The Limits of onetary Economics

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Is the medium-of-exchange role of money relevant for Monetary Economics?

Current wisdom: Monetary Economics without M

Medium-of-exchange considerations are irrelevant for monetary transmission in modern high-velocity credit economies.

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Medium-of-exchange considerations are irrelevant for monetary transmission in modern high-velocity credit economies.

Based on two results:

1. Monetary equilibrium is continuous under a certain "cashless limit"
2. Real balances play small quantitative role in calibrations

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Based on two results:

1. Monetary equilibrium is continuous under a certain "cashless limit"
2. Real balances play small quantitative role in calibrations

Both rely on a class of reduced-form monetary models (CIA/MIU)

What we do

1. Develop a model
    - explicit about the roles of money and credit in exchange
    - can exhibit any transaction velocity of money
    - allows for market power in credit intermediation
2. Study monetary policy as velocity becomes very high

Main finding

Medium-of-exchange considerations are resilient and significant.

Main findings

Given financial frictions (credit intermediaries with *some* market power):

1. As the cash-and-credit economy converges to a pure-credit economy, the monetary equilibrium does not converge to the equilibrium of the economy without money.

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2. Effects of monetary policy remain large even as aggregate real money balances vanish along the cashless limit.

Main findings

Given financial frictions (credit intermediaries with *some* market power):

1. As the cash-and-credit economy converges to a pure-credit economy, the monetary equilibrium does not converge to the equilibrium of the economy without money.

2. Effects of monetary policy remain large even as aggregate real money balances vanish along the cashless limit.

$\Rightarrow$ Cashless economies are not good approximations to monetary economies—even high-velocity economies

Intuition

Money affects prices in transactions that do not involve money.

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Money affects prices in transactions that do not involve money.

- The *option* to engage in monetary trade disciplines the market power of financial intermediaries.

- *Off-equilibrium* small volume of monetary trades feeds back into the prices negotiated in all pure-credit nonmonetary transactions.

Related work

Leverage and asset prices

Kiyotaki and Moore (1997, 2005)

Strategic bargaining advantage from holding money

Zhu and Wallace (2007), Rocheteau, Wright and Zhang (2018)

Trade option as disciplining device for market power and mark-ups

Bhagwati (1965), Markusen (1981), Baumol (1982), Holmes et al. (2014)

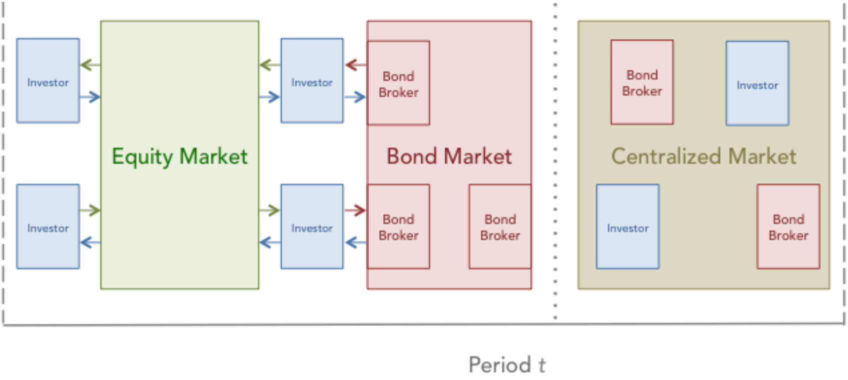
Value of resale options

Harrison and Kreps (1978)

Monetary policy in cashless and near-cashless economies

Woodford (1998, 2003), Galí (2008)

Preview


Investor
Investor
Equity Market
Investor
Investor
Bond Broker
Bond Market
Bond Broker
Bond Broker
Bond Broker
Investor
Centralized Market
Investor
Bond Broker
Period t

Environment

- *Time.* Discrete, infinite horizon, two subperiods per period
- *Population.* $[0,1]$ investors, $[0,1]$ brokers
- *Commodities.* Two divisible, nonstorable consumption goods:
  - *dividend good*
  - *general good*

Preferences

Brokers: $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t (c_t - h_t)$

Investors: $\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\varepsilon_t y_t + c_t - h_t\right)$

- ε_t : valuation shock, i.i.d. over time, cdf $G(\cdot)$ on $[\varepsilon_L, \varepsilon_H]$

