An Agent-Based Model of Strategic Adoption of Real-Time Payments

Katherine Mayo, Shaily Fozdar, Michael P. Wellman

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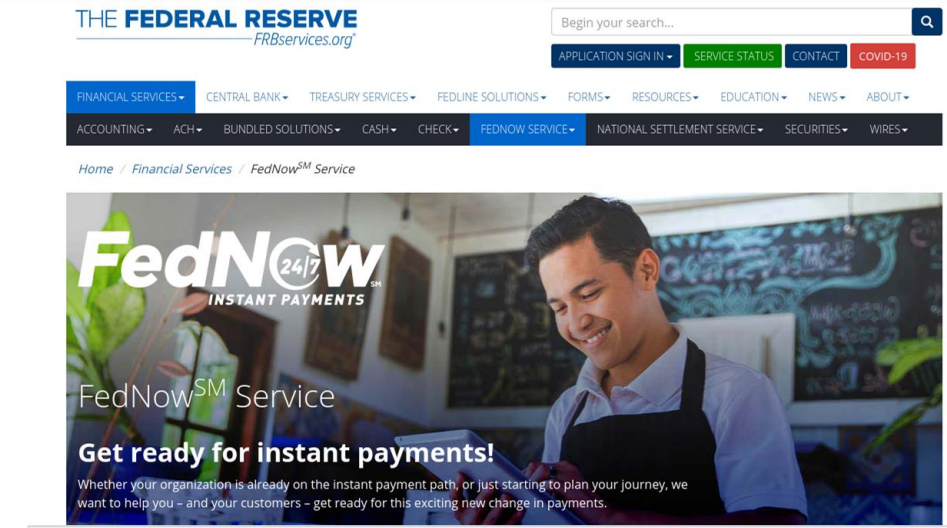
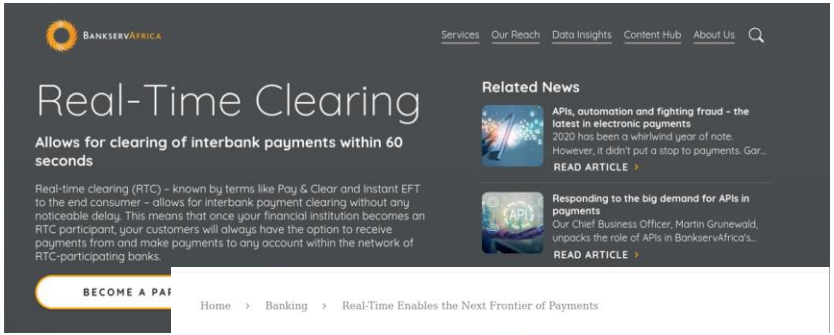
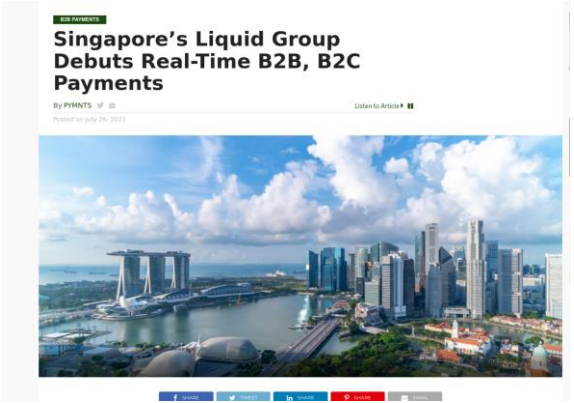
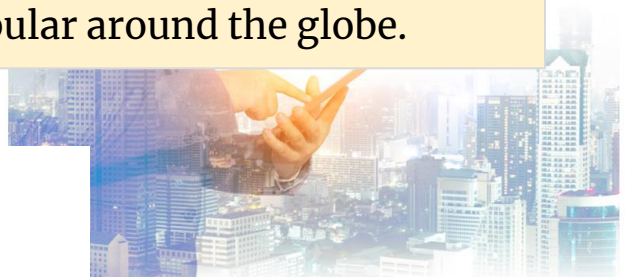


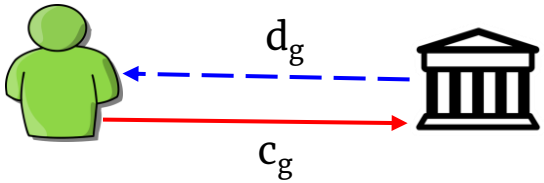


Real-time payment systems are becoming increasingly popular around the globe.



