

# Quantifying the Economic Benefits of Payments Modernization: The Case of Large Value Payment System

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# Motivation

- ▶ The major payment systems in Canada
  - ▶ Large value transfer system (LVTS): as a wholesale payment system for the processing of large value and time-critical payments, with the BoC's residual value guarantee.
  - ▶ Automated clearing settlement system (ACSS): as a retail payment system for the processing of relatively small value payments.
- ▶ Payments modernization in Canada
  - ▶ The modernized ecosystem: fast, flexible, and secure, promotes innovation and strengthens Canada's competitive position

# Motivation

- ▶ Payments modernization overview
  - ▶ Lynx, a real-time-gross-settlement system for large value payments, is replacing LVTS
  - ▶ SOE (tentative name), a deferred-net-settlement system for less urgent lower-value payments, is replacing ACSS
  - ▶ RTR, a payment system for real-time processing of small-value payments.
  - ▶ The use of the ISO 20022 payment messages standard for all payments systems

# Motivation

- ▶ To understand the economic impact of the payment modernization, it is critical to answer such a research question:
  - ▶ what are the economic benefits to participants from the payments modernization?
- ▶ Very limited work that quantifies the economic benefits because it is a challenge in using an economic model to quantifying the benefits (Arjani,2015)
- ▶ As an initial step in quantifying the full range of the economic benefits, we focus on quantifying the economic benefits from the replacement of LVTS with Lynx

## Related literature

- ▶ Using the discounted cash flow analysis, Arjani (2015) examines the benefits of adopting ISO 20022 in the following aspects:
  - ▶ Improved efficiency in payments process
  - ▶ Enhanced domestic and global interoperability
  - ▶ Opportunity for innovation throughout the payments value chain
  - ▶ The estimated economic benefits of adopting ISO 20022 could be as high as 4.5 billion over 5 years
- ▶ However, it is important to investigate the economic benefits generated from other components in the payments modernization, e.g., the ways that settlement take places, and credit risk management, etc.

# Contribution

- ▶ Propose an empirical framework for quantifying the economic benefits arising from the replacement of LVTS with Lynx
  - ▶ The framework depends on the estimation of a random payoff model that highlights two important aspects: liquidity cost and liquidity risk
  - ▶ Discrete choice approach (Berry et al. 1995) is used to estimate the random payoff model
- ▶ Based on the estimated results, we conduct counterfactual analyses to predict how the economic benefits will change from the replacement

## Overview of the Methodology

- ▶ Specify the random payoff model associated with a participant of sending a payment through a given payment system, which depends on
  - ▶ key characteristics of the payment system
  - ▶ observed market characteristics
  - ▶ unobserved market and payment system characteristics
- ▶ Estimate the random payoff using high-frequency LVTS data
- ▶ Evaluate the random payoff based on the characteristics of the Lynx, the new payment system
- ▶ Calculate the welfare change when we replace LVTS with Lynx.

# Data Overview

- ▶ Main data source: LVTS transaction data of 2019
  - ▶ observables of each transaction (payment): value, timing, sending/receiving financial institution (FI), system choice (Tranche 1 or 2)
  - ▶ each FI's intra-day liquidity positions in Tranche 1 & 2: bilateral and/or multilateral credit limits (determined by collateral), payment income/demand (constructed from transaction data)



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- ▶ Supplementary data: daily, bilateral (sending and receiving FI) total value/volume of ACSS payments in 2019

# Sample Construction

- ▶ Basic logic
  - ▶ outcome variable: the choice of systems, i.e., T1, T2 and "outside option"
  - ▶ explanatory variables: characteristics of payment systems (and payments themselves)

