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

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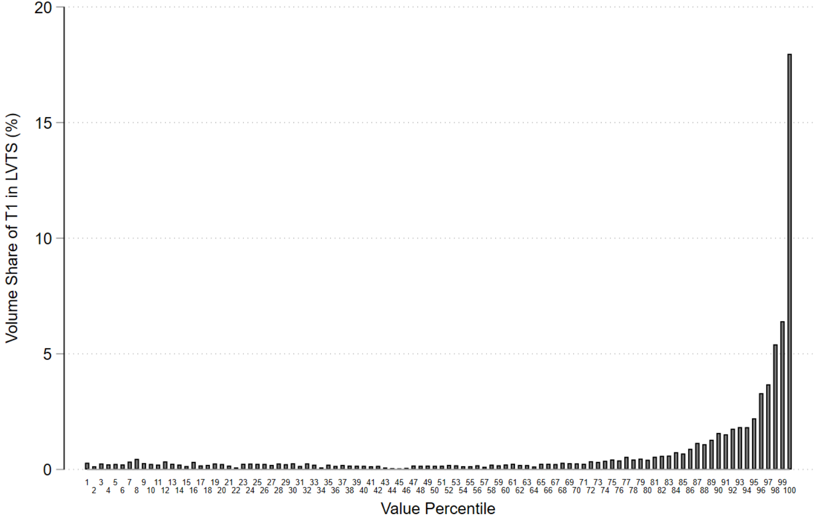
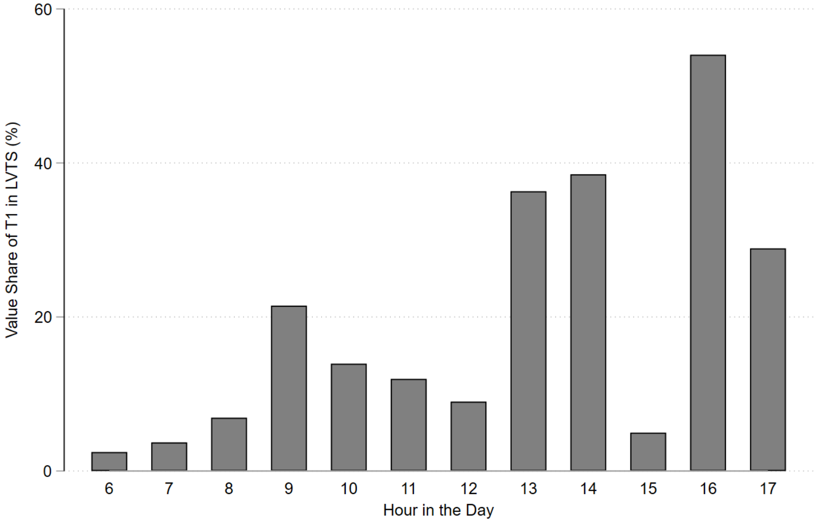
- Payment system characteristics: factors that a payment "considers" when "choosing" a system, e.g., liquidity cost and safety (or risk)

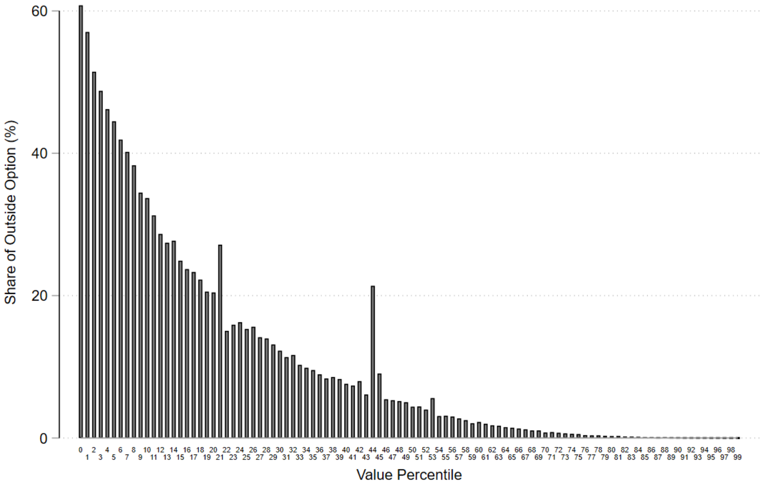
Value Distribution of LVTS Payments



Intra-day Distribution of LVTS Payments



Outside Share



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- 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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- safety indicator for payment i in T1