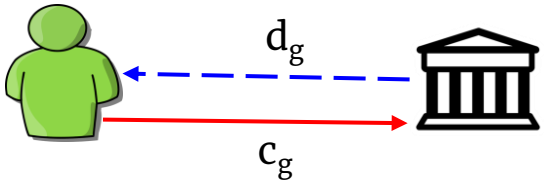


Modeling Payments



Green holds some amount of deposits, d_g, in its bank account, which is considered a debt owed by the bank to Green.

Modeling Payments



The maximum amount of additional deposits green is willing to hold in its account, c_g, is considered credit Green extends to its bank.

Modeling Payments: Standard Payment

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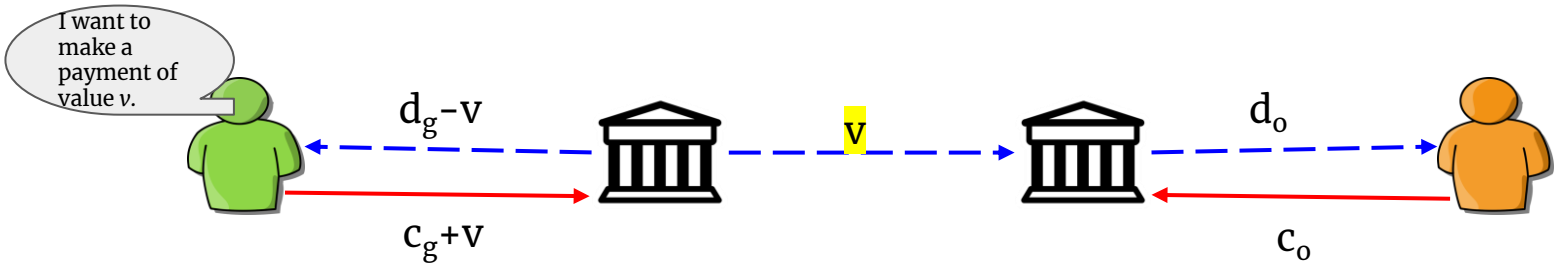
Payment requests are stored in a queue and processed in batches in regular intervals referred to as *clearing periods*.

Modeling Payments: Standard Payment

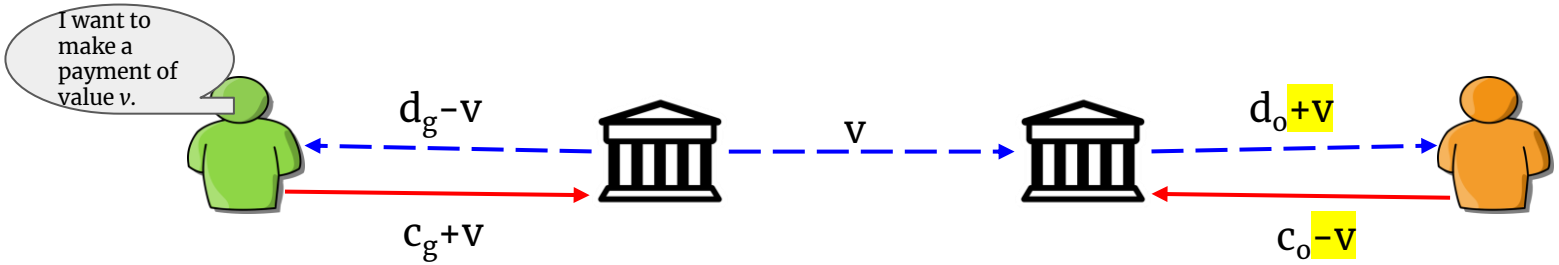
The bank uses Green's deposits to make the payment, withdrawing the amount equal to the value of the payment, *v*, from Green's account.

