Payments on Digital Platforms: Resilience, Interoperability and Welfare

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Motivation

- Emergence of digital tokens issued by platforms:
  - Social media platforms (e.g., Tencent QQ, Facebook Libra)
  - Blockchain-based platforms (e.g., Ethereum, Filecoin)
  - Circulatible outside platforms (e.g., WeChat Pay and Alipay)
- But some (e.g. Amazon) still prefer cash settlement.
- Positive: *token* platform v.s. *cash* platform?
- Normative finding:
  1. issuing *tokens* can increase seignorage but hurt welfare;
  2. regulations don't always work, but they could when there is moral hazard of investing cyber security.

Related Literature

- **Design and functioning of Bitcoin**

  - **Pricing**: Choi & Rocheteau (2019), Schilling & Uhlig (2018)

  - **Resilience**: Chiu & Koeppl (2019), Pagnotta (2018)

  - **Mining**: Huberman et al. (2017) and Easley et al. (2019).

- **Platform-based tokens and ICO**

  - Cong, et al. (2018), Gans & Halaburda (2015) Garratt & van Oordt (2019), You & Rogoff (2019)

- **Central bank digital currencies in GE**

  - Barrdear & Kumhof (2016), Brunnermeier & Niepelt (2019), Chiu, et. al. (2020), Davoodalhosseini (2018), Keister & Sanches (2018), Williamson (2019), Zhu & Hendry (2019)

- **Payment Security**

  - Kahn and Roberds (2008), Kahn et al (2020)

Basic Model

Environment

Consumers

- consume retail goods in stage 1 w.p. σ
- transacted on the platform w.p. α; off the platform otherwise
- CRRA preference in stage 1 with $\eta < 1$; linear preference in stage 2

Cash platform

- allows cash settlement and charges a proportional fee τ_t

Merchants

- competitive; linear production in stage 1; linear preference in stage 2

Central bank

- target $i_t = i$ by lump sum transfers Υ_t to consumers

Consumer's problem

Consumer's value function with cash M:

$$W_{t-1}(M) = \max\left\{ c_{t-1} + \beta \left\{ \begin{array}{l} \sigma\alpha\left[U(y_t) + W_t\left(M' - \frac{P_t y_t}{1-\tau_t}\right)\right] \\ +\sigma(1-\alpha)\left[U(q_t) + W_t(M' - P_t q_t)\right] \\ +(1-\sigma) W_t(M') \end{array} \right\} \right\}$$

$$\begin{aligned} \text{budget} &: \quad c_{t-1} + \phi_{t-1} M' = \phi_{t-1} M + \Upsilon_{t-1}, \\ \text{on-platform CIA} &: \quad M' \geq \frac{P_t y_t}{1-\tau_t}, \\ \text{off-platform CIA} &: \quad M' \geq P_t q_t. \end{aligned}$$

Fee and the interest rate

Interest rate given by the no-arbitrage condition,

$$1 + i = \frac{\phi_{t-1}}{\beta \phi_t}.$$

Lemma:

Off-platform CIA always binds.

On-platform CIA does not bind iff $\tau_t > 1 - \left[1 + \frac{i}{\sigma(1-\alpha)}\right]^{-1/(1-\eta)}.$

- A lower τ_t raises y_t;
- but the total spending on-platform increases,
- as long as CIA not binding

$\therefore$ A high interest rate limits the platform's ability to collect fees

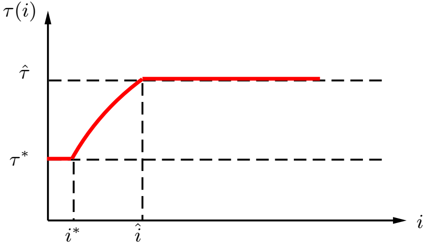
Cash platform design

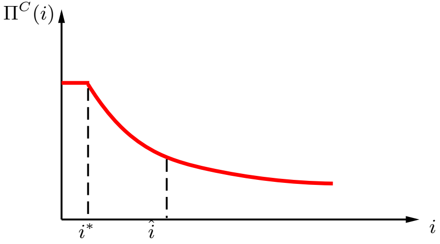
Given the prob. of a **cyber attack** γ,

$$\Pi^C \equiv \max_{\tau_t} \sum_{t=1}^{\infty} (1-\gamma)^{t-1} \beta^t \alpha \sigma \phi_t \tau_t \frac{P_t y_t}{1-\tau_t}$$

s.t. the consumer's demand *schedule* of y_t.

