Strategic Money and Credit Ledgers

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Bank of Canada Conference 2024

27th September 2024

Introduction

- ⋆ Long standing interest in creating a system of "bills-of-exchange":
  - ⋆ Firms issue IOUs to purchase inputs that are repaid when firm sells outputs.
  - ⋆ The IOUs can be re-traded and used as a medium-of-exchange.
  - ⋆ Benefits: provides uncollateralized credit to firms and makes productive assets liquid.
- ⋆ Long-standing practical challenges:
  - ⋆ Need to ensure enforcement of uncollateralized IOUs.
  - ⋆ Need IOUs to be effective currency (medium of exchange, unit of account, store of value).
- ⋆ Theory: frictionless public record keeping on a ledger allows trade with IOUs. [Aiyagari and Wallace, 1991], [Kocherlakota, 1998]
- ⋆ Practical solution: Amazon "backs" a ledger where agents write and exchange IOUs.

This Paper: Trading Platform Backs a System of Tradable IOUs

- ⋆ Platform controls a trading tech. and centralized, record keeping device (= ledger).
- ⋆ **Q. Can the platform set up a system of uncollateralized IOUs?** *Yes.*
  - ⋆ Agents trading on platform must pay using ledger, where IOUs are automatically settled.
  - ⋆ Agents trading off-platform cannot make cash trades because agent no longer store cash.
- ⋆ **Q. Will the platform set it up?** *Maybe.* Only if they control large share of trade.
- ⋆ **Q. Can other arrangements work?** *Not as successfully.* Because:
  - ⋆ Stand alone ledger (e.g. Etherium) cannot incentivize agents to use the ledger.
  - ⋆ Banks can only exclude agents from future lending; cannot exclude from future trade.
  - ⋆ Industry supply chain cannot offer IOUs denominated in consumption basket.
- ⋆ **Q. Policy maker concerns?** *Yes?* Platform rents; loss of control; "black" market.

Literature Review

- ⋆ Ledgers, contracting, and settlement assets
  Aiyagari and Wallace (1991), Freeman (1996a, 1996b), Kocherlakota (1998), Kahn and van Oordt (2022).
  - ⋆ This paper: large, private, profit maximizing institution controls ledger.

- ⋆ Digital Currencies and currency competition
  Svensson (1985), Gans and Halaburda (2015), Catalini and Gans (2018), Chiu and Wong (2020), Fernadez-Villaverde (2018), Cong, Li & Wang (2019); Rogoff & You (2019); Chiu et al. (2019); Benigno et al. (2019); Brunnermeier et al. (2020), Piazzesi et al. (2019); Keister & Sanches (2020); Uhlig (2019), Kahn et al. (2019), Hayek (1976); Kareken & Wallace (1981); Brunnermeier & Sannikov (2018), Lagos et al. (2019, 2020), and Chiu et al. (2019)
  - ⋆ This paper: centralized, private digital currencies provided by trading platforms.

- ⋆ Platforms
  Diamond & Maskin (1979), Rochet & Tirole (2002, 03, 06), Spulber (1999, 2018)
  - ⋆ This paper: integrates monetary economics with platform economics

This paper attempts to bring together money theory with IO

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Environment

- ⋆ Two periods. Storable input good and collection of perishable output goods.
- ⋆ Two types of agents: lenders and producers.
- ⋆ $t = 0$: (construction of projects)
  - ⋆ Each lender is endowed with an input good.
  - ⋆ Each producer can use 1 input good to start a project (but has no input good).
- ⋆ $t = 1$: (production and consumption)
  - ⋆ Each producer's project pays $z > 1$ output goods.
  - ⋆ Agents get linear utility from consuming other agents' input and output goods.

First best: Planner reallocates:

- ⋆ Input goods from lenders to producers so they can start projects.
- ⋆ Output goods across agents so they can consume.