Modeling Payments: Standard Payment



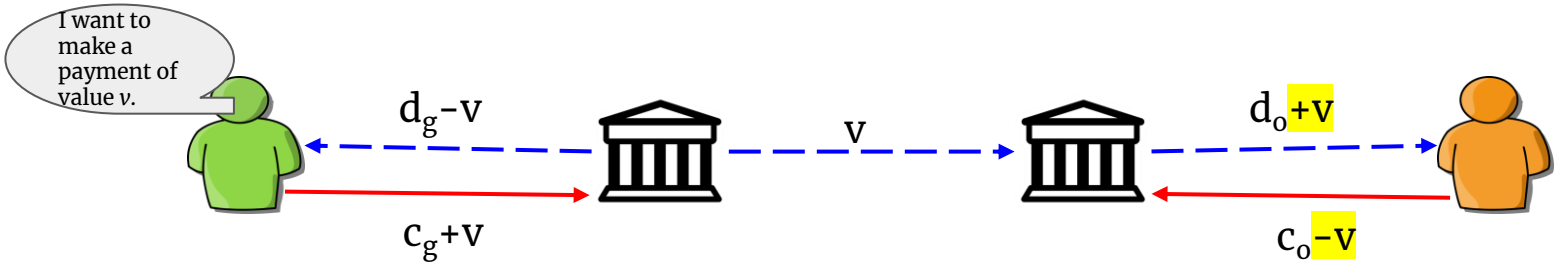
The bank will use the *interbank network* to send the payment to Orange's bank.

Modeling Payments: Standard Payment



Upon receiving the funds, Orange's bank will credit Orange's account with the funds by increasing their deposits by the value of the payment.

Modeling Payments: Standard Payment



This series of steps represent the *clearing* and *settlement* of a payment and must be completed for a payment to be executed.

Modeling Payments: Real-Time Payment

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Orange's bank will immediately credit Orange's account with the value of the payment. This action is irrevocable and available 24/7, 365 days a year.

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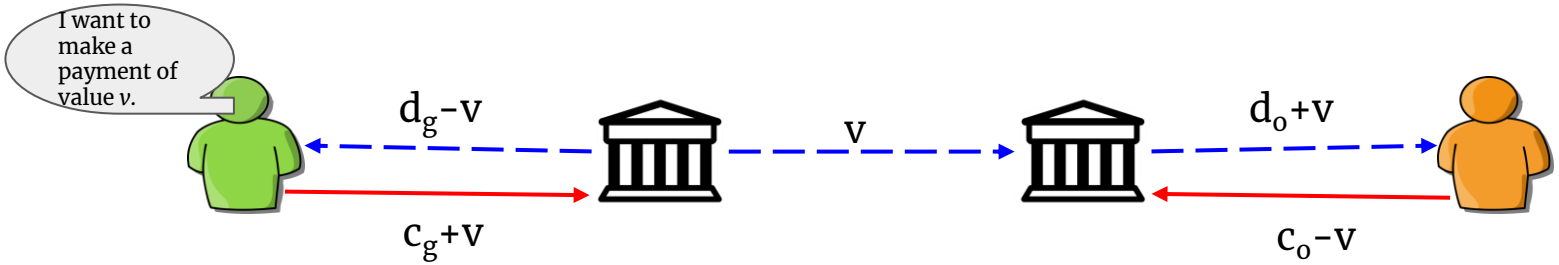


In the deferred settlement case, the remaining settlement steps are stored in the queue and handled during the next clearing period.

