



**PAYMENTS
CANADA**

Monitoring Intraday Liquidity Risk in Real Time Gross Settlement Systems

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Overview

1. Objectives
2. Motivations
3. Related literature
4. Contributions
5. Intraday liquidity risk indicator
6. Predict the likelihood of occurrence of a high liquidity stress event
7. Conclusions and future work

1. Objectives

- In the Lynx payment system
 - Measure the status of intraday liquidity risk for each participant for an upcoming period of time
 - Predict the likelihood of the occurrence of a high liquidity stress event for an upcoming period of time

2. Motivations

Lynx

- A high-value payments system in the modernization program of Canadian payments
 - A real time gross settlement system
 - Replace the current Large Value Transfer Systems (LVTS)
 - Increase the intraday liquidity requirements

⇒ **Regularly monitor the intraday liquidity risk in the Lynx**

2. Motivations

- Monitor the intraday liquidity risk in the LYNX
 - How will the intraday liquidity risk develop in future?
- =>build an intraday liquidity risk indicator for each participant in the remaining day
- =>Predict the likelihood of a high intraday liquidity stress event in the remaining day

3. Related literature

- BCBS (2013) proposes a set of monitoring tools for intraday liquidity
 - Monitor the current status of intraday liquidity
- Li and Perez Saiz (2018)
 - Monitor the credit risk of LVTS
- Baek et al (2014) propose an approach of monitoring intraday liquidity
 - Monitor the intraday liquidity risk for

4. Contributions

- For each participant, propose an intraday liquidity risk indicator in the remaining day
- For each participant, predict the likelihood of a high intraday liquidity stress event

5. An intraday liquidity risk indicator

- An intraday liquidity risk indicator in the remaining day for each participant in the LYNX
 - Compare the participant's expected intraday source for settlement with its expected liquidity requirements in the remaining day
- ⇒ If the expected source is less than the expected liquidity requirements, the participant is to experience high intraday liquidity pressure

5. An intraday liquidity risk indicator

- The expected intraday liquidity source for participant i at time t on day j
 - Net payment incoming up to time t : $NPI_{t,j}^i$
 - Intraday credit limits at central bank at time t : $CL_{t,j}^i$
 - The payments incoming to be received during the remaining day: $RPI_{t,j}^i$

=>

$$NPI_{t,j}^i + CL_{t,j}^i + RPI_{t,j}^i$$

5. An intraday liquidity risk indicator

- The expected intraday liquidity requirements for participant i : $RPD_{t,j}^i$

The intraday liquidity risk indicator is defined as:

$$LRI_{t,j}^i = \frac{RPD_{t,j}^i}{NPI_{t,j}^i + CL_{t,j}^i + RPI_{t,j}^i}$$

$LRI_{t,j}^i \leq 1 \Rightarrow$ the liquidity sources cover its liquidity requirements

$LRI_{t,j}^i > 1 \Rightarrow$ the liquidity sources are not enough to cover liquidity requirements

5.1. Calculate the expected payment transactions in the remaining day

- Calculate the expected payment incomings

$$RPI_{t,j}^i = TPI_j^i - PI_{t,j}^i, \quad TPI_j^i = \text{the total payment incomings}$$

- Calculate the expected payment requirements

$$RPD_{t,j}^i = TPD_j^i - PD_{t,j}^i, \quad TPD_j^i = \text{the total payment requirements}$$

=> Which model should be used to predict both TPI_j^i and TPD_j^i ?

5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- LVTS
 - Canada's real time electronic payment system for processing large-value payments including payment streams:

Tranche 1 and Tranche 2

- With settlement finality in real time on a multilateral net basis at the end of day
- Settlement is guaranteed under all circumstances by the use of collateral and also by a residual guarantee provided by the BoC

5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- Risk control tests for LVTS

For tranche 1

Submitted T1 payment value \leq T1NDC+NPI

For tranche 2

Submitted T2 payment value \leq BCL+NPI

Submitted T2 Payment Value \leq T2NDC+NPI

5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- Predict the daily receiving and sending payments

