Coexistence of Money and Interest-Bearing Bonds

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Research question and motivation

Why should money and bonds coexist, and why may zero nominal interest rates be sub-optimal?

Topical debate on the distribution of assets in an economy:

- Gained momentum during the zero lower bound (ZLB) episode.
- Monetary theory prescribes optimality of the ZLB—the Friedman rule.

An important question in monetary theory: Why do money and bonds coexist, i.e., how can a mere savings instrument be useful in a monetary economy?

Contribution and key results

I construct and analyze a model of a monetary economy with:

- idiosyncratic shocks to agents' rate of time preference;
- information frictions rendering prefect insurance infeasible;
- bonds that can be traded for money once preferences are revealed.

Positive nominal rates imply a more efficient distribution of savings.

- Agents become constrained by their money holdings.
- Trade in financial markets arises.
- There is a net transfer of savings from impatient to patient agents.

When sufficiently many agents can trade in the financial market, the re-distributive effect dominates the negative in goods markets.

Related literature

Coexistence puzzle:

- Kocherlakota (2003), Shi (2008), Andolfatto (2011).

Sub-optimality of the FR:

- Shi (1997), Aruoba, Rocheteau, and Waller (2007), Nosal (2011).

Heterogeneous time preferences in monetary economies:

- Boel and Camera (2006), Boel and Waller (2019), Van Buggenum and Uras (2022).

Secondary financial markets:

- Duffie, Garleanu, and Pedersen (2005), Berentsen, Camera, and Waller (2007), Li and Li (2013), Geromichalos and Herrenbrueck (2016).

Heterogeneous asset valuations:

- Trejos and Wright (2016).

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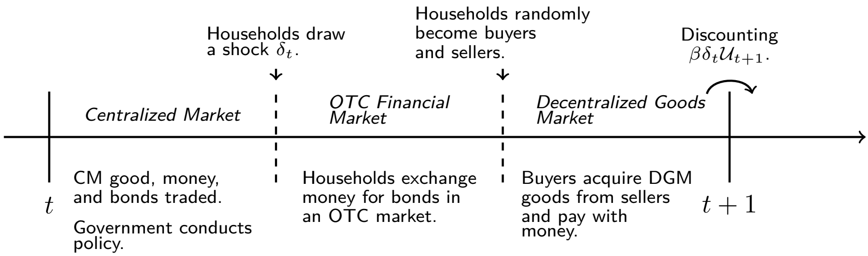
Core structure



- Time t is discrete and the horizon is infinite.
- Infinitely lived households and a government populate the economy.
- All goods are perfectly divisible and fully perishable.
- Government issues perfectly divisible fiat money and bonds.
- Agents trade in alternating markets as in Lagos and Wright (2005).

Actors

Unit mass of households with preferences recursively described by

$$\mathcal{U}_t = U(y_t) - \bar{y}_t + u(q_t) - \bar{q}_t + \beta\delta_t\mathcal{U}_{t+1}, \quad \beta \in (0,1).$$

- Consumption y and production $\bar{y}$ of a CM good.
- Consumption q and production $\bar{q}$ of a DGM good.
- Idiosyncratic δ_t, i.i.d. with $\delta^I < 1 < \delta^P$, $\mathbb{P}\{\delta = \delta^i\} = \pi^i$, and $\mathbb{E}\{\delta\} = 1$.

Government:

- Active only in the CM.
- Monopoly on money and nominal bond issuance.
- Can levy lump-sum taxes.
- Does not observe types.

Centralized market

Competitive market for CM goods (numeraire), money (price ϕ_t), and discount bonds (price ψ_t).

Households choose an optimal asset portfolio.

- CM good acts as transferable utility.
- Value function is linear in the real value of asset holdings: $W_t(m, b) = m + b + \overline{W}_t$. ▸ Details
- Optimal portfolio choices are the same across all housholds.

Government conducts policy:

- It controls money supply M_t and the face value of newly issued nominal bonds B_t
- It levies real lump-sum taxes to satisfy its budget constraint

$$\tau_t = \phi_t(M_{t-1} + B_{t-1} - M_t) - \psi_t B_t.$$

Decentralized goods markets I

Type-contingent value function

$$V_t^i(m,b) = \mathcal{L}^i(m) + \Delta_t^i + \beta\delta^i(m+b+\overline{W}_{t+1}), \quad i \in \{I,P\}.$$

Δ_t^i is value of becoming a seller and $\mathcal{L}^i(m)$ captures the value of money as a payment instrument when becoming a buyer.