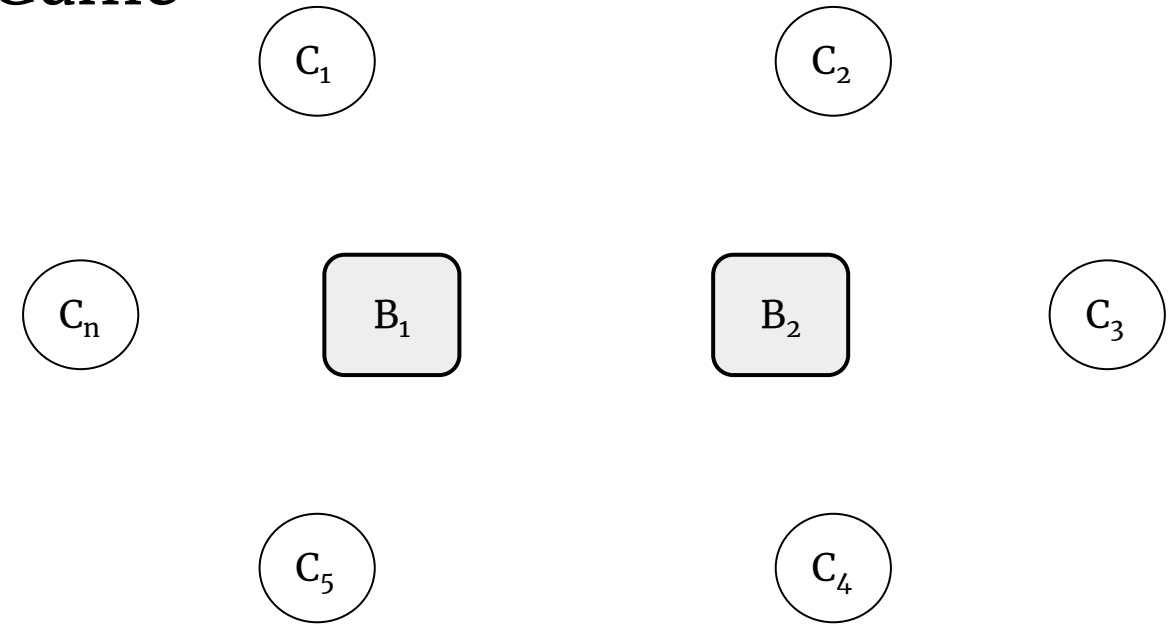
Real-Time Payments (RTPs) Risk

- Deferring settlement necessitates banks take on a credit risk
- Expediency of the payments make it more difficult to catch problems
  - Fraud, unintentional mistakes, etc.
  - Who is liable when issues arise?
- Given potential issues, banks may be selective in which consumers are allowed to use RTPs

Contributions

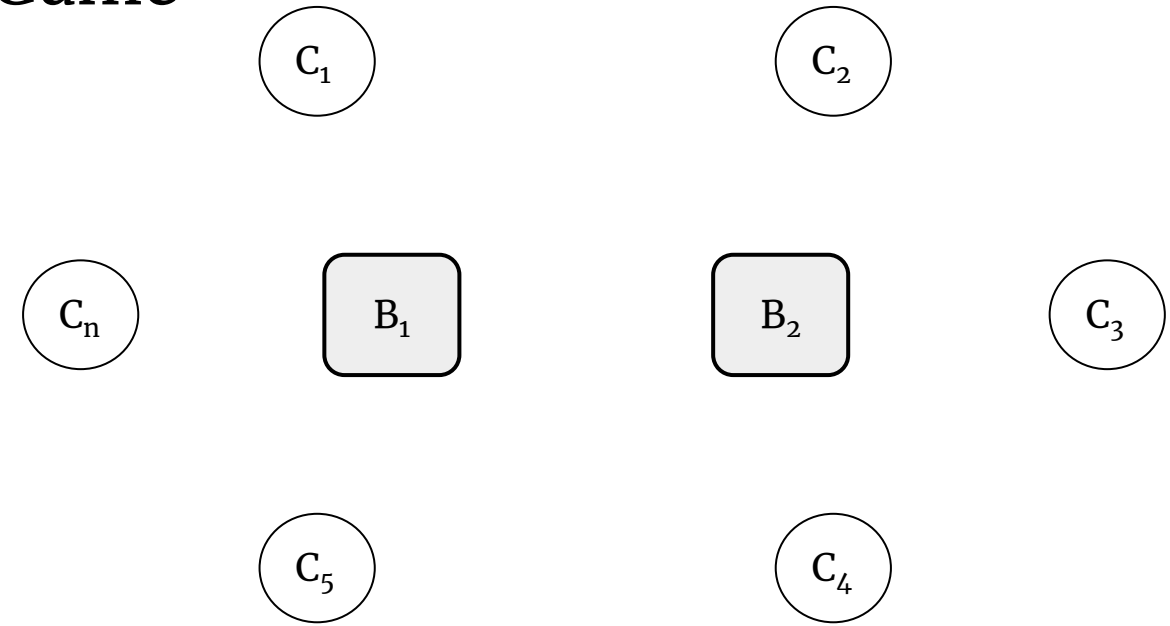
- Formulate the RTP adoption question as a strategic decision made by banks
  - Explore the scenario where consumers may accidentally make payments with values larger than their deposit holdings
    - Referred to as *insufficient payments*
- Define an agent-based simulation framework that supports standard payments and real-time payments with deferred settlement
- Analyze the effects of RTP adoption on banks and consumers