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

  - numerator: total liquidity supply of the day
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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

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

  - $P_{j,m}$: 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

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

  - $s_{j,m}$ is the volume 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: $E\left[\xi_{j,m} | Z_{j,m}\right] = 0$
  - IV for endogenous variable $\log\left(s_{j|g,m}\right)$ 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	-0.0443	-0.0220	-0.0299
	(0.00250)	(0.00467)	(0.00440)	(0.00438)
Safety Index	0.0154	0.0246	0.0264	0.0202
	(0.00248)	(0.00187)	(0.00181)	(0.00180)
Network Effect	6.191	9.788	6.001	1.549
	(0.0175)	(0.260)	(0.223)	(0.117)
Nesting Parameter			0.515	0.724
			(0.00775)	(0.0218)
Constant	-8.140	-7.082	-5.262	-4.522
	(0.0335)	(0.130)	(0.123)	(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

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

  - LVTS (for $j = T1$ or $T2$):

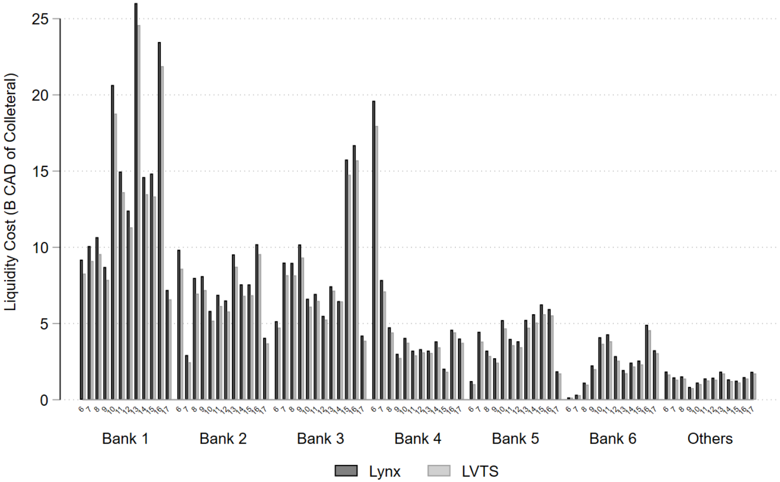
$$\hat{\delta}_{j,m} = \hat{\alpha}P_{j,m} + \hat{\beta}SI_{j,m} + \hat{\gamma}\bar{s}_{j,m} + X_m\hat{\rho} + \hat{\xi}_{j,m}$$

  - Lynx:

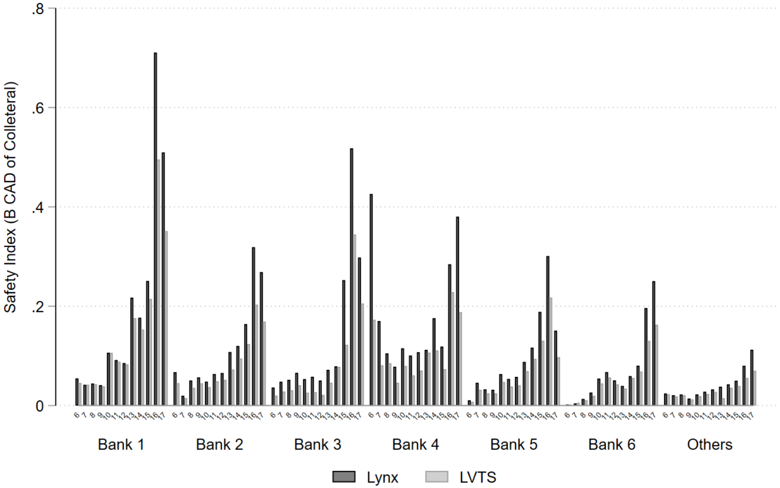
$$\delta_{\text{Lynx},m} = \hat{\alpha}P_{\text{Lynx},m} + \hat{\beta}SI_{\text{Lynx},m} + \hat{\gamma}\bar{s}_{\text{Lynx},m} + X_m\hat{\rho} + \hat{\xi}_{\text{Lynx},m}$$