Proposition *Optimal transaction fee and platform's profits:*





Comparative statics

	$\frac{\partial \tau_t}{\partial i}$	$\frac{\partial q_t}{\partial i}$	$\frac{\partial y_t}{\partial i}$	$\frac{\partial \Pi^C}{\partial i}$	$\frac{\partial \tau_t}{\partial \alpha}$	$\frac{\partial q_t}{\partial \alpha}$	$\frac{\partial y_t}{\partial \alpha}$	$\frac{\partial \Pi^C}{\partial \alpha}$
(a). $i < i^*$	0	$-$	0	0	0	$-$	0	$+$
(b). $i \in [i^*, \hat{\imath}]$	$+$	$-$	$-$	$-$	$+$	$-$	$-$	$\pm$
(c). $i > \hat{\imath}$	0	$-$	$-$	$-$	$-$	$\pm$	$\pm$	$\pm$

Tokens

Token platform

- pays a setup cost $\kappa\alpha$ to issue tokens for on-platform transactions
- stands ready to redeem and sell tokens at e_t in the normal time
- redeemable at $b_t e_t$ in case of a collapse

Consumer's problem:

$$V_t(M,K) = \max_{q_t, y_t} \left\{ \begin{array}{l} \sigma\alpha \left\{ U(y_t) + W_t\left(M + e_t K - \frac{P_t^T y_t}{1-\tau_t}\right) \right\} \\ +\sigma(1-\alpha)\left[U(q_t) + W_t\left[M - P_t q_t + e_t K\right]\right] \\ +(1-\sigma) W_t(M + e_t K) \end{array} \right\} \text{ s.t.}$$

$$\begin{aligned} \text{on-platform TIA} &: \quad e_t K \geq \frac{P_t^T y_t}{1-\tau_t}, \\ \text{off-platform CIA} &: \quad M \geq P_t q_t. \end{aligned}$$

Token platform design

$$\Pi^T = -\kappa\alpha + \max\{\pi_0 + \sum_{t=1}^{\infty} (1-\gamma)^{t-1} \beta_t^t \pi_t\}$$

given the consumer's demand *schedule* of real token $k_t = \phi_t e_t K_t$ and

$$\begin{aligned}
\pi_0 &= \beta\left[1+\rho_1-(1+i)\,b_1\right]k_1 \\
\pi_t &= (1-\gamma)\left\{\begin{array}{c}\left[\sigma\alpha\tau_t-(1-b_t)\right]k_t \\ +\beta\left[1+\rho_{t+1}-(1+i)\,b_{t+1}\right]k_{t+1}\end{array}\right\}+\gamma\sigma\alpha\tau_t b_t k_t
\end{aligned}$$

and $\rho_t = \frac{e_{t-1}\phi_{t-1}}{\beta e_t \phi_t} - 1$ is the (shadow) interest rate of holding tokens

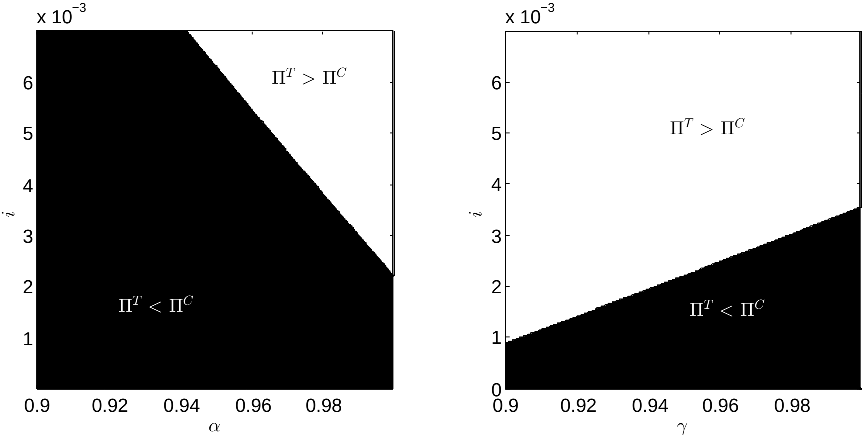
Token platform features

- zero fees: $\tau_t = 0$
  - costly when $b > 0$, redundant when $b = 0$ by setting e_t
- zero reserves: $b_t = 0$
  - costly when $i > 0$
- why do not both? not good idea
  - cash acceptance crowds out the demand for tokens
- the platform maximizes consumer surplus extraction by adjusting the appreciation rate of token price
  - faster when γ is high (to cover consumers' expected loss)
  - slower when α is high (to extract surplus)

Equilibrium Business Model and Welfare

Equilibrium business model

Proposition $\Pi^T > \Pi^C$ *iff* $i > \iota^{\Pi}(\alpha, \gamma)$ *which is a function decreasing in* α *and increasing in* γ*.*



Equilibrium business model

Proposition $\Pi^T > \Pi^C$ *iff* $i > \iota^{\Pi}(\alpha, \gamma)$ *which is a function decreasing in* α *and increasing in* γ.