Endowments and production technology

First subperiod

- A^s productive units (*trees*)
- Each unit yields y_t dividend goods *at the end of the first subperiod*

Second subperiod

- Linear technology to transform effort into general goods

Financial assets

Money

- $A^m_{t+1} = \mu A^m_t$, $\mu \in \mathbb{R}_{++}$ (implemented with lump-sum taxes)

Equity

- A^s equity shares

Bond

- issued by investors in first subperiod of t, repaid next subperiod
- 1 bond = claim to 1 unit of general good
- no commitment; if issuer defaults, bond holder appropriates fraction λ of the issuer's equity shares

Market structure | first subperiod: OTC trade

Two contemporaneous competitive markets

- bond market (bonds and money)
- equity market (equity and money)

Brokers

- always access bond market

Investors

- prob. α: access equity market *only*
- prob. $\alpha_c \equiv 1 - \alpha$: access equity market *and* contact a bond broker

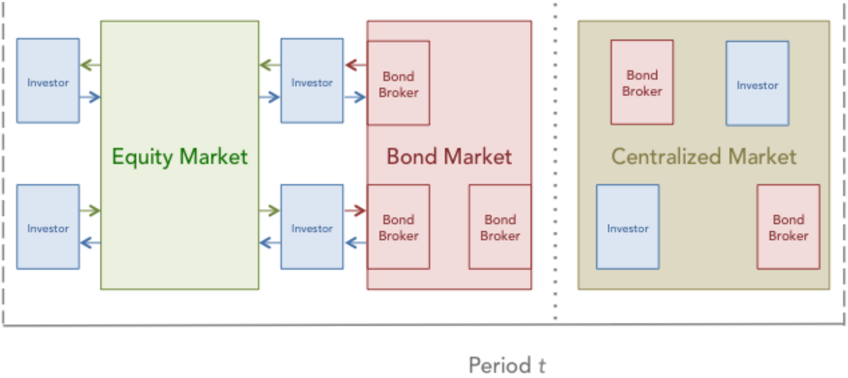
Bilateral terms of trade between investor and broker

- Nash bargaining (investor bargaining power θ)

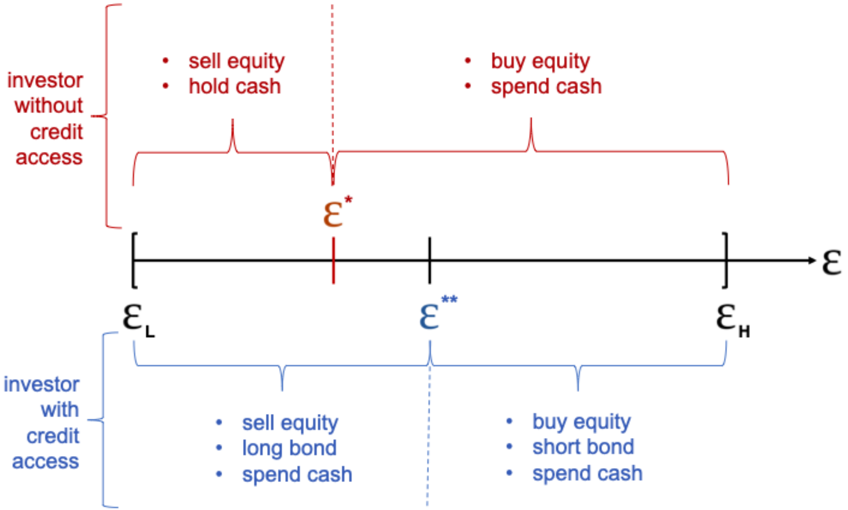
Market structure | second subperiod: centralized trade

- Walrasian trade between all brokers and investors
- equity, general good, money

