High-Frequency Analysis of Financial Stability

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Motivation

• Large-value payment systems are fundamental for the financial system
  ▶ Quadrillions in annual transfers
  ▶ Designated by regulators as systemically important in all countries

• Efficiency-stability trade-off in the design of a payment system
  ▶ Using collateral reduces risk but is costly
  ▶ Using credit saves on collateral, but introduces risk

• Canada’s large value payment system is unique in the world
  ▶ Allows banks to choose collateral-based or credit-based payments
  ▶ Very efficient, high level of trust, relies mostly on intraday credit
  ▶ Argued to function normally during the crisis
  ▶ If adopted by other countries can save trillions of collateral

• We evaluate Canada’s LVTS financial stability
  ▶ Develop new high-frequency measures of intraday liquidity risk
  ▶ Rely on more than 500 trillion CAD of payments
  ▶ Utilize second-by-second intraday evolution of payments, credit limits, and collateral
THE ROLE OF A PAYMENT SYSTEM IN THE ECONOMY

**Figure:** An Illustration of a Financial System
Payment System Design: Efficiency-Stability Trade-Off

- **Real Time Gross Settlement System (RTGS):**
  - each payment is fully collateralized (high stability, low efficiency)
  - stable, but inefficient because requires collateral

- **Deferred Net Settlement System (DNS):**
  - each payment draws on a credit line (high efficiency, low stability)
  - ultra-short counterparty risk with ultra large losses given default
  - EURO1 in Europe (€50 trillion in 2015).

- **A Hybrid system (HS) attempts to combine RTGS’s stability with DNS’s efficiency**
  - banks decide in real-time whether to use collateral (like RTGS) or credit limits (like DNS) when sending payments. Banks adjust credit limits in real-time.
  - The only HS in the world is Canada’s LVTS ($43 trillion CAD in 2015)
Main Insights

- **Intraday liquidity shortage can cause a systemic risk**
  - The systemic risk in Canada’s LVTS is global because of the international participants and critical payments to other systems (e.g., CLS)
  - Requires a real-time monitoring to allow for a timely intervention

- **Need high-frequency measures to identify high-frequency systemic risk**
  - Bilateral credit limits can be cut any second, if not enough collateral payments are rejected/delayed
  - A flash crash in credit limits can me more severe than a slow change because less predictable and less time to respond
  - Credit limits can change for non-fundamental reasons

- **Efficiency-stability trade-off in a hybrid system vs. RTGS**
  - If enough excess collateral to operated without credit then no efficiency benefit relative to RTGS
  - If not enough excess collateral at the system or bank levels, then less stable than RTGS because of rejected payments
**LVTS Description**

- **Payments**: large-value or and time-sensitive (e.g. interbank loans; settlement of FX derivatives). Payments are processed continuously.

- **Collateral vs. Credit**: Banks can send payments either via Tranche 1 (T1) or Tranche 2 (T2). T1 requires collateral. T2 utilizes bilateral credit limits (BCLs). Collateral & BCLs are set at the beginning of the day and are updated intraday.

- **Default**: If a bank defaults, losses are allocated to surviving banks proportional to max intraday BCL they granted to the failing bank. Bank of Canada covers losses beyond the first default.
The Data

- **Payment-level info**: size, sender, receiver, tranche, jumbo ($\geq 100M$ CAD), time (sent/settled), bank/customer (2013-2014), success/failure.

- **Bank-level info**: bilateral credit limits (interday/intraday), collateral (interday/intraday), payment flows (interday/intraday).