Information and Enforcement Frictions

- ⋆ **F1.** Agents have public identities but their actions are private.
- ⋆ **F2.** Agents cannot commit.
- ⋆ **F3.** No public legal system (or an imperfect system) for contract enforcement.
- ⋆ ⇒ Producers cannot issue IOUs privately to lenders because they will not be repaid

Q: Can we introduce a privately controlled recording keeping system (i.e. a "ledger") and get IOUs issuance and first best production in a market economy?

Two Market Economies

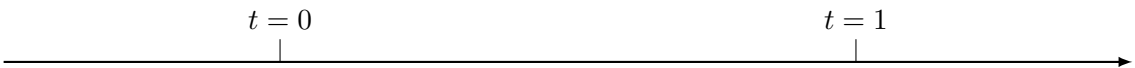
1. Economy with a independent privately operated ledger.

2. Economy with a tech platform controlling the ledger.

Market Economy 1: Trading and Record Keeping

- ⋆ Independent, privately operated ledger that records & executes trades & contracts.
- ⋆ Two payment options at $t = 1$:
  - ⋆ Spot payments (s) are not recorded and are settled immediately,
    - ⋆ Output goods must be paid using input goods (no "double coincidence of wants")
    - ⋆ No input good market at $t = 1$ so producers must hold input goods in advance.
  - ⋆ Centralized payment (l) on a ledger.
    - ⋆ Agents can use certain future revenue on the ledger to pay for goods.
    - ⋆ So no "resource-in-advance" constraint.
- ⋆ Producers can issue IOUs on the ledger:
  - ⋆ Promise $R \geq 1$ goods at $t = 1$ for each input good given at $t = 0$.
  - ⋆ Ledger automatically uses revenue from ledger trades to settle contracts
  - ⋆ But revenue from spot trades cannot be used.

Market Economy 1: Timeline



- Lenders endowed with input goods
  - Chooses to trade inputs for IOUs
- Producers issue IOUs and choose to:
  - Use inputs to produce output, or
  - Store input goods (to default).

- Agents meet randomly and swap goods (i.e. terms-of-trade of 1-1).
  - If spot payment, then goods are exchanged immediately.
  - If ledger payment, then the goods are given to the ledger.
- Agents ask ledger to redeem IOUs.
- Ledger settlement (if possible) & consumption occurs.

Market Economy 1: Equilibrium

Result: *In equilibrium, no agents accept IOUs and no production takes place.* Why?

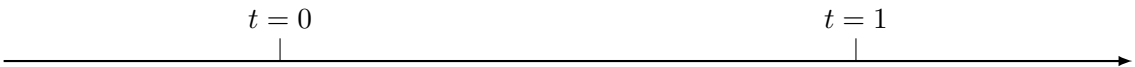
- ⋆ If other agents are producing, then it is optimal for an agent to:
  - ⋆ Store input goods,
  - ⋆ Purchase output goods using unrecorded spot trade, and
  - ⋆ Default.
- ⋆ Relative to [Kocherlakota, 1998]:
  - ⋆ The ledger in our environment has competition from another payment technology,
  - ⋆ So, the economy needs an institution to incentivize the use of the ledger.

Introducing an independent "unbacked" common ledger does not expand contracting.

Market Economy 2: Platform Controlling Trading Technology

- ⋆ Same environment as before but with trading frictions.
- ⋆ There are now two trading technologies for connecting goods traders:
  - ⋆ Open public marketplace (o).
  - ⋆ Private platform (p) that is controlled by profit maximising operator.
  - ⋆ Agents find platform trades with probability η (and marketplace trades with $1-\eta$) (Endogenized in the monetary dynamic model.)
- ⋆ Platform provides the trading technology *and* the settlement ledger:
  - ⋆ Forces agents using the platform to make payments using their ledger
  - ⋆ Charges markup μ when agents trade on the platform

Market Economy 2: Timeline



- ⋆ Lenders endowed with input goods
  - ⋆ Chooses to trade inputs for IOUs
- ⋆ Producers choose whether to:
  - ⋆ Use inputs to produce output, or
  - ⋆ Store input goods (to default).