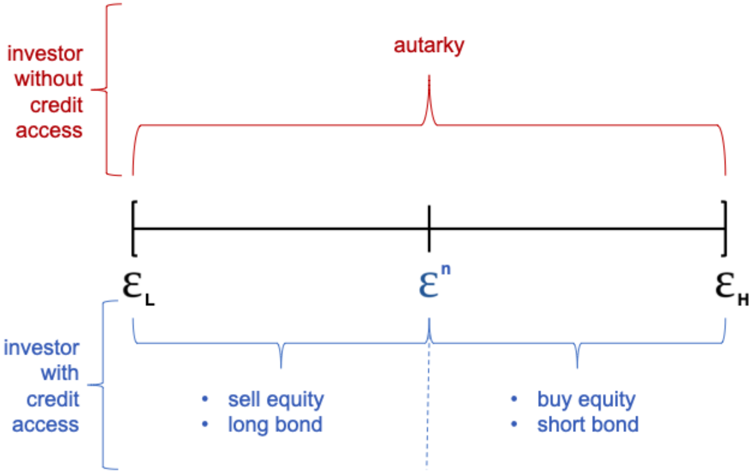
Timeline and market structure



Investor trade in the OTC market | monetary economy



Investor trade in the OTC market | nonmonetary economy



OTC trade | valued money | with credit access

$$\max_{(\bar{a}^m,\bar{a}^s,\bar{a}^b,k)\in\mathbb{R}_+^2\times\mathbb{R}\times\mathbb{R}_+} \Gamma_t(\boldsymbol{a},\varepsilon)^\theta k^{1-\theta}$$

$$\bar{a}^m + p_t\bar{a}^s + q_t\bar{a}^b \leq a^m + p_t a^s$$

$$-\lambda\phi_t^s\bar{a}^s \leq \bar{a}^b$$

$$0 \leq \Gamma_t(\boldsymbol{a},\varepsilon)$$

$$\begin{aligned}\Gamma_t(\boldsymbol{a},\varepsilon) \equiv\; & \varepsilon y_t\bar{a}^s + W_t(\bar{a}^m,\bar{a}^s,\bar{a}^b,k) \\ & -\left[\varepsilon y_t\hat{a}_t^s(\boldsymbol{a},\varepsilon) + W_t\left(\hat{a}_t^m(\boldsymbol{a},\varepsilon),\hat{a}_t^s(\boldsymbol{a},\varepsilon),0,0\right)\right]\end{aligned}$$

Euler equation

Euler equation | equity | monetary equilibrium

$$
\begin{aligned}
\phi_t^s \quad &= \beta \mathbb{E}_t \Bigg\{ \bar{\varepsilon} y_{t+1} + \phi_{t+1}^s \\
+ \quad & \alpha_c \theta \frac{\lambda \phi_{t+1}^s}{\bar{\phi}_{t+1}^s - \lambda \phi_{t+1}^s} \int_{\varepsilon_{t+1}^{**}}^{\varepsilon_H} \left(\varepsilon y_{t+1} + \phi_{t+1}^s - \bar{\phi}_{t+1}^s \right) dG\left(\varepsilon\right) \\
+ \quad & \alpha_c \theta \int_{\varepsilon_L}^{\varepsilon_{t+1}^{**}} \left[\bar{\phi}_{t+1}^s - \left(\varepsilon y_{t+1} + \phi_{t+1}^s \right) \right] dG\left(\varepsilon\right) \\
+ \quad & \Bigg\}
\end{aligned}
$$

Euler equation | equity | monetary equilibrium

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+ \quad & \left[\alpha + \alpha_c \left(1 - \theta\right) \right] \int_{\varepsilon_L}^{\varepsilon_{t+1}^{*}} \left[p_{t+1} \phi_{t+1}^m - \left(\varepsilon y_{t+1} + \phi_{t+1}^s \right) \right] dG\left(\varepsilon\right) \Bigg\}
\end{aligned}
$$

Nonmonetary equilibrium

Nonmonetary equilibrium

Proposition

There exists a unique RNE:

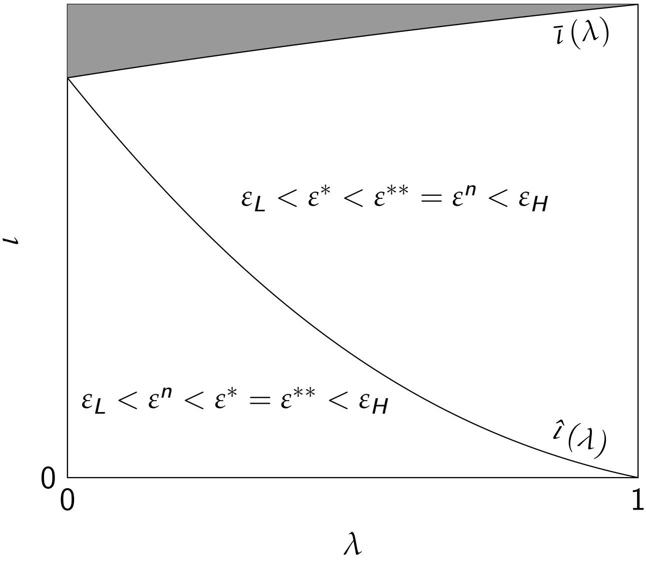
$$\varphi^n = \bar{\varepsilon} + \alpha_c \theta \left[\int_{\varepsilon_L}^{\varepsilon^n} (\varepsilon^n - \varepsilon)\, dG(\varepsilon) + \frac{\lambda}{1-\lambda} \int_{\varepsilon^n}^{\varepsilon_H} (\varepsilon - \varepsilon^n)\, dG(\varepsilon) \right]$$

