credit is sufficient to cover rejected payments, we assume a participant would reorder their payments and send them later in the day. If EOD credit is insufficient, we assume additional collateral would be pledged in order to resend the rejected payments. When comparing the value of rejected payments to EOD credit, we find that the vast majority of rejected payments can be settled without additional collateral.[23]

Table 6: Rejected payments

	Average daily value of rejected payments* ($ million)
System	10.0
Large (6)	21.6
Small (9)	2.2

*Including zeros

In Table 7, the average daily collateral required in Case 2 is compared to the base case. In this scenario, the system as a whole sees a decrease in collateral requirements (-$4.6 million). Large participants, however, face an increase in daily collateral requirements, on average ($55.3 million), but the increase is much smaller than in Case 1 ($758.5 million). Small participants tend to see a reduction in daily collateral requirements (-$44.5 million) compared to the base case. This is in contrast to Case 1, where smaller participants actually face an average increase ($154.8 million).

[23] In fact, only one participant on one day in the sample required additional collateral to cover rejected payments.

Table 7: Change in daily collateral requirements

	Average daily ($ million)	Minimum ($ billion)	Maximum ($ billion)	St. dev. ($ million)
System	-4.6	- 6.8	+ 1.7	526.8
Large (6)	+ 55.3	- 6.8	+ 1.7	802.0
Small (9)	- 44.5	- 1.1	+ 0.9	173.1

Relative to Case 1, both large and small participants face an increase in collateral requirements less often, and face much smaller average increases (Table 8). This suggests that queuing is effective for reducing the collateral requirements for both small and large participants.

Table 8: Increases in collateral requirements

	% of days increased	Average daily Increase	Median daily increase	Minimum increase	Maximum increase	St. dev.
Large (6)	66	$396.3m	$334.5m	$330.4	$1.7b	$138.5m
Small (9)	33	$80.7m	$23.1m	$70.4k	$858.0m	$1825k

In Case 2, both small and large participants are almost always able to meet the collateral requirements when compared to collateral that is currently pledged in the base case, with or without excess collateral (Table 9). For large participants, this is an improvement from Case 1, where base case collateral was more often insufficient to meet the increase in collateral requirements.

Table 9: Case 2 collateral requirements relative to the base case

	% of base case collateral	% days base case collateral sufficient	% base case collateral including excess	% days base case collateral including excess sufficient
Large (6)	81	98	35	100
Small (9)	58	100	29	100

Again, we can examine the collateral needed for each dollar of payment sent and compare it to the base case and Case 1 (Table 10). Most participants are better off in Case 2 than in Case 1, particularly participants A and B. Participant M also stands out because it sees even greater savings in Case 2 than in Case 1. For the system as a whole, the net effect of Case 2 is zero.

Table 10: Collateral required per dollar of payment sent

Participant*	Case 2	Base case	Case 2 – Base case	Case 1 – Base case
A	$0.12	$0.12	$0.01	$0.22
B	$0.09	$0.13	-$0.04	$0.20
C	$0.37	$0.20	$0.17	$0.18
D	$0.11	$0.08	$0.04	$0.08
E	$0.06	$0.07	-$0.01	$0.04
F	$0.06	$0.06	$0.00	$0.03
G	$0.22	$0.21	$0.01	$0.00
H	$0.07	$0.08	-$0.01	$0.00
I	$0.13	$0.21	-$0.08	-$0.02
J	$0.17	$0.17	$0.00	-$0.01
K	$0.09	$0.19	-$0.11	-$0.09
L	$0.20	$0.30	-$0.10	-$0.10
M	$0.10	$0.36	-$0.27	-$0.17
N	$0.08	$0.53	-$0.45	-$0.45
System-wide	$0.08	$0.08	$0.00	+$0.05

*Large participants are denoted in blue.

8. Policy Considerations

Under the current LVTS design, participants pledge collateral in order to extend credit to other participants in the system. This allows participants to more readily receive payments earlier in the day, which becomes a source of liquidity to fund their own payments. If LVTS participants were to collateralize their own credit at a greater cost, they may delay payments and wait for the additional liquidity from incoming funds. Delaying payments could potentially lead to gridlock if other participants also delay their payments. Perlin and Schanz (2011) explore how a “receipt-reactive” payments strategy, where a participant sends payments only after receiving payments so as to never need to draw on credit, can impact the liquidity of other participants in the United Kingdom’s large-value payment system. Perlin and Schanz find that unless other participants revise their payment behaviour, at least one participant will become illiquid within one hour. The impact is greater the larger the participant withholding payments. Since our simulations show that large participants face higher collateral costs, we expect that if the LVTS were fully collateralized, large participants would be more likely to delay their payments.