- ⋆ Fraction η find trades on platform and so must trade through ledger:
  - ⋆ Ledger takes resources to settle IOUs.
  - ⋆ Producer gets $(1 - \mu)(z - R)$
  - ⋆ Buyers with input goods get 0.
- ⋆ Fraction $1 - \eta$ find trades off-platform:
  - ⋆ If find buyer with input goods, then spot trade and default.
  - ⋆ Otherwise, must use ledger.
- ⋆ Agents redeem any IOUs they have and ledger settlement occurs.

Market Economy 2: Equilibrium

Result:

(i) *For sufficiently large η, the platform constructs the ledger and sets the maximum markups that are incentive compatible with no default and first best production:*

$$\mu \leq \frac{1}{z-1}\left(1-\frac{z}{\eta}\right) =: \bar{\mu}$$

- ⋆ Why? Platform penalizes agents attempting to trade using input goods.
- ⋆ So, agents don't store input goods and producers cannot do spot side trades.

(ii) For low η, the platform does not set up a ledger to enforce contracts.

- ⋆ Why? Platform subsidy needed to make platform exclusion incentivize no-default.

Only a dominant trading platform will set up the ledger and expand contracting.

Other Potential Ledger Providers?

- **Q.** Can a traditional bank provide a ledger with uncollateralized loans?
  - Not in our environment because the only possible threat is exclusion from trade.
  - If repeated borrowing, then exclusion from future credit can incentivize repayment.
  - But in this case, banks, platforms, or any other lender can incentivize repayment.
- **Q.** Can an industrial supply chain (e.g. automotive industry) provide a ledger?
  - Our platform provides trading technology for all consumer goods so it can exclude agents from consuming a broad basket.
  - Industrial supply only concerns only a subsets of goods (e.g. everything related to cars)
    $\Rightarrow$ IOUs are not denominated in overall consumption basket.
    $\Rightarrow$ "Exchange rate risk" when IOUs repay (e.g. in cars) .

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Environment Changes

- ⋆ Goal: understand the macro implications of using the IOUs as "currency".
- ⋆ Changes to the model:
  - ⋆ Introduce settlement using currency, (government cash in spot trades, IOUs on ledger)
    Why? Introduce secondary market for IOUs and endogenous terms-of-trade.
  - ⋆ Move to an infinite horizon OLG model.
    Why? So currency is valued and we can discuss dynamic feedback.
  - ⋆ Allow agents to choose where to trade, (endogenous η)
    Why? Endogenize platform ability to "back" ledger through trading advantage.
  - ⋆ Introduce saving into financial intermediaries ("funds"),
    Why? To get aggregation and explore exclusion from financial markets
  - ⋆ Introduce flexible project size,
    Why? Mark-ups distorts production level
  - ⋆ Allow other platforms to provide ledgers.
    Why? To consider regulated competition.

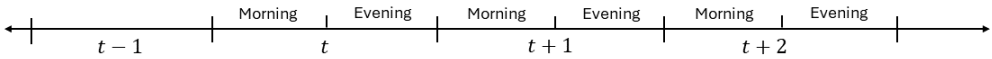
Environment Changes: Demographics

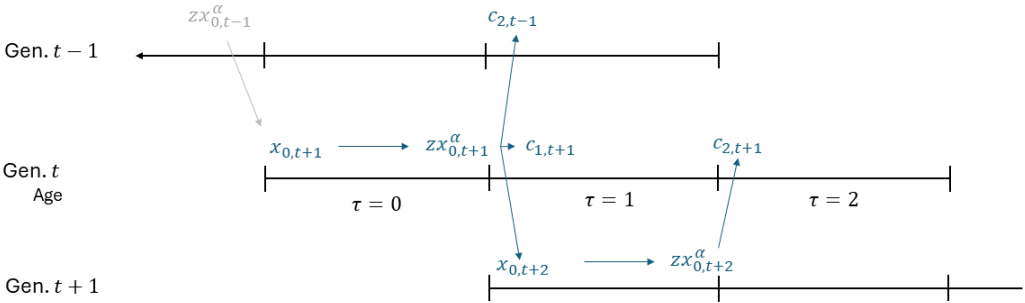
- ⋆ Discrete time, infinite horizon, OLG model with one consumption good.
- ⋆ Agents start as **producers** then become **log-utility consumers**:
  - ⋆ Age 0: born without resources but with technology: x_t goods $\mapsto y_{t+1} = z x_t^{\alpha}$ goods
  - ⋆ Age 1: produce and sell their goods, consume, repay or default on IOUs, and save.
  - ⋆ Age 2: consume and exit
- ⋆ Each age, agents choose trading technology $n \in \{o \text{ (open market)}, p \text{ (platform)}\}$
  - ⋆ Get i.i.d. extreme value "search" amenity from trading on n:

$$\zeta_\tau^{ni} \sim \underbrace{Gu(1/\gamma_\tau, \cdot)}_{\text{Agent specific}} + \underbrace{\log(\zeta^n)}_{\text{Technology specific}} \quad , \quad i \in [0,1]$$

  - ⋆ So γ_τ is the elasticity of substitution at age τ and ζ^n is technology trading advantage.

OLG: Production and Goods Flow

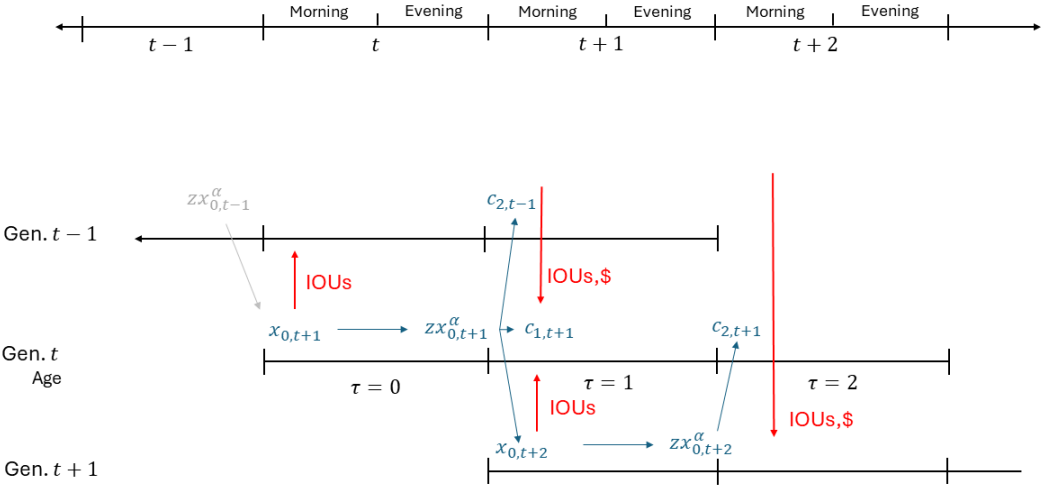




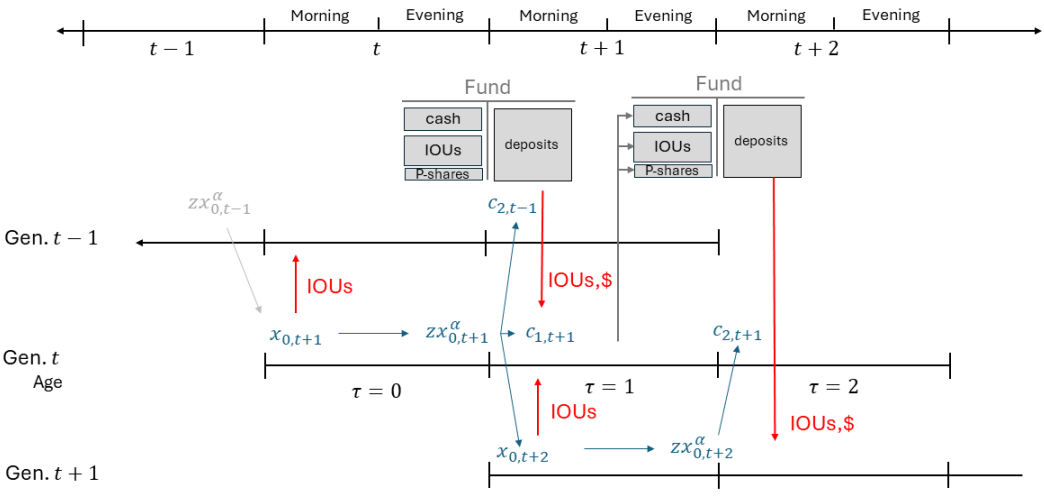
Environment Changes: Currencies

- Government now supplies money, $\bar{M}_t$, to the economy.
- The two payment technologies now **settle using financial assets**:
  - Spot transactions have a **resource-in-advance constraint**:
    - Fraction κ of payment must be made using public money and/or barter. ("cash-goods")
  - The digital ledger has **no** resource-in-advance **constraint**:
    - agents pay on ledger using tokenized claims to any non-risky future income on the ledger.
    - ("Ledger-IOUs", "credit-goods" or digital "bills-of-exchange")
- $\epsilon_t = \epsilon_t^o / \epsilon_t^p$ is price on marketplace dividend price on platform (real exchange rate)