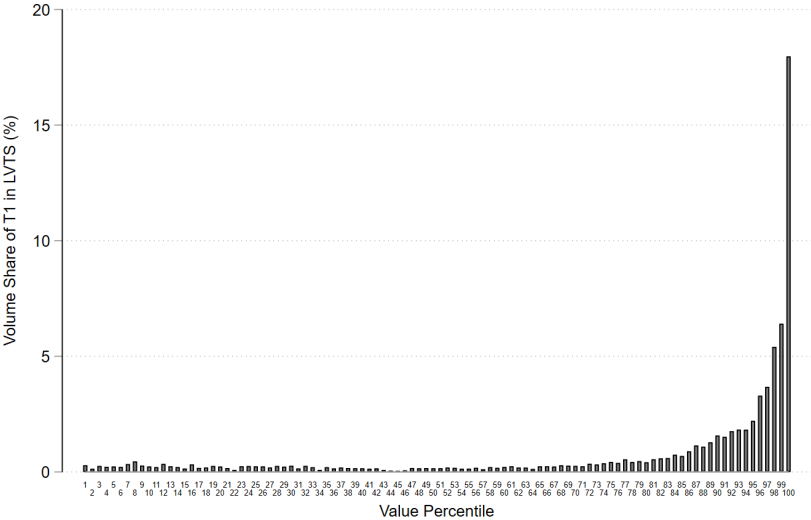
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- ▶ Measure of choice probabilities: market (volume) shares of T1/T2/outside option
  - ▶ market definition: sender-receiver-hour(in a day)-value percentile
  - ▶ outside share: calibrated from ACSS data, adjusted to match an average LVTS transaction in a given market

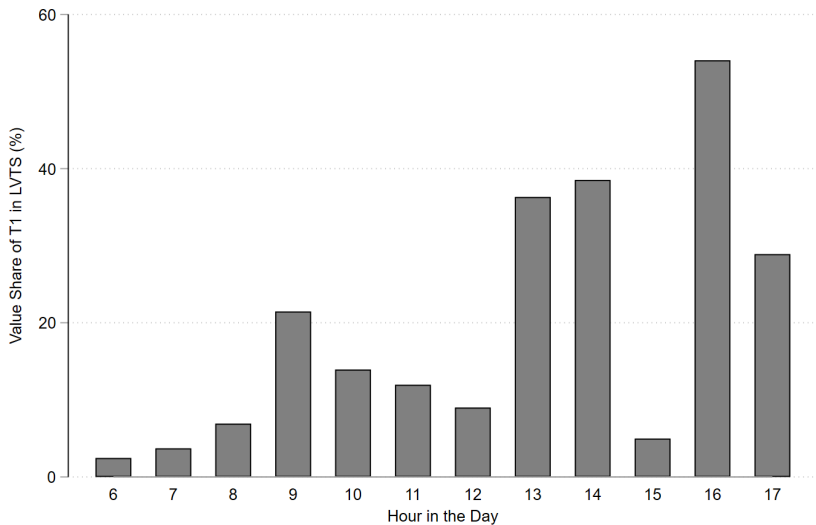
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- ▶ Payment system characteristics: factors that a payment “considers” when “choosing” a system, e.g., liquidity cost and safety (or risk)

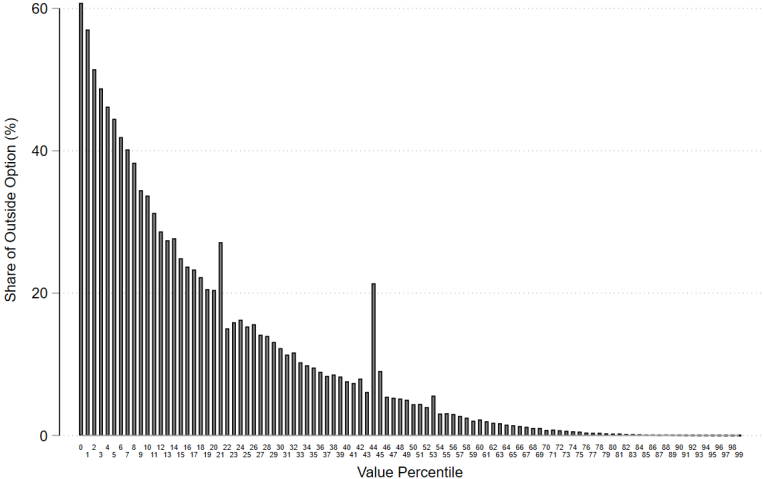
# Value Distribution of LVTS Payments



# Intra-day Distribution of LVTS Payments



# Outside Share



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  - ▶ Chapman, Kosse, Rivadeneyra (with CPMI)'s recent work addresses this problem by pooling data from different jurisdictions
- ▶ Here we exploit intra-day variations in LVTS data and construct payment-varying characteristics of T1 and T2.