- A linear regression model (Baek et.al, 2014)

$$TPI_j^i = \alpha_i + \beta D_j + \gamma_i H_j + \varepsilon^i$$

- A seasonal autoregressive integrated moving average model (Bewaji and Li, 2018)

$$ARIMA(p, d, q) * (P, D, Q)S$$

- A log normal diffusion process model

$$\frac{dTPI_j^i}{TPI_j^i} = \mu_i dt + \sigma_i dw_i$$

5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- The data, from 2016 January 4 to 2017 December 29, are divided into two subsamples :
 - the first subsample, from 2016 January 4 to 2017 November 30 is used to evaluate the in-sample forecasting performance
 - the second sample, from 2017 December 1 to December 29, is used to evaluate the out-of-sample forecasting performance

5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- For daily sending payment (MSE)

In-sample predictive ability for payments received from alternative models

BMO	CIBC	BNS	RBC	TD
Tranche 1				
<u>Linear regression model</u>				
0.6638	0.5340	0.9494	0.3966	0.6844
<u>Autoregressive integrated moving average</u>				
0.0211	0.0167	0.0008	0.0008	0.0143
<u>Log normal diffusion porocess</u>				
0.6867	0.5894	0.9826	0.4510	0.7019
Tranche 2				
<u>Linear regression model</u>				
0.1772	0.1681	0.2666	0.1644	0.2387
<u>Autoregressive integrated moving average</u>				
0.0219	0.0004	0.0077	0.0077	0.0090
<u>Log normal diffusion porocess</u>				
0.3733	0.4371	0.3805	0.3390	0.4405

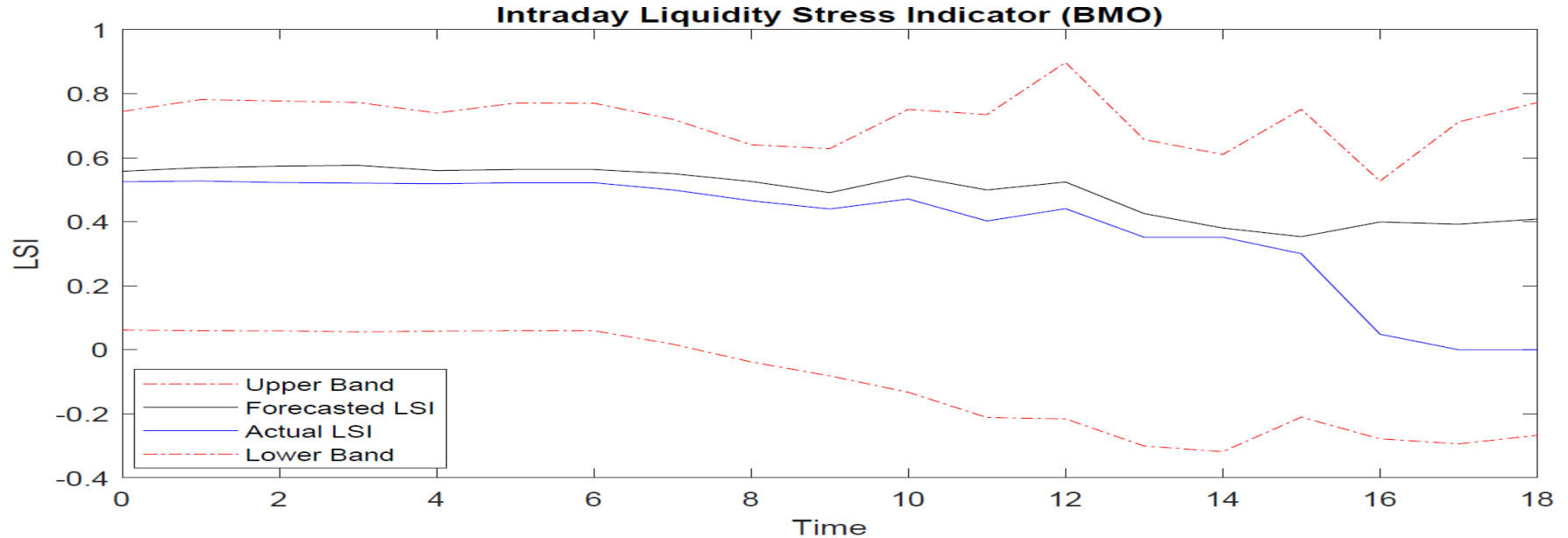
5.2. Evaluate the accuracy of predicting payment transactions from alternative models

- For daily sending payments (MSE)