RTP Game



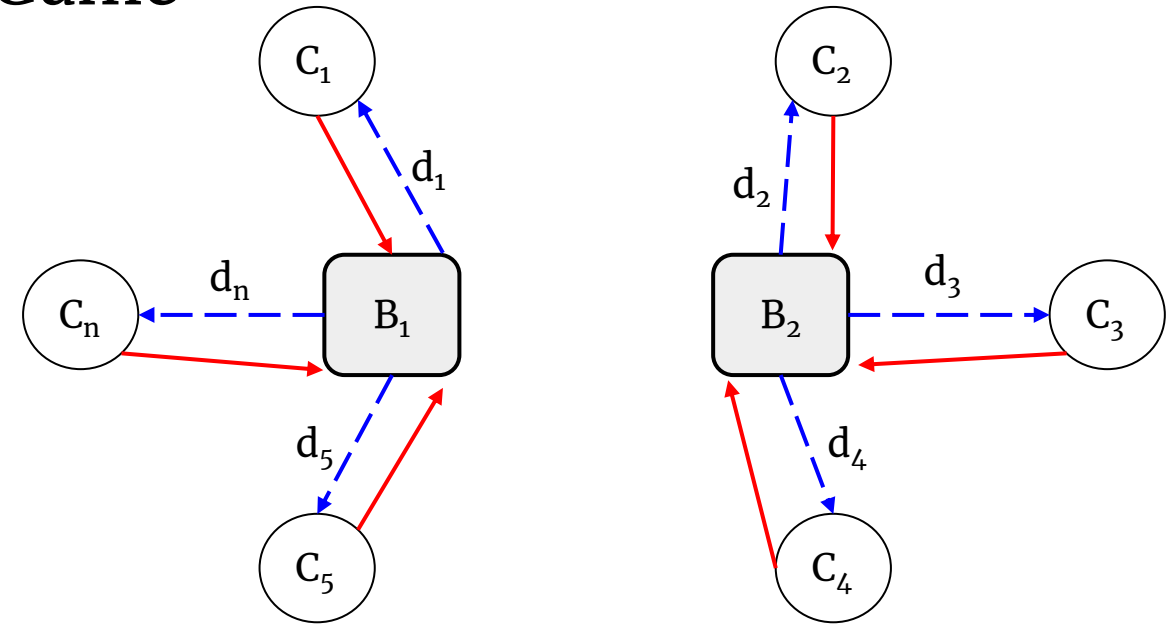
Consumer nodes are initialized with a random amount of deposits and a desire to receive certain kinds of payments (any or RTP-only).

RTP Game



Bank nodes adopt a strategy that determines which consumer nodes are allowed to send RTPs, balancing the risk of insufficient payments and benefit of attracting consumers.

RTP Game

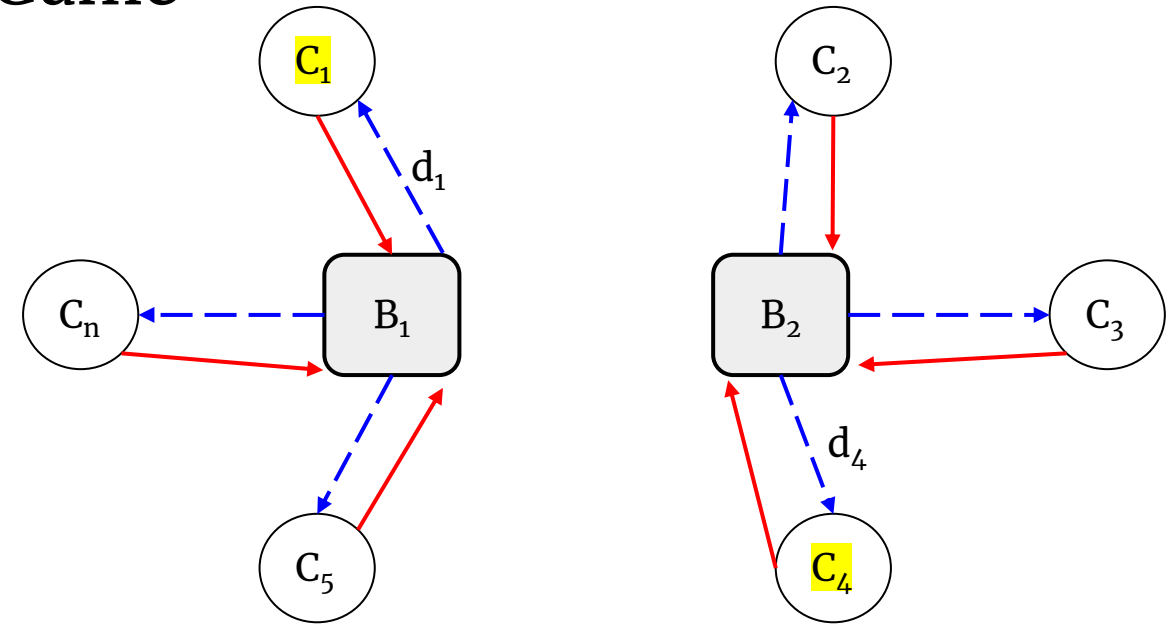


Consumer nodes are assigned to banks with a preference for banks that would allow them to send RTPs.