- $\hat{m}^i$ is a type-contingent satiation level rendering liquidity constraints slack.
- $\mathcal{L}$ is increasing until the satiation level: $\mathcal{L}_m^i(m) \geq 0$, with "$>$" iff $m < \hat{m}^i$.
- $\mathcal{L}$ increases at a decreasing rate: $\mathcal{L}_{mm}^i(m) < 0$ for $m < \hat{m}^i$.

Assumption

Impatient households need higher real money balances than patient households to have slack liquidity constraints; $\hat{m}^I > \hat{m}^P$.

Decentralized goods markets II

Social surplus of the money balances as a payment instrument is

$$\mathcal{L}^i(m)/\theta^i(m), \quad \text{where} \quad \theta^i(m) \in (0,1].$$

- $\theta^i(m)$ captures the household's share of social surplus.

Assumption

The social surplus $\mathcal{L}^i(m)/\theta^i(m)$ is increasing in m.

OTC financial market

Matches between households with δ^I and δ^P, with transaction (l, a).

$$\mathcal{F}_{IP} = [\mathcal{L}^P(l+m) - \mathcal{L}^I(m)] + [\mathcal{L}^P(m-l) - \mathcal{L}^P(m)] \\ + \beta(\delta^P - \delta^I)(a-l) \\ \text{s.t.} -b \leq a \leq b \quad \text{and} \quad -m \leq l \leq m.$$

- Re-distribution of savings across heterogeneous agents.
- Focus on proportional bargaining with shares α^I and α^P.

Probability of finding a match with the opposite type is η^i.

- The indirect liquidity of bonds is captured by $\omega = \pi^I \eta^I = \pi^P \eta^P$.

Value of entering the OTC market given by the concave function

$$O_t^i(m, b) = \eta^i \alpha^i \mathcal{F}_{ij}(m, b; m', b') + \mathcal{L}^i(m) + \Delta_t^i + \beta\delta^i(m + b + \overline{W}_{t+1}).$$

Symmetric equilibrium

Definition

Given $\{M_t, B_t\}_{t=0}^{\infty}$, a symmetric equilibrium are CM portfolio choices and prices $\{m_t, b_t, \phi_t, \psi_t\}_{t=0}^{\infty}$ such that for all $t \geq 0$:

1. *Households maximize utility.*
2. *Markets clear; $m_t = \phi_{t+1} M_t$ and $b_t = \phi_{t+1} B_t$*

Private surplus of an OTC_t match is $\mathcal{F}(m_t, b_t)$ and the externalities on sellers are captured by $\mathcal{E}(m_t, b_t)$. ▸ Details

Lemma

Utilitarian welfare satisfies the recursive relationship $W_t = \mathcal{W}(m_t, b_t) + U(y^*) - y^* + \beta W_{t+1}$, where

$$\mathcal{W}(m, b) = \omega[\mathcal{F}(m, b) + \mathcal{E}(m, b)] + \pi^I \frac{\mathcal{L}^I(m)}{\theta^I(m)} + \pi^P \frac{\mathcal{L}^P(m)}{\theta^P(m)}.$$

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Stationary equilibria and DGM trade

Focus on stationary policies $\langle \gamma, \mathcal{B} \rangle$ in a stationary equilibrium

- γ is the growth rate of money supply,
- $\mathcal{B} = b/m$ is the bonds-to-money ratio.

Let $i^f = (\gamma - \beta)/\beta$ denote the Fisher rate and i^b the nominal return on bonds.

Lemma

All (m, b) can be implemented as a stationary equilibrium.

- *m is continuous in γ.*
- *$\hat{m}^I \geq m \Leftrightarrow \gamma = \beta$ and $\hat{m}^I < m \Leftrightarrow \gamma = \beta$.*
- *$0 = i^b = i^f \Leftrightarrow \gamma = \beta$ and $0 < i^b \leq i^f \Leftrightarrow \gamma > \beta$.*

Away from the FR,

- nominal rates are strictly positive;
- at least some liquidity constraints for impatient households are tight.