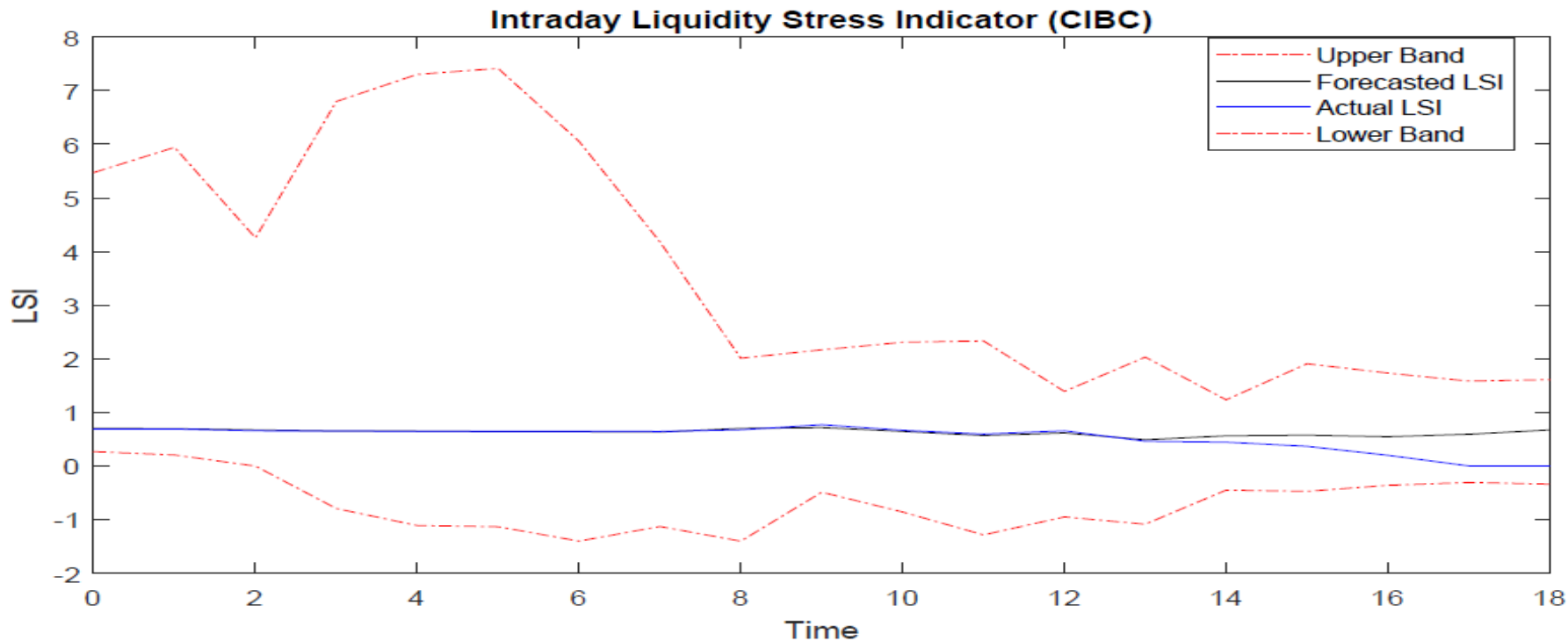
Out-of-sample predictive ability for payments received from alternative models

BMO	CIBC	BNS	RBC	TD
Tranche 1				
<u>Linear regression model</u>				
0.6532	0.5454	0.6849	0.4011	0.4667
<u>Autoregressive integrated moving average</u>				
0.5463	0.3974	0.5680	0.2856	0.8955
<u>Log normal diffusion porocess</u>				
0.6494	0.5409	0.6715	0.4145	0.6589
Tranche 2				
<u>Linear regression model</u>				
0.1951	0.1893	0.3362	0.1626	0.2706
<u>Autoregressive integrated moving average</u>				
0.2144	0.1924	0.3023	0.2889	0.2706
<u>Log normal diffusion porocess</u>				
0.2659	0.1903	0.3363	0.2798	0.2376