$\varepsilon^n \in [\varepsilon_L, \varepsilon_H]$ *is the unique solution to*

$$G(\varepsilon^n) = \lambda$$

Monetary equilibrium

Monetary equilibrium | existence



Monetary equilibrium | existence | high policy rate

Proposition

If $\hat{\imath}(\lambda) < \imath < \bar{\imath}(\lambda)$, there exists a unique RME:

$$\varphi = \varphi^n + [\alpha + \alpha_c(1-\theta)] \int_{\varepsilon_L}^{\varepsilon^*} (\varepsilon^* - \varepsilon)\, dG(\varepsilon)$$

$\varepsilon^{**} = \varepsilon^n$ *and* $\varepsilon^* \in (\varepsilon_L, \varepsilon^n)$ *is the unique solution to*

$$\frac{[\alpha+\alpha_c(1-\theta)] \int_{\varepsilon^*}^{\varepsilon_H} (\varepsilon-\varepsilon^*) dG(\varepsilon) + \alpha_c\theta\left[\varepsilon^n - \varepsilon^* + \frac{1}{1-\lambda} \int_{\varepsilon^n}^{\varepsilon_H} (\varepsilon-\varepsilon^n) dG(\varepsilon)\right]}{\varphi^n + [\alpha+\alpha_c(1-\theta)] \int_{\varepsilon_L}^{\varepsilon^*} (\varepsilon^*-\varepsilon) dG(\varepsilon)} = \imath$$

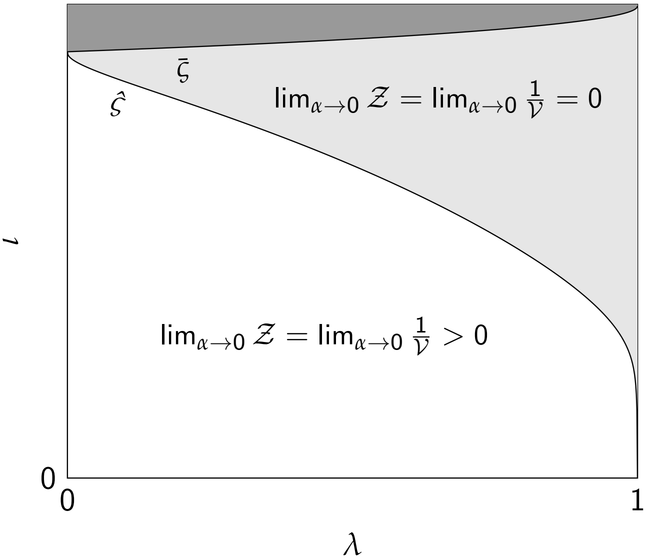
Cashless limit

Limit as fraction of cash-only trades goes to zero

- $\alpha = 1 - \alpha_c \in [0, 1]$: prob. of *not* accessing credit
- As $\alpha \to 0$, the equity price in the RNE converges to:

$$\lim_{\alpha \to 0} \varphi^n = \bar{\varepsilon} + \theta \left[\int_{\varepsilon_L}^{\varepsilon^n} (\varepsilon^n - \varepsilon)\, dG(\varepsilon) + \frac{\lambda}{1-\lambda} \int_{\varepsilon^n}^{\varepsilon_H} (\varepsilon - \varepsilon^n)\, dG(\varepsilon) \right]$$

What happens to monetary equilibrium as $\alpha \to 0$?