Stationary equilibria and OTC trade

Lemma

- $l = a = 0 \Leftrightarrow m \geq \hat{m}^I$.
- *When* $(\hat{m}^I + \hat{m}^P)/2 \leq m < \hat{m}^I$ *and* b *is sufficiently large, then* $a > l = \hat{m}^I - m$ *so that* $l + m = \hat{m}^I$ *and* $m - l \geq \hat{m}^P$.

At the FR, OTC trade vanishes.

For small deviations from the FR, impatient households are not yet satiated with liquidity.

Impatient households sell bonds at a discount to patient households, leading to

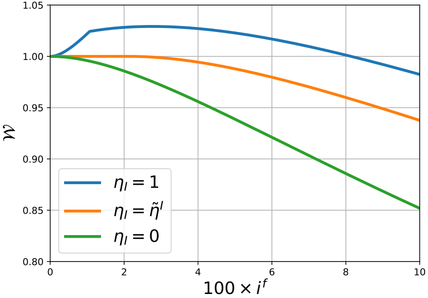
- a more efficient distribution of payment instruments;
- a more efficient distribution of savings instruments.

Mass $\pi(1 - \eta^I)$ of households face binding liquidity constraints in the DGM.

Sub-optimality of the Friedman rule

Proposition

There exists an $\tilde{\omega}$ such that the FR is sub-optimal iff $\tilde{\omega} > \omega$ and $b > 0$.



If $\omega > \tilde{\omega}$, endogenous optimal coexistence of money and interest-bearing bonds.

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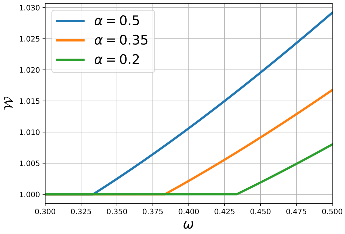
Indirect liquidity

Proposition

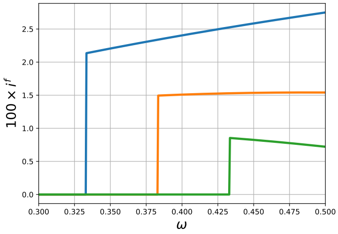
When policy is chosen optimally,

- *welfare is strictly increasing in ω if $\omega \geq \tilde{\omega}$;*
- *welfare is independent of small changes in ω if $\omega < \tilde{\omega}$.*

The effect of ω on optimal policy is theoretically ambiguous.



(a) Optimized welfare.



(b) Optimized nominal rate.

Direct liquidity

Extended model with notes to study the direct liquidity of assets:

- Notes can be transacted in all OTC meetings.
- Notes can be transacted in a fraction χ of DGM meetings.
- χ captures the direct liquidty of notes.

Proposition

In an economy with money and bonds, notes are inessential.

Proposition

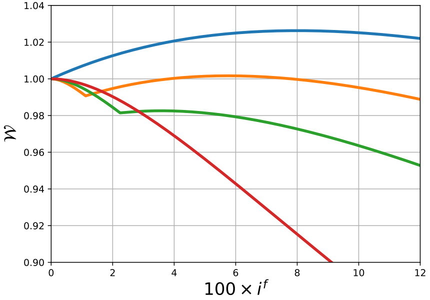
- *In an economy with money and notes, there exists a critical threshold $\tilde{\omega}_\chi$ to render the FR sub-optimal.*
- *In an economy with money and notes, welfare is globally decreasing in χ.*

Details

Walrasian financial market

Market clearing nominal rate ι_t.

The possibility of a liquidity trap ($\iota = 0$ while $i^f > 0$) changes the qualitative effects of deviating from the FR.



The FR is still sub-optimal when the financial market is well-developed.

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Conclusion

A theory that explains coexistence of money and interest-bearing bonds which incorporates:

- a role for the distribution of savings and payment instruments across HHs;
- optimally determined policies, abstracting from tax considerations.

Zero nominal rates maximize efficiency in goods markets but undermine financial markets' ability to provide insurance against preference shocks.

