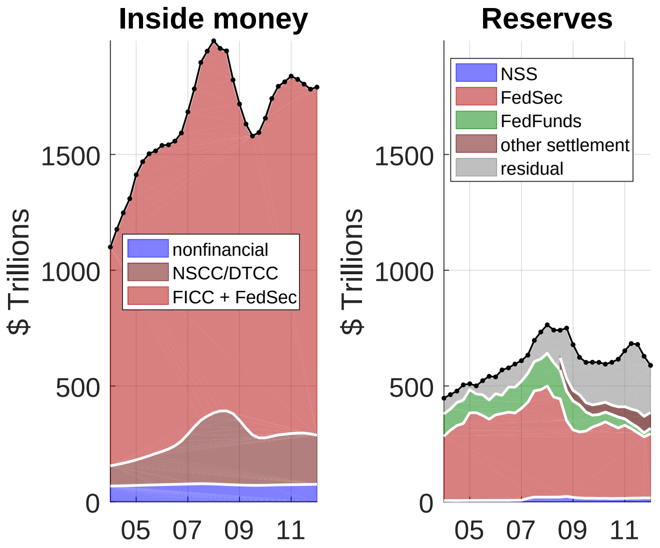
Payments, Credit & Asset Prices

Monika Piazzesi
Stanford, NBER, CEPR

Martin Schneider
Stanford, NBER, CEPR

National Bank of Belgium, December 2019

U.S. dollar payments; quarterly data at annual rates



Simple model of payments & asset pricing

- End users = households & institutional investors
  - pay for goods & assets with payment instruments = inside money
  - payment instruments = deposits, MMF shares, credit lines
- Banks handle payment instructions by end users
  - make interbank payments with reserves = outside money
  - liquidity management: hold reserves or rely on interbank credit?
  - capital structure: how much leverage?
- Two key features typically absent from monetary models
  - layered payment system: end users, banks
  - money demand from institutional investors

⇒ Questions
  - how does monetary policy affect asset & goods prices?
  - how do asset markets & payment system interact?

Implications

- Baseline: Lucas 1980
  - quantity equation connects outside money, output
  - asset prices reflect representative agent marginal utility

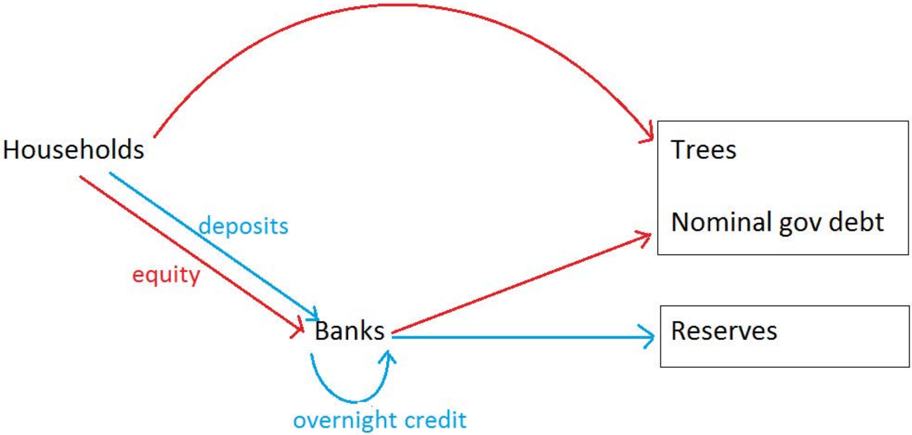
- This paper
  - quantity equation connects inside money, output + asset volume
  - intermediary asset pricing
    - banks value assets as collateral to inside back money
    - institutional investors value inside money to trade assets

- Asset prices, inside money supply & inflation jointly determined
  - asset market shocks $\rightarrow$ nominal price level
    - money supply: value of bank assets $\downarrow$, money multiplier $\downarrow$, deflationary
    - money demand from asset markets $\downarrow \sim$ velocity $\uparrow$, inflationary
  - monetary policy $\rightarrow$ (real) asset prices
    - supply: asset purchases make bank assets more scarce, prices $\uparrow$
    - demand: asset purchases increase cost of liquidity, prices $\downarrow$