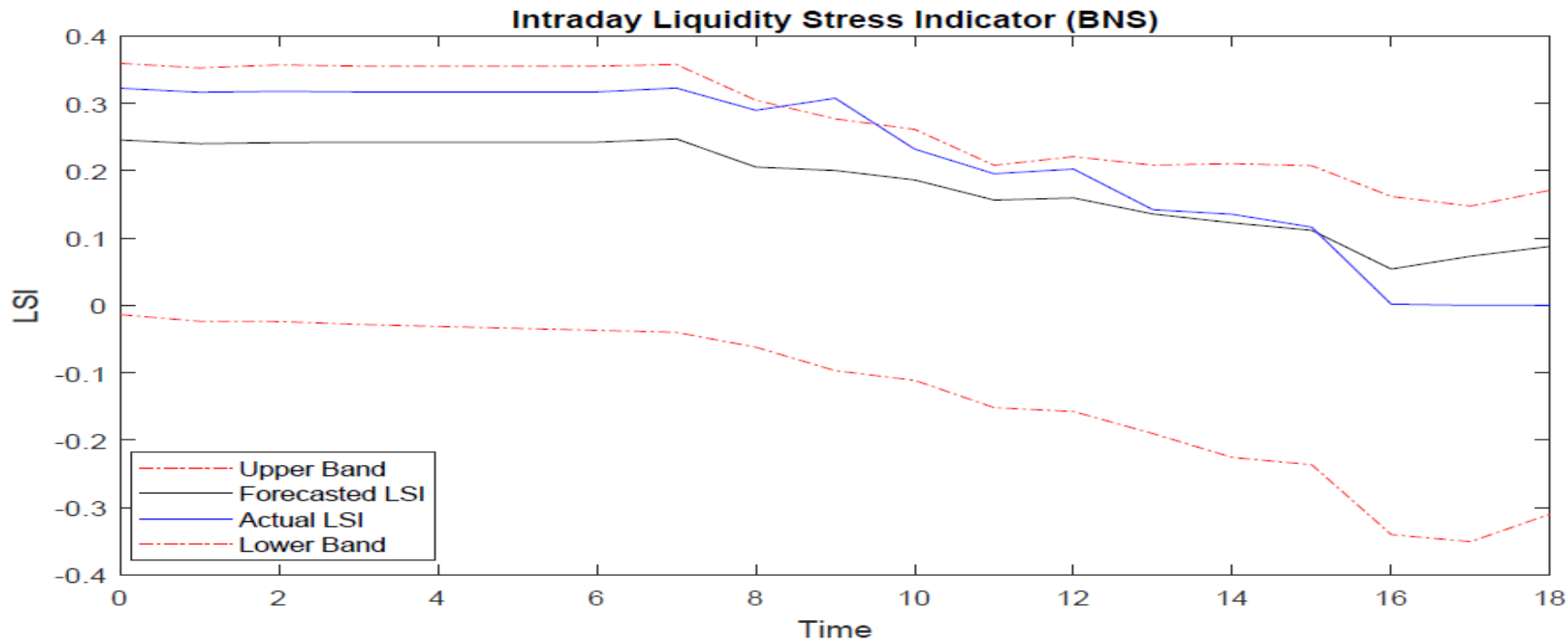
5.3. Intraday liquidity risk indicator in T1