## Liquidity Cost Measure

- ▶ liquidity cost of settling payment  $i$  in system  $j \in \{T1, T2\}$  (given that the payment can pass the risk-control tests)

$$\varphi_{i,j} \cdot \max \{V_i - NI_{i,j}, 0\}$$

- ▶  $V_i$ : value of the payment
- ▶  $NI_{i,j}$ : the net payment income (of the same sender) before payment  $i$  in system  $j$
- ▶  $\varphi_{i,j}$ : a cost factor measuring liquidity cost in terms of collateral spending
  - ▶  $\varphi_{i,T1} = 1$ : \$1 collateral required for spending \$1 credit limit (T1NDC)
  - ▶  $\varphi_{i,T2} = \frac{MaxASO_{i,T2}}{T2NDC_{i,T2}}$ : (daily average) how much collateral required for spending \$1 credit limit (T2NDC)

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$$\frac{NI_{i,T1} + CL_{i,T1} + RPI_{i,T1}}{RPD_{i,T1} + V_i}$$

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- ▶ numerator: total liquidity supply of the day
- ▶ denominator: total liquidity demand for the remaining of the day (right before payment  $i$ )
- ▶ safety indicator for payment  $i$  in T2

$$\min \left\{ \frac{NI_{i,T2} + CL_{i,T2} + RPI_{i,T2}}{RPD_{i,T2} + V_i}, \frac{BNI_{i,T2} + BCL_{i,T2} + BRPI_{i,T2}}{BRPD_{i,T2} + V_i} \right\}$$

# Random Payoff Model

- ▶ for a payment  $i$  in “market”  $m$ , the (random) payoff to the associated participants of sending it through system  $j \in \{T1, T2, 0\}$  is

$$\begin{aligned}\pi_{i,j,m} &= \alpha P_{j,m} + \beta SI_{j,m} + \gamma \bar{s}_{j,m} \\ &\quad + X_m \rho + \xi_{j,m} + \zeta_{i,g,m} + (1 - \lambda) \varepsilon_{i,j,m}\end{aligned}$$

- ▶  $P_{j,m}$ : log of value-weighted average of liquidity cost in  $m$
- ▶  $SI_{j,m}$ : log of value-weighted average of safety index in  $m$
- ▶  $\bar{s}_{j,m}$ : total market share of system  $j$  of the sender, capturing certain “network effect”
- ▶  $X_m$ : other observed market characteristics
- ▶  $\xi_{j,m}$ : unobserved system/market characteristics
- ▶  $\zeta_{i,g,m} + (1 - \lambda) \varepsilon_{i,j,m}$ : preference shock following nested-logit structure (two nests:  $\{T1, T2\}$  and 0)

# Estimation of the Model

- ▶ Based on the model, we can derive the estimation equation

$$\log \left( \frac{s_{j,m}}{s_{0,m}} \right) = \alpha P_{j,m} + \beta SI_{j,m} + \gamma \bar{s}_{j,m} + \lambda \log (s_{j|g,m}) + X_m \rho + \xi_{j,m}$$

- ▶  $s_{j,m}$  is the volume share of  $j$  in market  $t$
- ▶  $s_{j|g,m}$  is the within-group share of  $j$  in market  $t$



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- ▶  $s_{j,m}$  is the volume share of  $j$  in market  $t$
- ▶  $s_{j|g,m}$  is the within-group share of  $j$  in market  $t$
- ▶ Mean independence assumption:  $E[\xi_{j,m}|Z_{j,m}] = 0$ 
  - ▶ IV for endogenous variable  $\log(s_{j|g,m})$  and  $\bar{s}_{j,m}$ : average of the same variable in "adjacent" markets