- **Participants**:
  - The big six Canadian banks: RBC, CIBC, TD, Bank of Nova Scotia, Bank of Montreal, National Bank of Canada
  - Four foreign banks: HSBC, BNP Paribus, Bank of America, State Street
  - Four other participants: La Caisse Centrale Desjardins Du Quebec, ATB Financial, Laurentian Bank of Canada, and Central 1 Credit Union.
  - The Bank of Canada
## Summary Statistics

<table>
<thead>
<tr>
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<th>2003 - 2017 Mean</th>
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<tbody>
<tr>
<td><strong>Annual volume (million)</strong></td>
<td>5.84</td>
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<tr>
<td>T2 (credit-based)</td>
<td>98.56%</td>
</tr>
<tr>
<td>T2 without Bank of Canada (credit-based)</td>
<td><strong>99.44%</strong></td>
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<tr>
<td>Jumbo (≥ 100M CAD)</td>
<td>1.46%</td>
</tr>
<tr>
<td>Non-Jumbo</td>
<td>98.54%</td>
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<tr>
<td>Customers’ payments (2013-2014)</td>
<td>63.37%</td>
</tr>
<tr>
<td>Bank’s payments (2013-2014)</td>
<td>36.63%</td>
</tr>
<tr>
<td><strong>Annual value (trillion CAD)</strong></td>
<td>36.61</td>
</tr>
<tr>
<td>T2 (credit-based)</td>
<td>82.11%</td>
</tr>
<tr>
<td>T2 without Bank of Canada (credit-based)</td>
<td><strong>89.85%</strong></td>
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<tr>
<td>Jumbo (≥ 100M CAD)</td>
<td>61.07%</td>
</tr>
<tr>
<td>Non-Jumbo</td>
<td>38.93%</td>
</tr>
<tr>
<td>Customers’ payments (2013-2014)</td>
<td>22.17%</td>
</tr>
<tr>
<td>Bank’s payments (2013-2014)</td>
<td>77.83%</td>
</tr>
</tbody>
</table>
Systemic Risk from Failure to Process Payments

- Binding credit limits (in the extreme case all credit limits are reduced to zero)
  - A payment needs to pass both multilateral and individual credit constraints

- Binding collateral constraints
  - If firms have excess collateral at the Bank of Canada they can use it to relax the constraint. Any additional collateral cannot be injected during the same day.

- If both credit limits and collateral constraints are binding payments are delayed/rejected.
  - Rejected critical payments can cause a (global) crisis
Our High-Frequency Risk Measures

- Binding credit or collateral constraints
  - Rejected payments
  - Delayed payments
  - Slack in the constraints
  - Intuition: when constraints are binding, payments cannot be processed → systemic risk

- Intraday changes in bilateral credit limits (BCLs)
  - Difference between end of the day and beginning of the day aggregate BCLs
  - Volatility of intraday changes in aggregate BCLs
  - Intuition: when the risk is high, banks adjust BCLs intraday

- Fraction of credit-based payments: \( \frac{T2}{T1+T2} \)
  - If the ratio is 1 then all payments rely on credit (high level of trust)
  - If the ratio is 0 then all payments rely on collateral (lack of trust)
  - The risk is in an abrupt drop in the ratio
  - Intuition: if trust evaporates and not enough collateral, payments freeze.
CURRENT VIEW ABOUT PAYMENT SYSTEMS IN 2007-2008

- **Canada**: “our payments system has **functioned smoothly** and reliably, despite the **enormous shocks** to our financial system over the past two years” (Mark Carney, former governor of the Bank of Canada, on March 30, 2009).

- **US**: ”The U.S. payment and settlement systems continued to **function smoothly** during the 2007-2008 period of **market stress**.” (IMF Report, May 2010)

- **Europe**, Banque de France report (Q1, 2009):
  - ”During the financial crisis of the last few months, transfer systems have been faced with **extreme, even unprecedented, operating conditions** ...”
  - ”... transfer systems continued to **function well**, which is very positive given their importance for financial stability.”
  - ”the crisis has helped us to become fully aware of the **significance and scale of the interdependencies between transfer systems**.”
Rejected Payments

Figure: Number of Rejected Payments Due to Binding Credit Limits or Collateral Constraints
Rejected Payments to the Bank of Canada

**Figure:** Number of Rejected Payments Due to Binding Credit Limits or Collateral Constraints
Intraday BCL Adjustments ($\Delta BCL$)

Billion CAD

- Blue line: $\Delta BCL$
- Red line: 30-days moving average

High-Frequency Analysis of Financial Stability
Michael Gofman, University of Rochester
Volatility of Intraday BCL Adjustments

blue line: 30-days rolling std. dev. of $\Delta BCL$
A DAILY FRACTION OF CREDIT-BASED TRANSACTIONS \([T2/(T1+T2)]\)
LVTS and Lehman’s Failure

September 15, 2008
- 4 payments with total value of $160M CAD by Bank 10 to three other banks fail risk controls and get rejected.
- Delays in settlement of T1 (binding collateral constraint) and T2 (binding credit limit) valued $5B CAD.
- The only delayed T1 payment in September 2008.