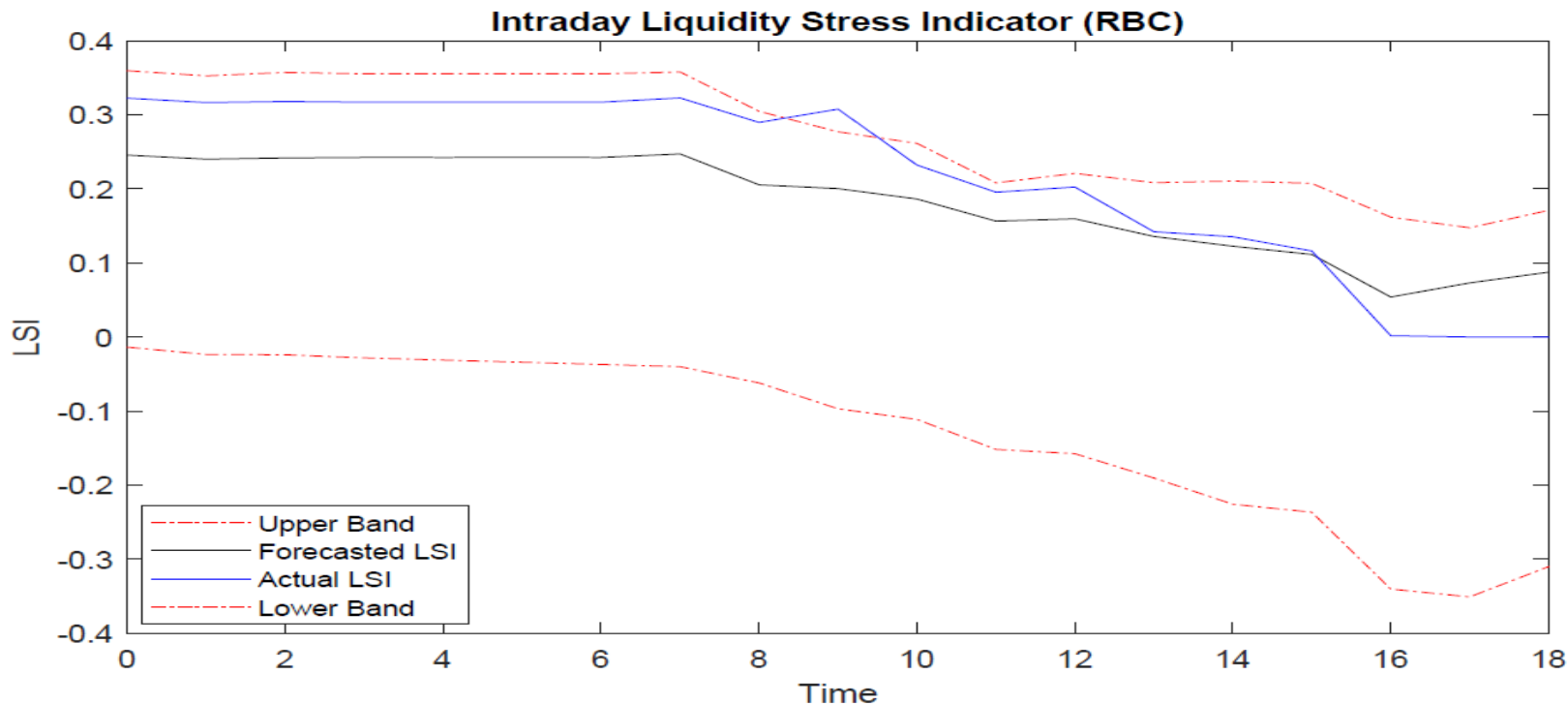
5.3. Intraday liquidity risk indicator in T1



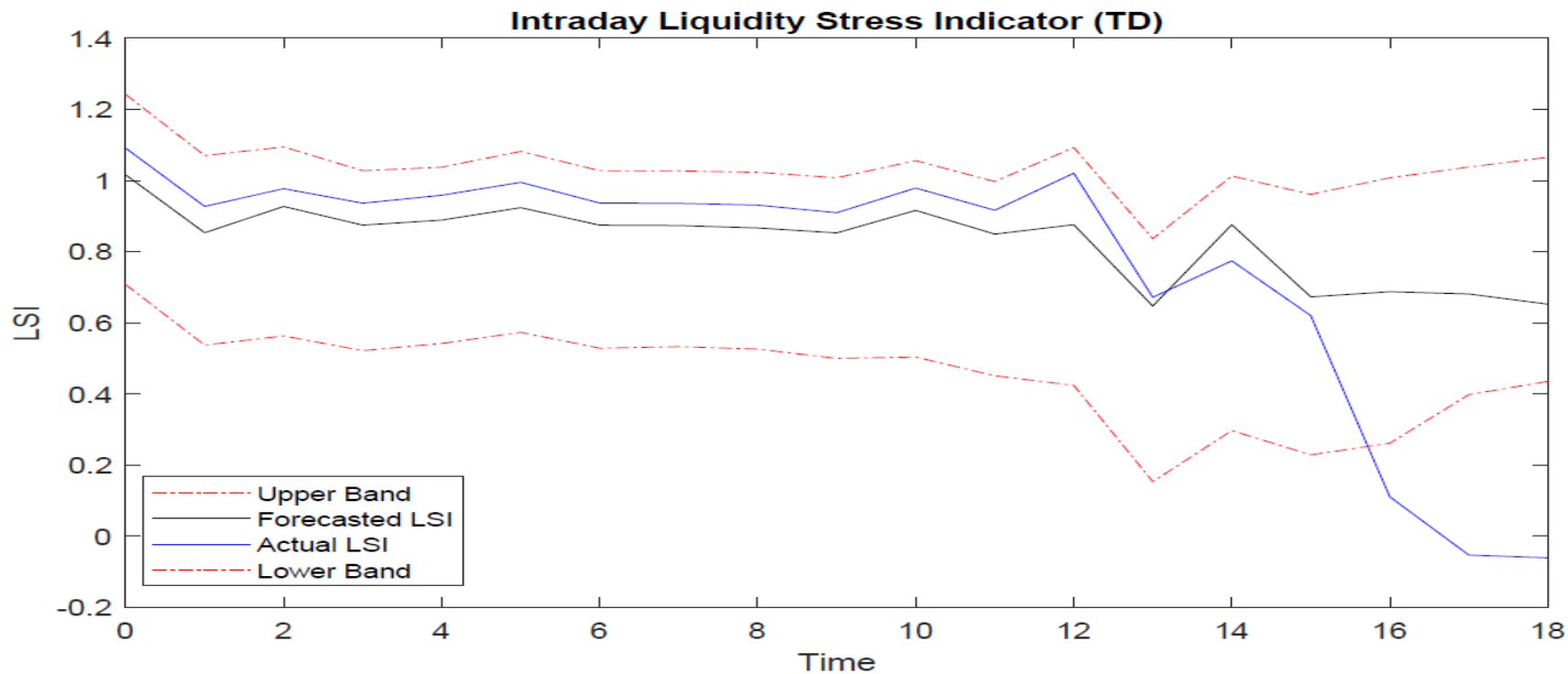
5.3. Intraday liquidity risk indicator in T1