- Pros of tokens: insulates consumers from CIA and the associated liquidity costs of using cash,
- more consumer surplus to extract without levying transaction fees.
- Cons: a token platform cannot free-ride on the cash system
- Token platform is chosen when
  - i is high (liquidity is costly)
  - α is high (makes CIA more binding under a cash platform)
  - γ is low (tokens are expected to circulate longer)

How does issuing tokens matter?

Proposition *When the platform chooses to issue tokens instead of accepting cash,*

- *on-platform consumption and social surplus go up,*
- *off-platform consumption and social surplus go down,*
- *seigniorage revenue goes down.*

Welfare and Regulation

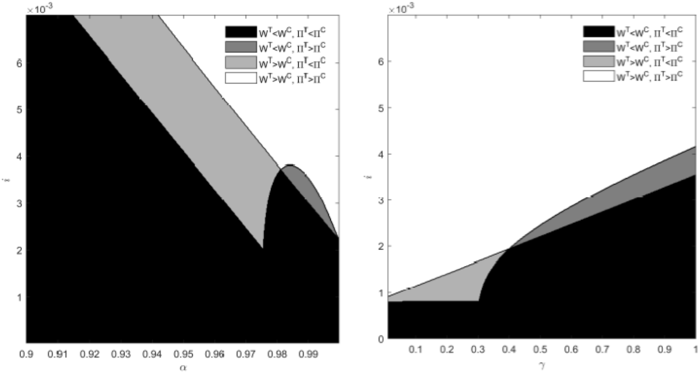
The welfare of this economy is defined as the discounted sum of utilities of consumers, merchants and the platform,

Proposition $\mathcal{W}^T < \mathcal{W}^C$ *iff* $i < \iota^{\mathcal{W}}(\alpha, \gamma)$.

- *A cash platform is a socially optimal business model iff* $i \leq \min\left\{\iota^{\Pi}(\alpha, \gamma), \iota^{\mathcal{W}}(\alpha, \gamma)\right\}$.
- *A token platform is a socially optimal business model iff* $i \geq \max\left\{\iota^{\Pi}(\alpha, \gamma), \iota^{\mathcal{W}}(\alpha, \gamma)\right\}$.

Welfare and Regulation

Under-issue (over-issue) tokens when the platform fails to fully internalize the social benefits (costs) of issuing tokens.



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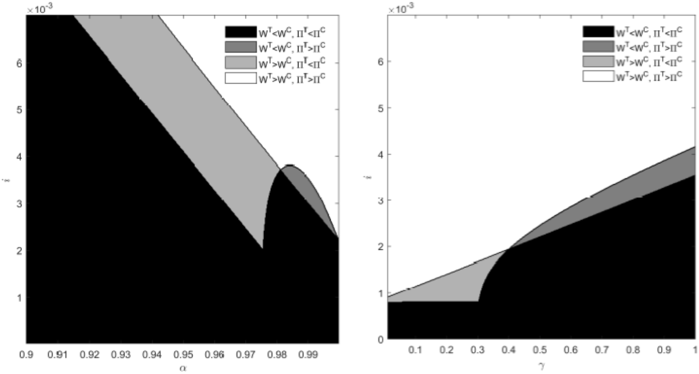


Does this justify reserve regulations?

Proposition *Reserve requirement reduces welfare and profits on a token platform. It enhances welfare only when the platform is induced to give up (sub-optimal) token issuance.*

Resilience

Endogenous resilience and moral hazard

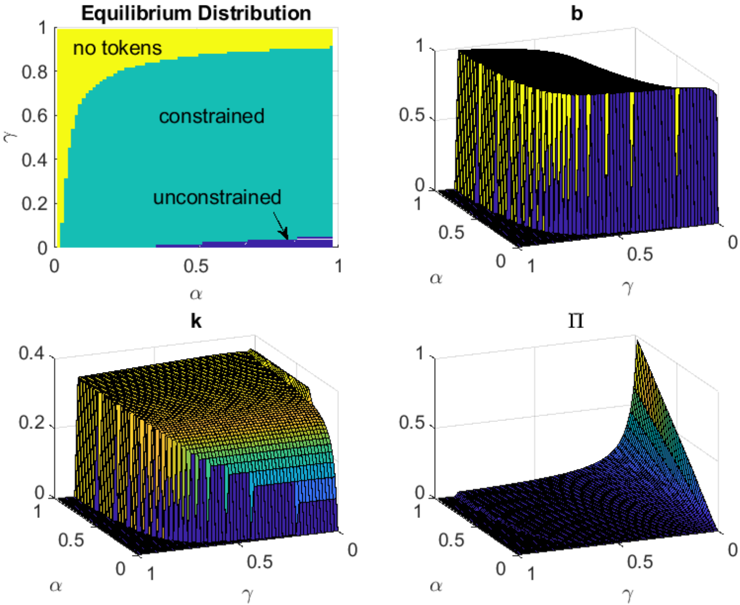
- Each period, the platform invests in cyber security to contain the attack
  - if investment $\geq \bar{\kappa}$, the platform fails w.p. γ
  - otherwise, fails for sure