September 16, 2008
- 32 payments with total value of $163M CAD by Bank 1 to seven other banks fail risk controls and get rejected.
- Delays in settlement of T2 payments valued $4.5B CAD, $2.8B sent by Bank 1.
- Bank 6 temporary increased a BCL to Bank 1 by $200M CAD.
SECOND-BY-SECOND ANALYSIS OF LVTS DAY AFTER LEHMAN’S FAILURE

**Figure:** Bank 1 experiences stress on September 16th, 2008
Flash Crash in 2008

Day 1: Bank A reveals large losses linked to the US sub-prime mortgages market.

Day 2: Bank A cuts credit limits to six banks by 20%
- From 13:14pm to 13:52pm, one of the six banks, Bank H, experiences 30 rejected payments
- Bank A & Bank H significantly delay sending T1 payments.
- In total, 10 T2 jumbo payments of $8B by three banks are queued and settled with an average delay of 10 minutes. Bank H experiences the longest delay of 38 minutes on its $500M payment.

Days 3-4: Three of the six banks reciprocate by cutting credit limits by 20%
- One jumbo T1 payment is queued and rejected. In total, 27 T2 jumbo payments of $19B are queued and delayed, 1 queued and rejected.
- Bank J temporary increases standing BCL to Bank B by 167%.

Without high frequency data: (1) the flash crash would not be observed as it lasted only several days, (2) we could conclude that the original write-down caused credit limits reduction to this bank.
Bank of Canada Interventions During the Crisis

Collateral in LVTS:

- **March, 2008**: expansion in the class of acceptable collateral, such as ABCP, that is used by LVTS participants to secure intraday liquidity
- **June, 2008**: allowing U.S. Treasury securities to be used as collateral
- **October, 2008 - March 2010**: further expansion in the class of acceptable collateral to include the Canadian-dollar non-mortgage loan portfolios (NMLP) of LVTS direct participants
- **February, 2009**: investment-grade corporate bonds added to the list of acceptable collateral

Other Interventions:

- **December 2007 - July 10, 2008**: purchase and resale agreements (PRAs)
- **May 1, 2008**: system wide percentage in LVTS is increased from 24% to 30%, increases throughput of credit-based payments by 25%
- **September, 2008**: resumption of term PRAs
- **November, 2008**: term loan facility at a penalty rate for LVTS direct participants secured by NMLP
Aggregate Value of Pledged Collateral

- **blue line**: daily aggregate collateral
- **red line**: 30-days moving average

- Intervention during the crisis substantially increased the amount of collateral
Policy Implications

- The frequency of the risk measures should match the frequency of the risk that they are trying to capture.
  - Real-time monitoring is required to allow real-time intervention.
  - Stress tests by a central bank should evaluate whether banks have enough collateral to process payments without disruption.

- Binding credit or collateral constraints constitute risk that (critical) payments will be delayed or rejected.
  - A transition from binding credit constraints to binding collateral constraints can happen instantaneously.
  - Not only the aggregate collateral matters, but also who holds this collateral.

- Central bank’s policy about acceptable collateral is an important regulatory tool, especially in a hybrid payment system
  - A timely injection of new collateral to the system can avoid systemic risk.
  - Accepting lower quality collateral transfers risk to the central bank.
CONCLUSION

- Most of the payments in Canada’s LVTS rely on credit, saving the need for collateral. [Higher efficiency]

- Our high-frequency stability measures show that Canada’s LVTS faces a risk of failed payments if credit lines and collateral constraints are binding. [Lower stability]

- We highlight an important efficiency-stability trade-off in a hybrid payment system by relying on high frequency analysis of Canada’s LVTS.