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5.3. Intraday liquidity risk indicator in T1



6. Predicted Probability of a High Liquidity Stress Event

- Predicted the probability of a high liquidity stress event

Define an event of high liquidity stress as an episode where LSR_t is greater than or equal to a positive constant C

The different values of C result in different dates being identified as high liquidity stress events. A lower value of C leads to the identification of more liquidity stress events

- Predict the possible uncertainty of a future liquidity stress event at a given time t :

$$P(LSR_t \geq C)$$

Provide insight on the likelihood of a liquidity stress event

6. Predicted Probability of a High Liquidity Stress Event

The bootstrap procedure used to estimate the probability comprises the following steps:

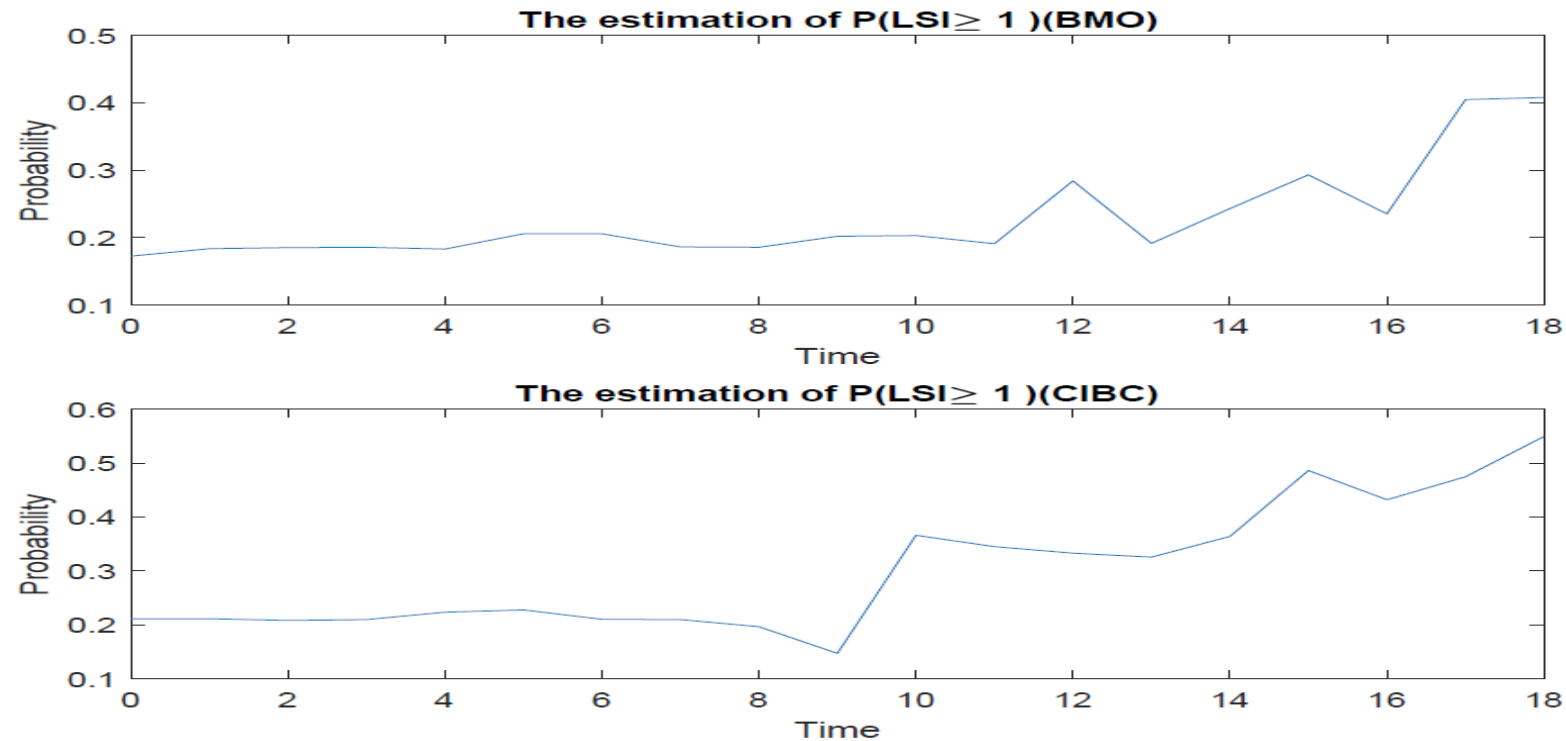
Step1: use the original sample to estimate the unknown parameters in the ARIMA model, and obtain the bootstrapping residuals for the ARIMA model