Heuristic Strategies

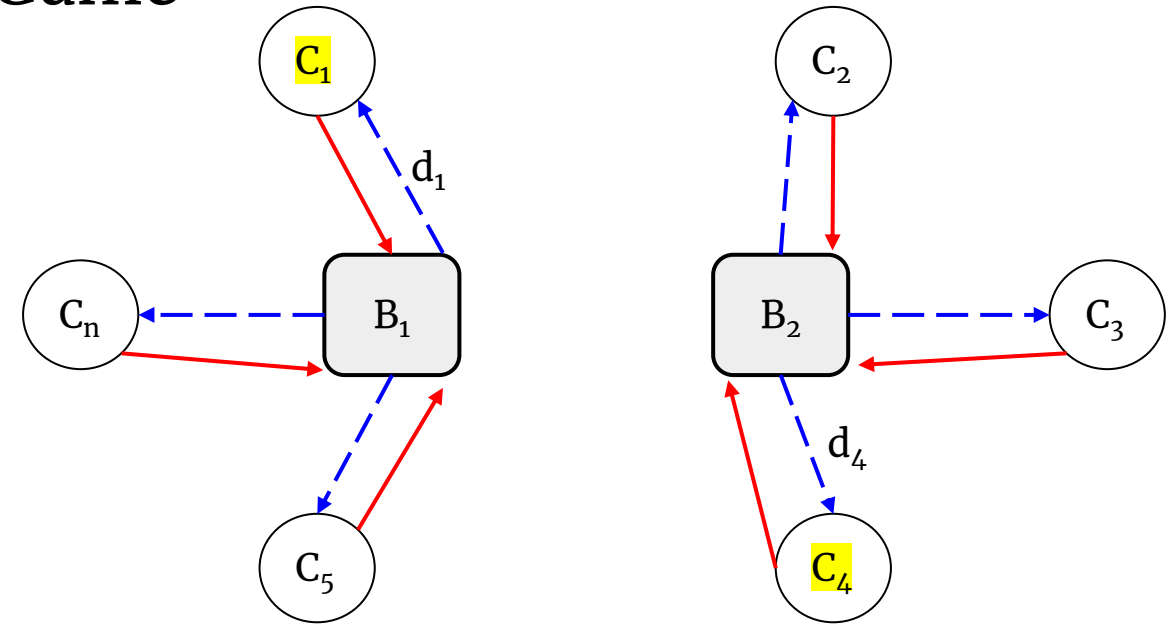
- Set thresholds on the initial deposit values of consumer nodes
  - Only consumer nodes above the threshold can send RTPs
- 6 such strategies
  - Low threshold that allows all consumer nodes to send RTPs
  - High threshold that allows no consumer nodes to send RTPs

RTP Game



Random payments are created in the network over *T* time steps. Each payment is created by randomly selecting the payment sender, receiver, and value of the payment.

RTP Game



With probability *p*, the *consumer check probability*, the sender checks their payment value before sending and adjusts its value if it is insufficient.

RTP Game

Sender	Receiver	Payment Processed As:
RTP	Any/only-RTP	RTP
Standard Payment	Any	Standard Payment
Standard Payment	only-RTP	---

The payment is then processed subject to the constraints of the sender and receiver.

RTP Game

Sender	Receiver	Payment Processed As:
RTP	Any/only-RTP	RTP
Standard Payment	Any	Standard Payment
Standard Payment	only-RTP	---

If a standard payment is insufficient, it is terminated immediately.

RTP Game

Sender	Receiver	Payment Processed As:
RTP	Any/only-RTP	RTP
Standard Payment	Any	Standard Payment
Standard Payment	only-RTP	---

If a RTP is insufficient, the sender's bank will be required to provide the *insufficient coverage* ($v - d_1$).