Limit as fraction of cash-only trades goes to zero

Proposition (high policy rate)

If $\hat{\varsigma} < \iota < \bar{\varsigma}$ (positive inside rate), then as $\alpha \to 0$,

$$\mathcal{Z} \to 0$$

$$\mathcal{V} \to \infty$$

$$\varphi \to \lim_{\alpha \to 0} \varphi^n + (1-\theta) \int_{\varepsilon_L}^{\varepsilon^*} (\varepsilon^* - \varepsilon)\, dG(\varepsilon)$$

where $\varepsilon^* \in (\varepsilon_L, \varepsilon^n)$ is the unique solution to

$$\frac{(1-\theta)\int_{\varepsilon^*}^{\varepsilon_H} (\varepsilon-\varepsilon^*) dG(\varepsilon) + \theta \left[\varepsilon^n - \varepsilon^* + \frac{1}{1-\lambda} \int_{\varepsilon^n}^{\varepsilon_H} (\varepsilon - \varepsilon^n) dG(\varepsilon)\right]}{\bar{\varepsilon} + (1-\theta)\int_{\varepsilon_L}^{\varepsilon^*} (\varepsilon^* - \varepsilon) dG(\varepsilon) + \theta \left[\int_{\varepsilon_L}^{\varepsilon^n} (\varepsilon^n - \varepsilon) dG(\varepsilon) + \frac{\lambda}{1-\lambda} \int_{\varepsilon^n}^{\varepsilon_H} (\varepsilon - \varepsilon^n) dG(\varepsilon)\right]} = \iota$$

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Intuition

Why the discontinuity as $\alpha \to 0$?

$$\lim_{\alpha \to 0} \frac{\mathcal{Z}}{\varphi} = \lim_{\alpha \to 0} \frac{1}{\mathcal{V}} = 0 < \lim_{\alpha \to 0} (\varphi - \varphi^n)$$

Why the discontinuity as $\alpha \to 0$?

$$\lim_{\alpha \to 0} \frac{\mathcal{Z}}{\varphi} = \lim_{\alpha \to 0} \frac{1}{\mathcal{V}} = 0 < \lim_{\alpha \to 0} \left(\varphi - \varphi^{n}\right) = \left(1 - \theta\right) \int_{\varepsilon_L}^{\varepsilon^*} \left(\varepsilon^* - \varepsilon\right) dG\left(\varepsilon\right)$$

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$$\lim_{\alpha \to 0} \frac{\mathcal{Z}/\varphi}{\alpha} = \lim_{\alpha \to 0} \frac{G\left(\varepsilon^*\right)}{1 - G\left(\varepsilon^*\right)\alpha} = \lim_{\alpha \to 0} G\left(\varepsilon^*\right) > 0$$

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$$\lim_{\iota \to \bar{\iota}(\lambda)} \frac{\mathcal{Z}/\varphi}{\alpha} = \lim_{\iota \to \bar{\iota}(\lambda)} \frac{G\left(\varepsilon^*\right)}{\left[1 - G\left(\varepsilon^*\right)\right]\alpha + \alpha_c} = 0$$

Quantitative analysis

Quantitative analysis

- The monetary equilibrium is not continuous under the cashless limit; is the discontinuity *quantitatively relevant?*
- Are these monetary frictions important for monetary policy transmission in modern high-velocity credit economies?

$\rightarrow$ Study monetary transmission to asset prices (well documented empirically)

Calibration

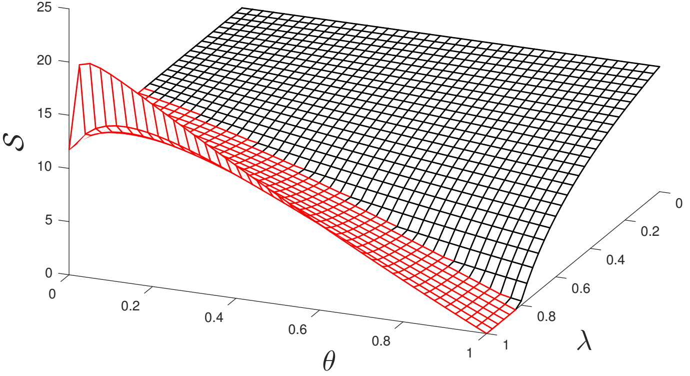
	variable	value	target
dividend process	$y_{t+1} = e^{x_{t+1}} y_t$ $x_{t+1} \sim \mathcal{N}\left(g, \Sigma^2\right)$	$g = .04$ $\Sigma = .12$	Ludvigson-Lettau (05)
asset depreciation	δ	.075	risk proxy
nominal policy rate	ρ^p	.0447	3-M ED future (94-08)
inflation rate	$\pi - g$	.0269	CPI inflation (94-08)
real risk-free rate	r	.0178	$\rho^p - (\pi - g)$
margin	$1 - \lambda$	.25	Rule 4210 (FINRA)
fraction with no credit	α	.04	$\mathcal{V} = 25$ daily (CHIPS)
broker market power	$1 - \theta$	.84	2.3% margin spread
idiosyncratic shocks	$\ln \varepsilon \sim \mathcal{N}\left(-\frac{1}{2}\Sigma_\varepsilon^2, \Sigma_\varepsilon^2\right)$	2.08	$\mathcal{S} \equiv \left\lvert \frac{d\phi^s/\phi^s}{d\rho^p} \right\rvert = 11$