Step2: use the bootstrapping residuals to calculate the predicted both payments sent (ps_j^*) and payments received (pr_j^*)

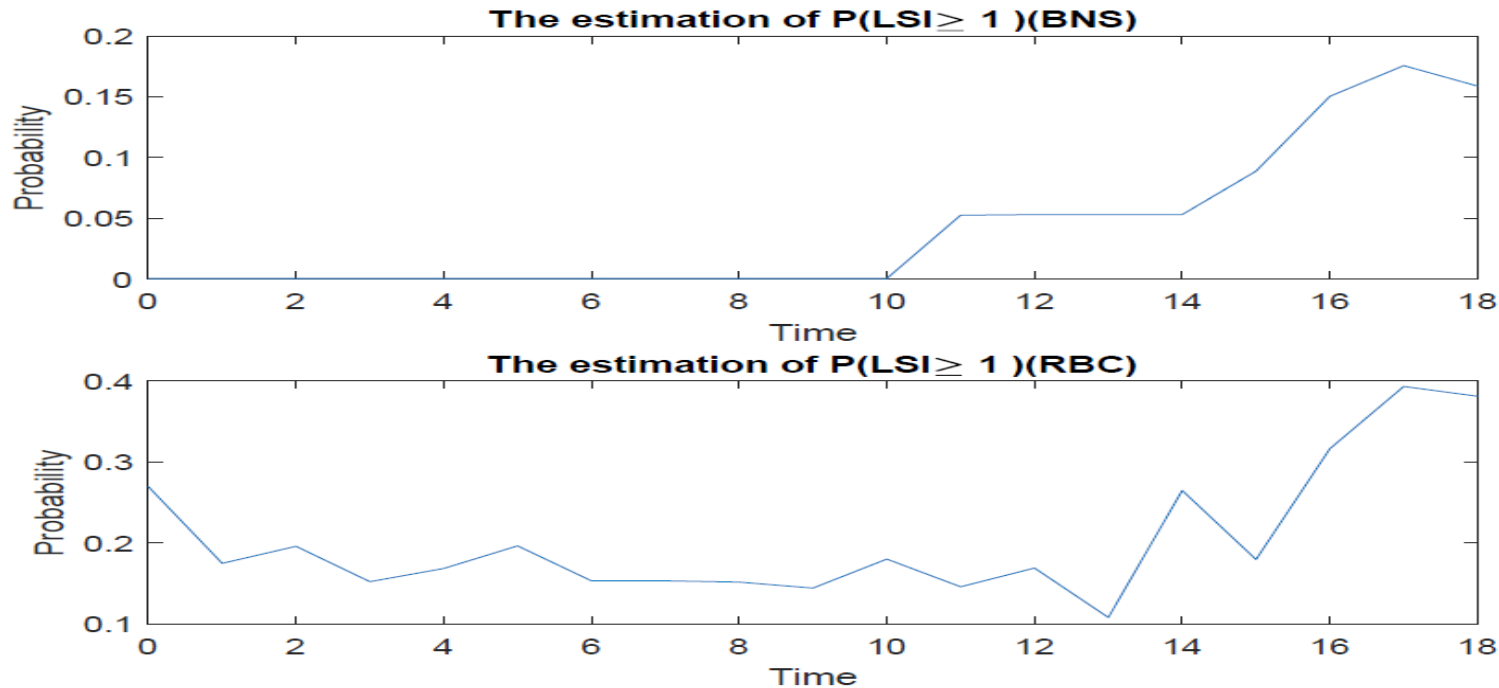
Step3: Repeat Step 1 and Step 2 R times. The probability of a high liquidity stress event is computed as:

$$\frac{1}{R} \sum_{j=1}^R I(LSI_t^{j*} \geq C)$$

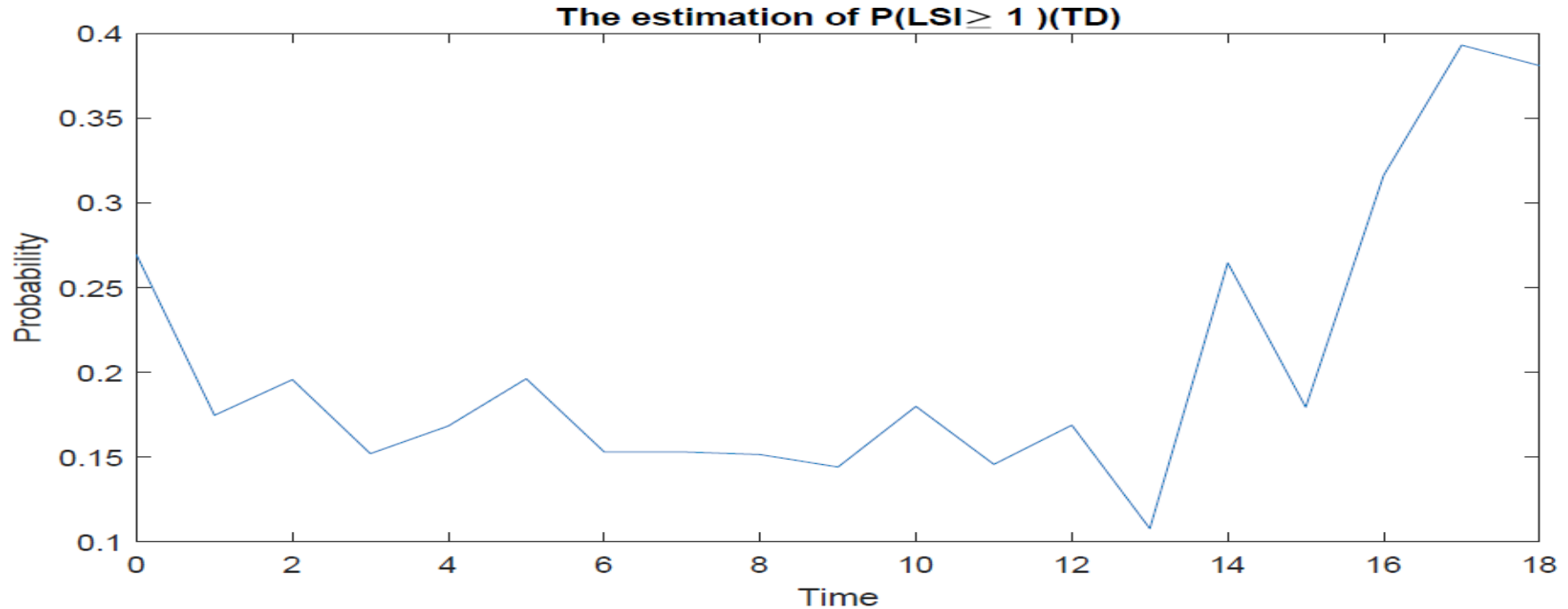
6. Predicted Probability of a High Liquidity Stress Event



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6. Predicted Probability of a High Liquidity Stress Event



7. Conclusions and future work

- Construct an analytical tool to monitor intraday liquidity risks in a RTGS
- Apply to LVTS
- Predict the likelihood of a liquidity risk for a given future time
- Stress-test for liquidity risk in the Lynx