Payoffs

- Banks receive a payoff at the end of T time steps equal to:

$$= 0.5D + 0.02R - I$$

D: total value of initial deposits attracted

R: total value of RTPs routed

I: total amount of insufficient payments coverage

Experiments

- Use empirical game-theoretic analysis to identify Nash equilibria
- Model details:
  - 225 consumer nodes and 3 bank nodes
  - 720 time steps
  - 45 payments attempted per time step
  - Payment values: $v \sim U\{1, \ldots, 100\}$
- Clearing period lengths: $X \in \{4, 6, 12, 24\}$
  - How frequently payments in the queue are cleared and settled
- Consumer check probabilities: $p \in \{0, 0.25, 0.5, 0.75\}$
  - How likely senders check their payment values before sending

Results

	Consumer Check p	0			0.25			0.5			0.75		
Clear Period X	Strategy Threshold	low	med	high	low	med	high	low	med	high	low	med	high
24		0.58	0.42	0	0.61	0.39	0	1	0	0	1	0	0
12								1	0	0	1	0	0
6								0.92	0.08	0	1	0	0
4		0.48	0.52	0	0.39	0.61	0	0.75	0.25	0	1	0	0

Probability in equilibrium of adopting a strategy with a low/med/high threshold in our game.

Results

	Consumer Check p	0			0.25			0.5			0.75		
Clear Period X	Strategy Threshold	low	med	high	low	med	high	low	med	high	low	med	high
24		0.58	0.42	0	0.61	0.39	0	1	0	0	1	0	0
12		0.54	0.46	0	0.46	0.54	0	1	0	0	1	0	0
6		0.51	0.49	0	0.37	0.63	0	0.92	0.08	0	1	0	0
4		0.48	0.52	0	0.39	0.61	0	0.75	0.25	0	1	0	0

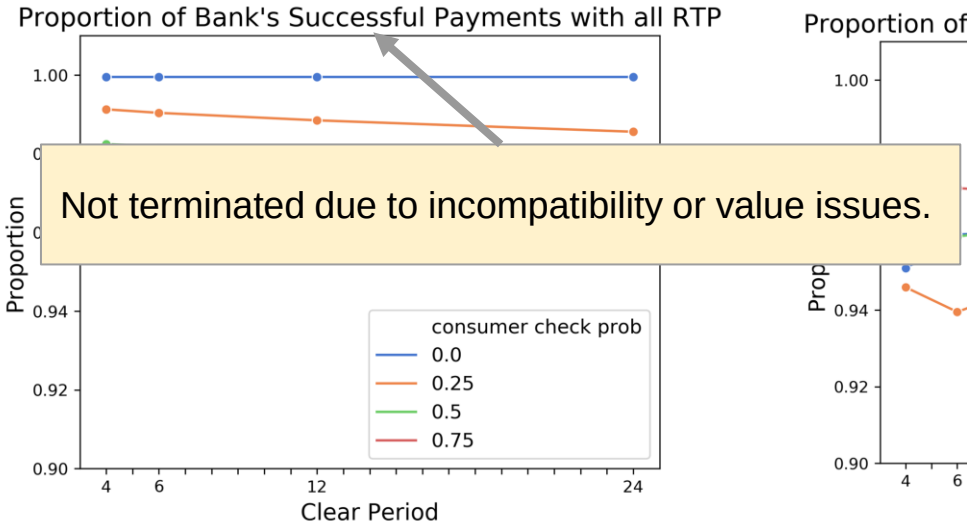
In all game configurations, the bank nodes prefer lower or medium level strategies that allow most, but not all consumer nodes the use of RTPs.