- Continuum of competitive mutual funds that pool resources across agents:
  - Issue deposits, make loans, hold money reserves, and hold platform equity.
  - **Funds excluding defaulting agents** have **access to the platform and ledger**.
  - Funds accepting defaulting agents are blocked from the ledger.

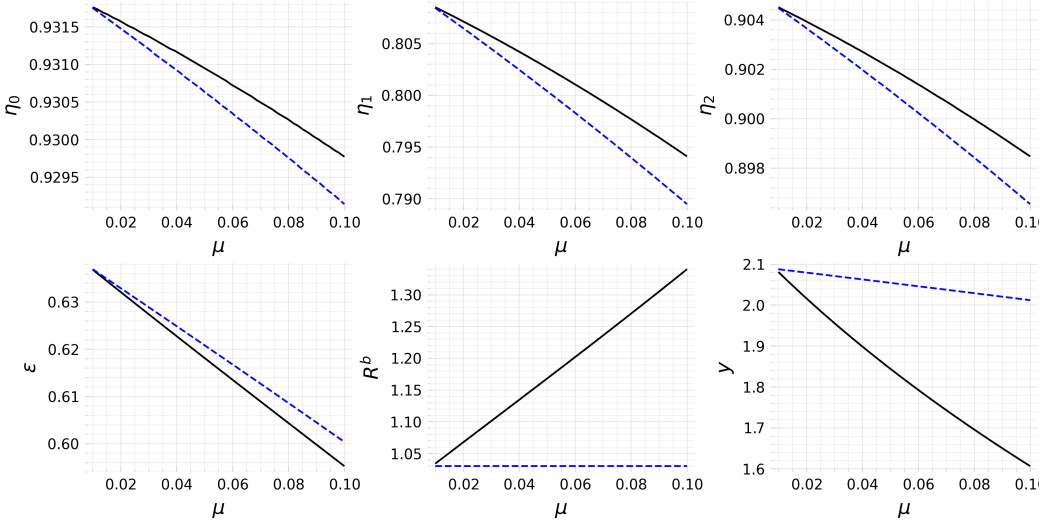
OLG: Payments Flow



OLG: Adding Funds



Equilibrium for Different Markup Policies



Black is general equilibrium. Blue is partial equilibrium with fixed interest rate.
Other variables are $z = 1$, $\alpha = 0.45$, $\beta = 0.9$, $\gamma_1 = 1.9$, $\gamma_2 = 1.5$, $\zeta = 1.0$, and $\kappa = 0.1$.

Platform Problem

The platform chooses a sequence $\boldsymbol{\mu}$ to maximise their equity price by solving problem:

$$q_0^s = \max_{\boldsymbol{\mu}} \left\{ \sum_{t=0}^{\infty} \xi_{0,t} \pi_t^s \right\} \quad s.t. \quad \text{Agent choices, Equilibrium prices,}$$

where $\xi_{0,t} = \prod_{j=0}^{t} (R_{j,j+1})^{-1}$ is the household SDF.