- Moral hazard problem: cyber security investment is private info, giving rise to an IC constraint:

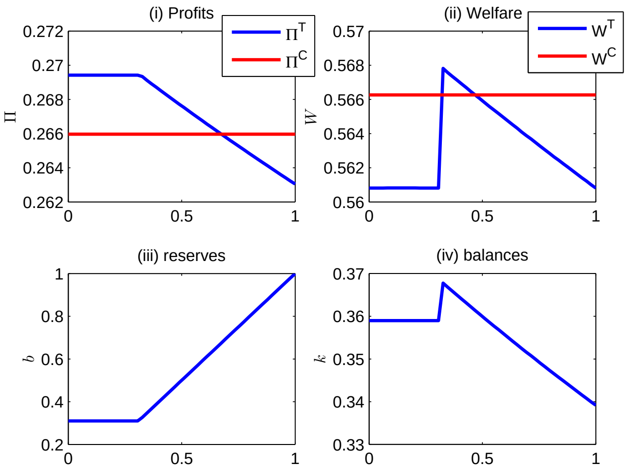
$$\underbrace{(1 - b_t)\, k_t}_{\text{not invest}} \leq \underbrace{-\bar{\kappa} + (1 - \gamma)\, \Pi^T}_{\text{invest}}$$

- Reserve holdings increase the platform's "skin in the game", relaxing the IC constraint and allowing higher token issuance

Optimal platform design



Optimal partial reserve regulation



Optimal to set $b_{\min} = 33\%$ to induce the platform to supply more tokens to increase welfare.

Endogenous Interoperability

Endogenous interoperability and circulatable tokens

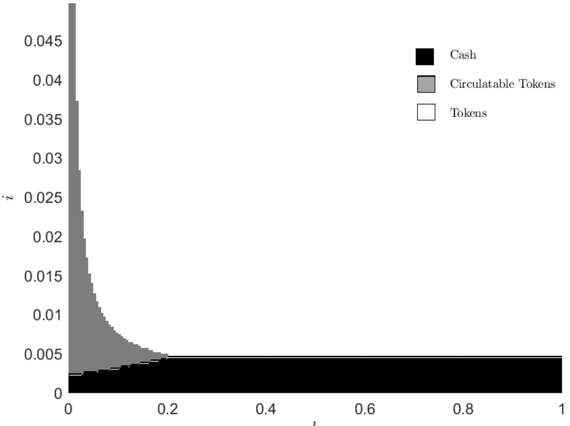
The platform can issue "circulatable tokens" and provide payment services outside the platform

- Need to satisfy a minimum reserve ratio b_{min} (e.g., PBoC)
- To simplify the analysis simple, we assume $\tau_t = 0$
- The platform's problem becomes

$$\Pi^{CT} = -\kappa\alpha + \max_{k_t} \left\{ \sum_{t=1}^{\infty} \frac{(1-\gamma)^{t-1} \beta^t}{1-\gamma(1-b)} [\gamma + \rho_t - (\gamma + i) b] k_t' \right\}$$

Platform choice

- when i is low: accept cash
- when i is high: issue tokens
  - circulatable tokens for low b_{min}
  - non-circulatable tokens for high b_{min}



Conclusion

- Token issuance allows the platform to insulate platform activities from costs associated with cash.
- However, the equilibrium choice of business model is not necessarily socially optimal.
- When cyber security is endogenous, imposing a minimum reserve requirement can sometimes improve welfare.

More in the paper

- Alternative regulation: deposit insurance
- Calibrating the model to match Amazon and Alipay
- More comparative statics

Thank you!

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Further works
Ackon and Wong, Why Short-selling Inflates Crypto-bubbles? Theory and Evidence from Bitcoin Futures;
Chiu, Davoodalhosseini, Jiang and Zhu, Bank Market Power and Central Bank Digital Currency;
Chiu and Koeppl, The Economics of Cryptocurrencies—Bitcoin and Beyond;
Chiu and Koeppl, Blockchain-Based Settlement for Asset Trading;
Chiu and Wong, On the Essentiality of E-Money;
Chiu and Wong, E-Money: Efficiency, Stability and Optimal Policy
Kahn, Rivadeneyra and Wong, Should the Central Bank Issue E-money?
Kahn, Rivadeneyra and Wong, Eggs in One Basket: Security and Convenience of Digital Currencies.