# Estimation Results

	Simple Logit		Nested Logit	
			Without IV	With IV
Liquidity Cost	0.564 (0.00250)	-0.0443 (0.00467)	-0.0220 (0.00440)	-0.0299 (0.00438)
Safety Index	0.0154 (0.00248)	0.0246 (0.00187)	0.0264 (0.00181)	0.0202 (0.00180)
Network Effect	6.191 (0.0175)	9.788 (0.260)	6.001 (0.223)	1.549 (0.117)
Nesting Parameter			0.515 (0.00775)	0.724 (0.0218)
Constant	-8.140 (0.0335)	-7.082 (0.130)	-5.262 (0.123)	-4.522 (0.157)
Sender FE		✓	✓	✓
Receiver FE		✓	✓	✓
Hour FE		✓	✓	✓
Value Pctile FE		✓	✓	✓
Cragg-Donald Wald F				7869.96
# Obs.	104,707	104,707	104,707	100,350
Adj. $R^2$	0.712	0.903	0.909	0.913

Note: Robust standard errors in parentheses, \*\*\*  $p < 0.01$ .

# Welfare Calculation: Economic Benefits to Participants

- ▶ Welfare change calculation

$$\Delta EB = \frac{\sum_m V_m \left\{ \log[1 + \exp(\delta_{Lynx,m})] - \log \left[ 1 + \left( \exp\left(\frac{\hat{\delta}_{T1,m}}{1-\lambda}\right) + \exp\left(\frac{\hat{\delta}_{T2,m}}{1-\lambda}\right) \right)^{1-\lambda} \right] \right\}}{\hat{\alpha}}$$

- ▶ LVTS (for  $j = T1$  or  $T2$ ):

$$\hat{\delta}_{j,m} = \hat{\alpha}P_{j,m} + \hat{\beta}SI_{j,m} + \hat{\gamma}\bar{s}_{j,m} + X_m\hat{\rho} + \hat{\xi}_{j,m}$$

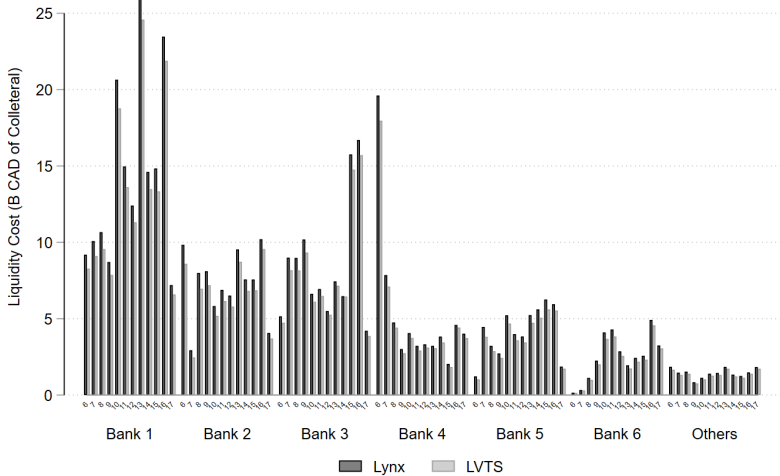
- ▶ Lynx:

$$\delta_{Lynx,m} = \hat{\alpha}P_{Lynx,m} + \hat{\beta}SI_{Lynx,m} + \hat{\gamma}\bar{s}_{Lynx,m} + X_m\hat{\rho} + \hat{\xi}_{Lynx,m}$$

- ▶ We do not know  $\bar{s}_{Lynx,m}$  and  $\hat{\xi}_{Lynx,m}$ , so need assumptions:

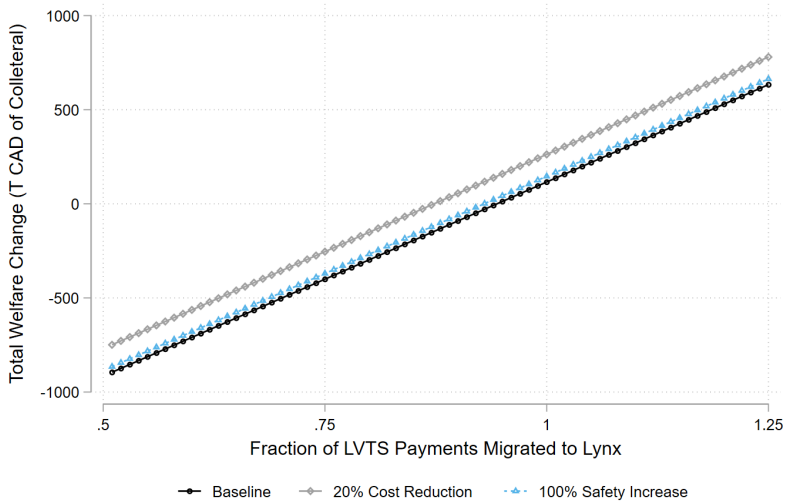
- ▶  $\hat{\xi}_{Lynx,m}$  is imputed as  $\hat{\xi}_{Lynx} = \frac{\theta_1}{2} \left( \hat{\xi}_{T1} + \hat{\xi}_{T2} \right)$ ,
- ▶  $\bar{s}_{Lynx,m}$  is either imputed as  $\bar{s}_{Lynx,m} = \theta_2 (\bar{s}_{T1,m} + \bar{s}_{T2,m})$  or computed as a new equilibrium