Centralized market

Households choose the real amount of money and bonds they carry into the OTC.

$$W_t(m_{-1}, b_{-1}) = \max_{y, \bar{y}, m, b} \left\{ U(y) - \bar{y} + \pi^I O_t^I(m, b) + \pi^P O_t^P(m, b) \right\}$$

$$\text{s.t.} \quad y + \tau_t + [\phi_t m + \psi_t b]/\phi_{t+1} \leq \bar{y}_t + m_{-1} + b_{-1}.$$

- With $y^* : U'(y^*) = 1$ sufficiently large, the non-negativity constraint on $\bar{y}$ is slack so that

$$W_t(m_{-1}, b_{-1}) = \max_{\{m,b\} \geq 0} \left\{ -[\phi_t m + \psi_t b]/\phi_{t+1} + \sum_{i \in \{I,P\}} \pi^i O_t^i(m, b) \right\}$$
$$+ m_{-1} + b_{-1} + U(y^*) - y^* - \tau_t.$$

◂ Back

Matches in the DGM

Surplus of a match between a buyer with δ^i and a seller with δ^j:

$$\mathcal{S}_{ij} = u(q) - q + \beta(\delta^j - \delta^i)p, \quad \text{s.t.} \quad p \leq m_i.$$

Price protocol $\upsilon_{ij} : \mathbb{R}^2_+ \to \mathbb{R}^2_+$ maps q into p—the value of money, expressed in CM $t+1$ goods, transferred from the buyer to the seller.

$$q = \begin{cases} \upsilon_{ij}^{-1}(m_i) & \text{if } m_i < \upsilon_{ij}(\hat{q}_{ij}) \\ \hat{q}_{ij} & \text{if } m_i \geq \upsilon_{ij}(\hat{q}_{ij}) \end{cases}, \quad \hat{q}_{ij} : \; u'(\hat{q}_{ij}) = \beta\delta^I \upsilon'_{ij}(\hat{q}_{ij})$$

Assumption

$u'(q)/\upsilon'(q)$ *is decreasing in* q.

Back

Surplus of potentially becoming a seller

Surplus of potentially becoming a seller in the DGM—Δ_t^i—is given by

$$\Delta_i^t = \pi^I \int \frac{[1-\theta^I(m')]\mathcal{L}^I(m)}{\theta^I(m')} \mathrm{d}G_t(m'|\delta^I) + \pi^P \int \frac{[1-\theta^P(m')]\mathcal{L}^P(m)}{\theta^P(m')} \mathrm{d}G_t(m'|\delta^P).$$

- $G_t(\cdot|\delta^j)$ is the conditional CDF of money holdings in DGM_t.

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Welfare contribution of OTC matches

In a symmetric equilibrium, private surplus of an OTC$_t$ match is

$$\mathcal{F}(m_t, b_t) = [\mathcal{L}^I(l_t + m_t) + \mathcal{L}^I(m_t)] + [\mathcal{L}^P(m_t - l_t) + \mathcal{L}^P(m_t)].$$

The effect on the surplus of sellers;

$$\mathcal{E}(m_t, b_t) = \left[\frac{[1 - \theta^I(l_t + m_t)]\mathcal{L}^I(l_t + m_t)}{\theta^I(l_t + m_t)} - \frac{[1 - \theta^I(m_t)]\mathcal{L}^I(m_t)}{\theta^I(m_t)} \right] + \left[\frac{[1 - \theta^P(m_t - l_t)]\mathcal{L}^P(m_t - l_t)}{\theta^P(m_t - l_t)} - \frac{[1 - \theta^P(m_t)]\mathcal{L}^P(m_t)}{\theta^P(m_t)} \right].$$

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Conditions

Condition

At the margin, liquid assets are more valuable for impatient that for patient agents: $\mathcal{L}^I_m(m) \geq \mathcal{L}^m_m$, $\forall m \geq 0$.

Condition

Surplus of sellers in a DGM match is increasing in consumption by buyers: $\mathcal{L}^I(m)[1-\theta^i(m)]/\theta^i(m)$ *is increasing in* m *for* $m \in [0, \hat{m}^i]$ *and* $i \in \{I, P\}$.

◂ Back