Cash Marketplace Disciplines Platform Markups if γ_2 is High.

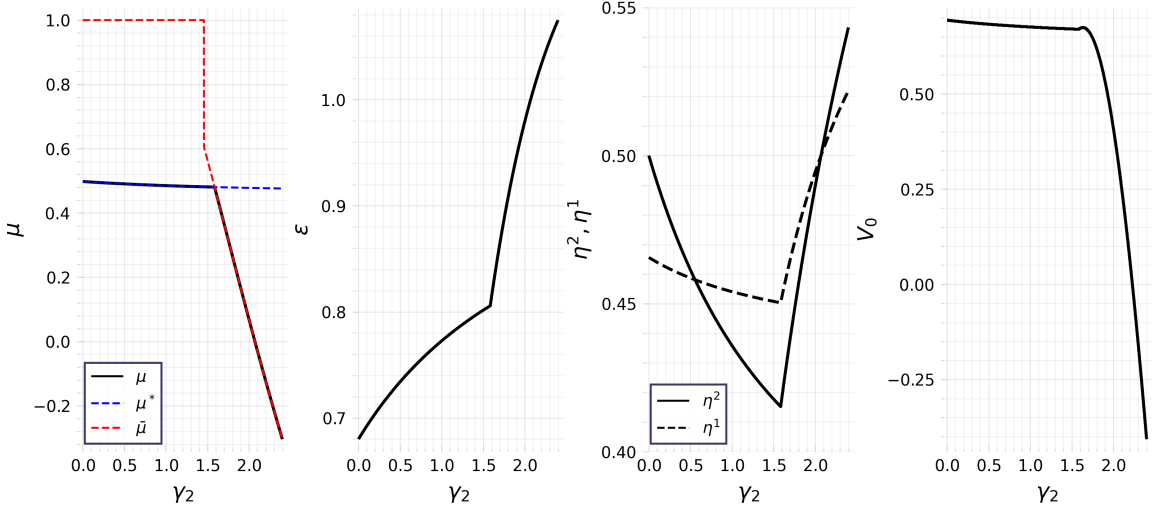


Figure: Steady state solution to platform problem for $\gamma_2 \in [0, 2]$.

Additional Lessons From The Macroeconomic Version

1. General equilibrium interest rate movements "lock-in" agents
   - ⋆ High markups encourage agents to trade on the public marketplace.
   - ⋆ This increases demand for cash, which limits loan supply and increases the interest rate.
   - ⋆ The higher interest rate increases the opportunity cost of holding cash and so partially offsets the markup disincentive to trade through the platform.
2. Having an unmonitored money storage technology disrupts the ledger system:
   - ⋆ Without cash, producers only ever receive IOUs as payment,
   - ⋆ And so they can never escape the ledger and default.
3. Public option (e.g. CBDC or broad FedNow) impact depends upon implementation:
   - ⋆ If the government creates a forced tender ledger, that must be used for all payments, then all contracts are enforced (recovers Kocherlakota (1998))
   - ⋆ If the government allows the platform to choose any payment technology, then the platform may respond by setting up its own token for hidden/defaulting trades.

Conclusion and Policy Takeaways

- ⋆ Dominant **platform** will provide a **ledger** and "back" a system of tradable IOUs.
- ⋆ **Coordinates** lenders **not to accept** agents who **default**ed on other lenders
- ⋆ **Cash-public market** may provide too much or too little competition.
- ⋆ **Lock-in effect** simplifies enforcement but increases rent extraction
- ⋆ Public option (e.g. **CBDC or broad FedNow**) impact depends on implementation

Thank you

References I

Aiyagari, S. R. and Wallace, N. (1991).
Existence of steady states with positive consumption in the kiyotaki-wright model.
The Review of Economic Studies, 58(5):901–916.

Kocherlakota, N. R. (1998).
Money is memory.
journal of economic theory, 81(2):232–251.