Results

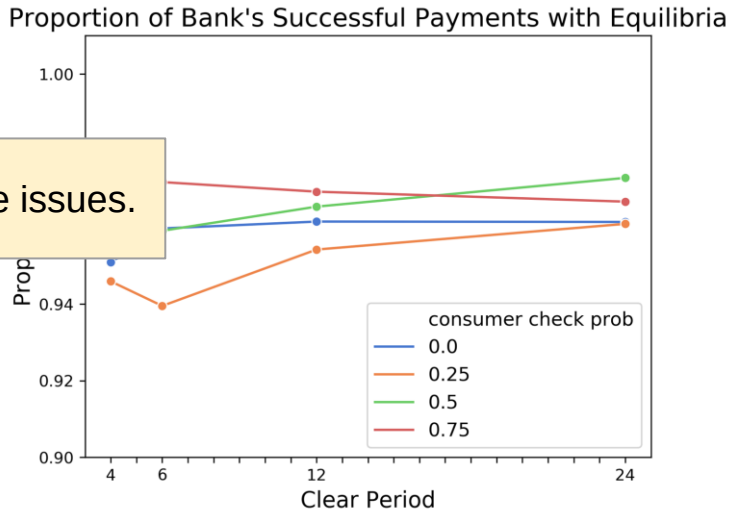
	Consumer Check p	0			0.25			0.5			0.75		
Clear Period X	Strategy Threshold	low	med	high	low	med	high	low	med	high	low	med	high
24		0.58	0.42	0	0.61	0.39	0	1	0	0	1	0	0
12		0.54	0.46	0	0.46	0.54	0	1	0	0	1	0	0
6		0.51	0.49	0	0.37	0.63	0	0.92	0.08	0	1	0	0
4		0.48	0.52	0	0.39	0.61	0	0.75	0.25	0	1	0	0

As consumer nodes are more likely to check their payments or the clear period increases, bank nodes are more likely to choose a low-threshold strategy.

Results



Not terminated due to incompatibility or value issues.



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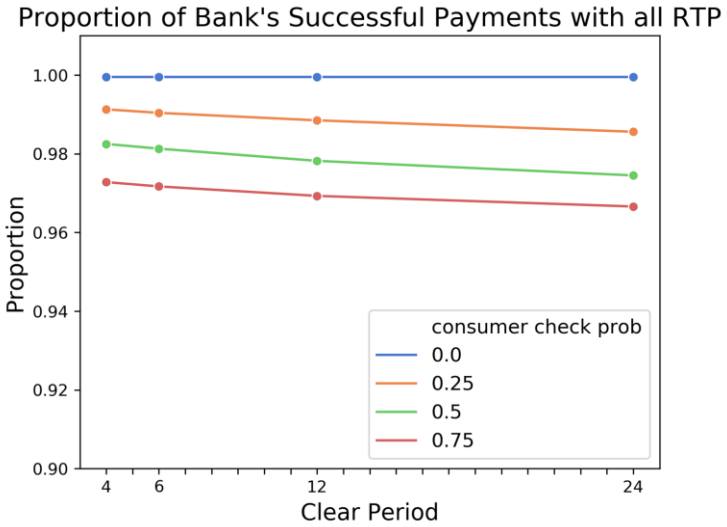

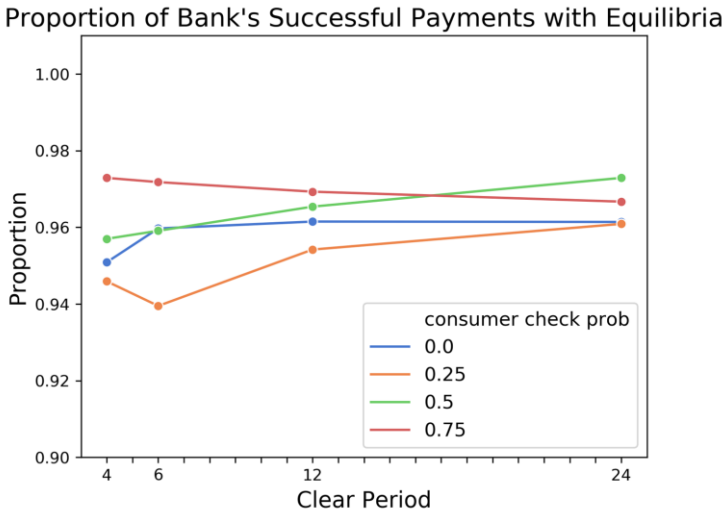

The proportion of successful payments is higher when all consumer nodes are allowed to send RTPs than under the equilibria.

Results

- Bank nodes in our game allow most, but not all consumer nodes the use of RTPs in equilibria
- Bank nodes in our game have more successful payments when all consumer nodes are allowed to send RTPs

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- Bank nodes in our game allow most, but not all consumer nodes the use of RTPs in equilibria
- Bank nodes in our game have more successful payments when all consumer nodes are allowed to send RTPs

While bank nodes in our game may be better off when all consumer nodes use RTPs, they are generally unwilling to accept the risk necessary to reach this outcome.

Questions?