If the LVTS were fully collateralized, however, various liquidity-saving mechanisms could be considered, including more advanced queuing algorithms.[24] The large-value payment system in the United Kingdom, for example, uses batch matching cycles, which allows for the offsetting of the majority of queued payments (Bank of England 2012). Further, to mitigate the potential for payment delay and gridlock, other measures could be considered, including throughput rules and a fee structure that encourages payments to be sent earlier in the day. The simulations presented in this paper demonstrate that queuing can reduce the increase in collateral requirements associated with full collateralization.

Further analysis could be performed to compare the effects of different liquidity-saving mechanisms. Consideration of more advanced queuing and other liquidity-saving mechanisms is important because participants may also face increases in collateral demands outside the LVTS. However, those participants that, in the simulation, see a decrease in collateral requirements could find themselves in a position to move the collateral they had been pledging to the LVTS to other purposes.

Another interesting policy consideration is the need for the Bank of Canada's residual guarantee. The Bank's guarantee is integral to the LVTS because it provides assurance that credit risk is fully covered while allowing for liquidity efficiency. However, our results show that LVTS may not necessarily be more efficient for all participants. Indeed, if LVTS participants were to fully collateralize their own credit exposure, the Bank's guarantee would no longer be needed. Further analysis must therefore consider whether the Bank's guarantee is still required under a new system design.

9. Conclusion

Our results indicate that if the LVTS were fully collateralized, some participants could face increases in collateral costs while others could see collateral savings. We also find that the introduction of a queuing mechanism with a bypass function allows for greater collateral savings at a system-wide level. In some ways, queuing can be seen as reflecting a slight change in participants' behaviour in terms of the time at which they submit payments as a means to optimize available liquidity or a centralized liquidity-saving mechanism.

Given that some participants could be better off in a fully collateralized system than the current LVTS design, these results serve as a starting point for further analysis. There are additional policy considerations the Bank and the CPA would need to review when considering a change to LVTS collateralization, particularly as it relates to the Bank's residual guarantee and other policies that could reduce the incentive to delay and offer liquidity-saving mechanisms under a fully collateralized design.

[24] Atalay et al. (2010) and Martin and McAndrews (2008) analyze several liquidity-saving mechanisms.

References

Arjani, N. and D. McVanel. 2006. “A Primer on Canada’s Large Value Transfer System.” Available at http://www.bankofcanada.ca/en/financial/financial_ref.html.

Atalay, E., A. Martin, and J. McAndrews. 2010. “The Welfare Effects of a Liquidity-Saving Mechanism.” Federal Reserve Bank of New York Staff Report No. 331 (June 2008, Revised January 2010).

Ball, D. and W. Engert. 2007. “Unanticipated Defaults and Losses in Canada’s Large-Value Payments System, Revisited.” Bank of Canada Discussion Paper No. 2007-5.

Bank of England. 2012. “Quarterly Bulletin 2012 Q3.” Available at http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/qb120304.pdf.

Committee on Payment and Settlement Systems (CPSS). 2003. “A Glossary of Terms Used in Payments and Settlement Systems.” March.

Committee on Payment and Settlement Systems and the Technical Committee of the International Organization of Securities Commissions (CPSS-IOSCO). 2012. “Principles for Financial Market Infrastructures.” April.

Engert, W. 1993. “Certainty of Settlement and Loss Allocation with a Minimum of Collateral.” Bank of Canada Working Paper No. 1993-14.

Martin, A. and J. McAndrews. 2008 “A Study of Competing Designs for a Liquidity-Saving Mechanism.” Federal Reserve Bank of New York Staff Report No. 336 (July).

McPhail, K. and A. Vakos. 2003. “Excess Collateral in the LVTS: How Much is Too Much?” Bank of Canada Working Paper No. 2003-36.

Perlin, M. and J. Schanz. 2011. “System-Wide Liquidity Risk in the United Kingdom’s Large-Value Payment System: An Empirical Analysis.” Bank of England Working Paper No. 427.

Zhang, N. and T. Hossfeld. 2010. “Losses from Simulated Defaults in Canada’s Large Value Transfer System.” Bank of Canada Discussion Paper No. 2010-14.