Quantitative exercises

- Compute asset price responses to increases in ρ^p for all $(\alpha, \lambda, \theta)$
- Since response is negative, report the *absolute value of the semi-elasticity of the asset price to the policy rate, i.e.,*

$$\mathcal{S} = \left| \frac{d\phi^s / \phi^s}{d\rho^p} \right|$$

$\lim_{\alpha \to 0} \mathcal{S}$ as a function of λ and θ



Reduced-form models of money demand

Reduced-form money

The recursive equilibrium conditions of our model can be obtained from the following representation:

$$\max_{\{c_t, h_t, \boldsymbol{a}_{t+1}\}} \mathbb{E} \sum_{t=0}^{\infty} \beta^t \left[U\left(c_{1t}, c_{2t}\right) + c_t - h_t \right]$$

$$\text{s.t. } c_t + \phi_t^s a_{t+1}^s + \phi_t^m a_{t+1}^m = h_t + \left(\bar{\varepsilon} y_t + \phi_t^s\right) a_t^s + \phi_t^m a_t^m + T_t$$

$$c_{1t} = \frac{a_t^m}{p_t} y_t$$

$$c_{2t} = a_t^s y_t$$

Reduced-form money

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with

$$U\left(c_{1t}, c_{2t}\right) \equiv u^z c_{1t} + u^s c_{2t}$$

Reduced-form money

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Reduced-form money | first-order conditions

$$\varphi = \bar{\varepsilon} + u^s$$

$$\iota \geq \frac{u^z}{\varphi}, \text{ with " = " if } 0 < \mathcal{Z}$$

- Since u^s and u^z are treated as "deep" parameters:
  - φ determined independently of ι and money
  - $\mathcal{Z} > 0$ only if $\iota = \frac{u^z}{\varphi}$, and $\mathcal{Z} = 0$ if $\iota > \frac{u^z}{\varphi}$

$\rightarrow$ Monetary considerations are irrelevant

Reduced-form money | first-order conditions

$$\varphi = \bar{\varepsilon} + u^s$$

$$\iota \geq \frac{u^z}{\varphi}, \text{ with " = " if } 0 < \mathcal{Z}$$

- But u^s and u^z are *not* "deep" parameters...

$$u^s = [\alpha + \alpha_c (1-\theta)] \int_{\varepsilon_L}^{\varepsilon^*} (\varepsilon^* - \varepsilon)\, dG(\varepsilon) + \alpha_c \theta \left[\int_{\varepsilon_L}^{\varepsilon^{**}} (\varepsilon^{**} - \varepsilon)\, dG(\varepsilon) + \frac{\lambda}{1-\lambda} \int_{\varepsilon^{**}}^{\varepsilon_H} (\varepsilon - \varepsilon^{**})\, dG(\varepsilon) \right]$$

Reduced-form money | first-order conditions

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- But u^s and u^z are *not* "deep" parameters...
- The utility function *itself* changes with monetary policy

$$u^s = u^s(\iota)$$

Reduced-form money | first-order conditions

$$\varphi = \bar{\varepsilon} + u^s$$

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- But u^s and u^z are *not* "deep" parameters...
- The *shape of the utility function* depends on:
  policy, credit conditions, and mark-ups in financial markets

$$U\left(c, \frac{M}{p}; \iota, \alpha, \lambda, \theta\right)$$

Conclusion

Medium-of-exchange considerations are important for monetary transmission—even in near-cashless economies where credit supports a large volume of transactions with arbitrarily small real balances.

Thank you all

for Minnesota Economics