# Liquidity Cost Change

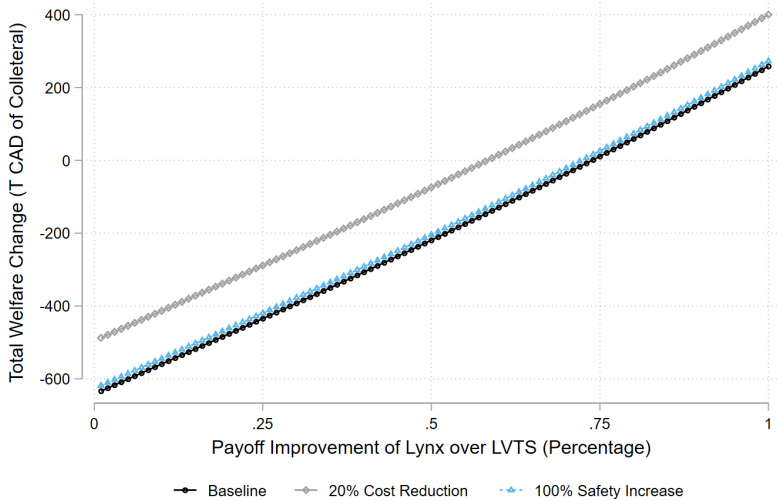




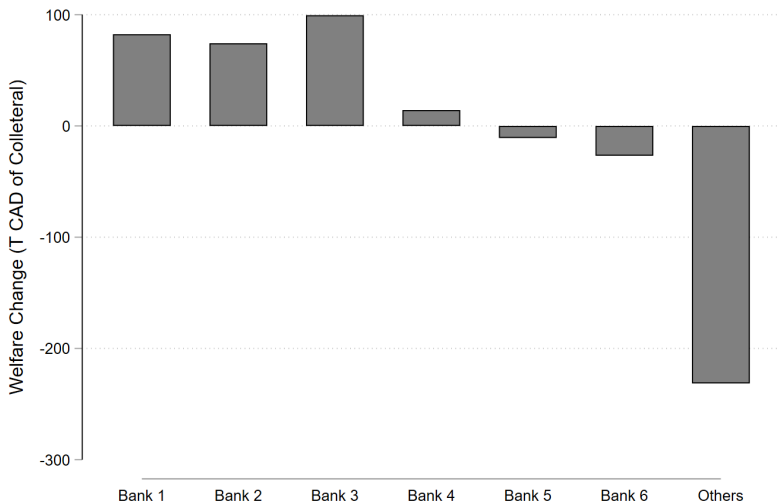
# Welfare Change: Migration to Lynx



# Welfare Change: Service Quality Improvement



# Welfare Change: Heterogeneity Across Banks





## Concluding Remarks

- ▶ In this project, we attempt to quantify the economic benefits of payment modernization, focusing on the large-value payment system
  - ▶ High migration ratio is important, however, it can be hard to achieve sufficiently high in the new equilibrium (about 60% based on the model prediction).
  - ▶ Improve service quality is important, e.g., reducing liquidity cost, increasing safety and modernizing messaging standard.
- ▶ Caveats and potential future research
  - ▶ Our discussion of welfare restricts to the participants, not necessarily coincide with policy objectives.
  - ▶ More payment system characteristics are needed for more accurate measurement of welfare.
  - ▶ We only focus on large-value payment system modernization, more broader analysis on the whole ecosystem modernization is an important direction.