  - We do not know $\bar{s}_{\text{Lynx},m}$ and $\hat{\xi}_{\text{Lynx},m}$, so need assumptions:
    - $\hat{\xi}_{\text{Lynx},m}$ is imputed as $\hat{\xi}_{\text{Lynx}} = \frac{\theta_1}{2}\left(\hat{\xi}_{\text{T1}} + \hat{\xi}_{\text{T2}}\right)$,
    - $\bar{s}_{\text{Lynx},m}$ is either imputed as $\bar{s}_{\text{Lynx},m} = \theta_2\left(\bar{s}_{\text{T1},m} + \bar{s}_{\text{T2},m}\right)$ or computed as a new equilibrium

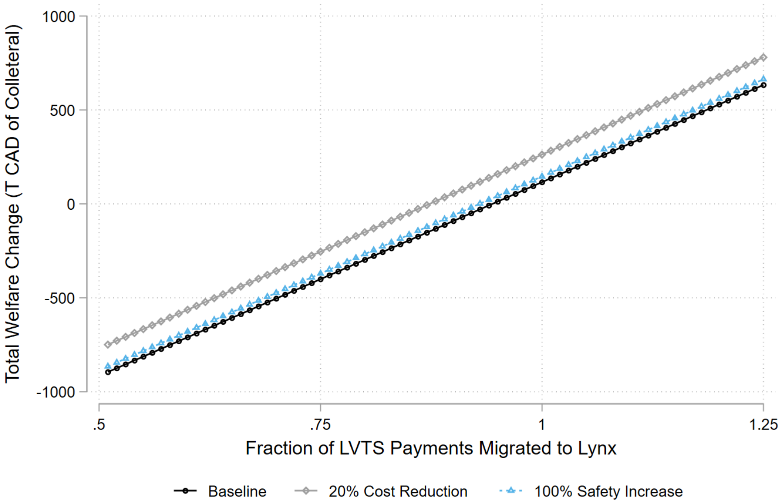
Liquidity Cost Change



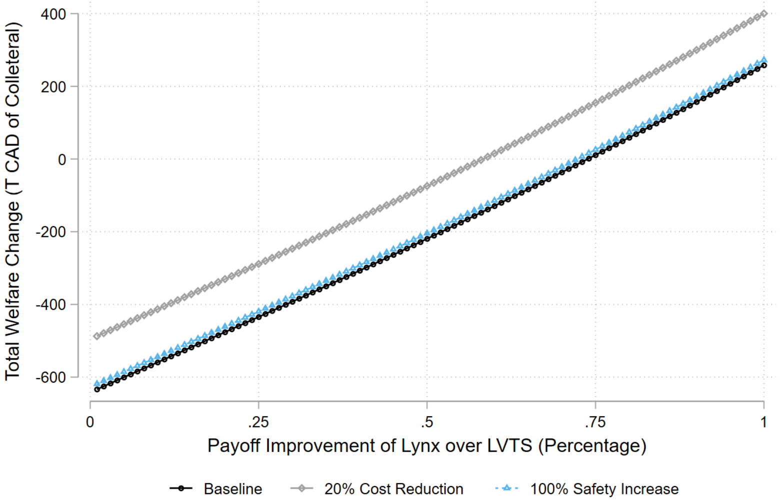
Safety Benefit Change



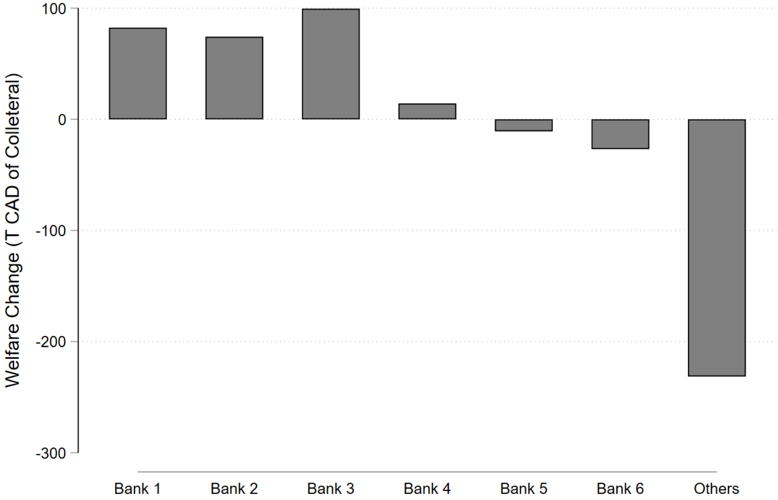
Welfare Change: Migration to Lynx



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.