Related Literature

- asset pricing with constrained investors
  Lucas 90, Kiyotaki-Moore 97, Geanakoplos 00, He-Krishnamurthy 12, Buera-Nicolini 14, Lagos-Zhang 14, Bocola 14, Moreira-Savov 14
- monetary policy & financial frictions
  Bernanke-Gertler-Gilchrist 99, Curdia-Woodford 10, Gertler-Karadi 11, Gertler-Kiyotaki-Queralto 11, Christiano-Motto-Rostagno 12, Brunnermeier-Sannikov 14, Jakab-Kumhof 15, Diamond 17
- banks & liquidity shocks
  Diamond-Dybvig 83, Bhattacharya-Gale 87, Allen-Gale 94, Holmstrom-Tirole 98, Bianchi-Bigio 14, Drechsler-Savov-Schnabl 14
- multiple media of exchange
  Freeman 96, Williamson 12, 14, Rocheteau-Wright-Xiao 14, Andolfatto-Williamson 14, Chari-Phelan 14, Lucas-Nicolini 15, Nagel 15
- interest on reserves
  Sargent-Wallace 85, Hornstein 10, Kashyap-Stein 12, Woodford 12, Ireland 13, Cochrane 14, Ennis 14

Model: only goods transactions require inside money



Model

- Constant aggregate output Y
  - bank trees yield fruit $x^b \leq Y$, can be held by banks
- Households
  - infinite horizon, linear utility, discount rate δ
  - can invest in trees, deposits, short bonds, bank equity
  - cannot borrow or hold reserves (= numeraire)
- Payments
  - consumption s.t. deposit-in-advance constraint $PC \leq D$
  - equilibrium deposit rate i^D low enough so constraint binds
- Flexible prices
- Many competitive banks
  - owned by households, maximize shareholder value
  - costless adjustment of equity

Banking sector overview

- Bank technology with constant returns to scale
- Payment system characterized by
  1. collateral ratio κ = risk-weighted assets / inside money
     $\rightarrow$ price of safe assets held by banks: short (real) interest rate
     more collateral, assets less scarce, prices lower, interest rates higher
  2. liquidity ratio λ = reserves / inside money
     $\rightarrow$ money multiplier $1/\lambda$, price level; lower λ, more broad money, inflation
  - both ratios lower end users' cost of liquidity
- Equilibrium balance sheet ratios lie on two curves
  1. liquidity management curve = banks' money demand schedule
     - hi κ, hi interest rate, opp cost of reserves, lower λ
  2. capital structure curve: ratios connected via accounting identities
     - e.g. narrow banks: assets = reserves, $\kappa = \lambda$

Bank balance sheet and cash flow

Assets		Liabilities	
M	Reserves	Deposits	D
F^+	Fed funds lending	Fed funds borrowing	F^-
B	Govmt bonds	Equity	
$Q^b\theta$	Bank trees		

- Bank cash flow

$$
\begin{aligned}
& M(1+i_R) - M' && -D(1+i_D) + D' \\
& +F^+(1+i) - F^{+\prime} && -F^-(1+i) + F^{-\prime} \\
& +B(1+i) - B' && \\
& +(Q^b + Px^b)\theta - Q^b\theta' && -c(\kappa)\left(D + F^-\right)
\end{aligned}
$$

Leverage cost

Assets		Liabilities	
M	Reserves	Deposits	D
F^+	Fed funds lending	Fed funds borrowing	F^-
B	Govmt bonds	Equity	
$Q^b\theta$	Bank trees		

- Bank cash flow

$$
\begin{aligned}
&M(1+i_R) - M' - D\,(1+i_D) + D' \\
&+(F^+ + B - F^-)(1+i) - (F^{+\prime} + B' - F^{-\prime}) \\
&+(Q^b + Px^b)\theta - Q^b\theta' - c\,(\kappa)\,\big(D + F^-\big)
\end{aligned}
$$

- Leverage cost c decreasing & convex in collateral ratio

$$
\kappa = \frac{M + F^+ + B + \rho Q^b\theta}{D + F^-}
$$

$\rightarrow$ assets valued as collateral, debt more costly as leverage $\uparrow$

Liquidity constraint

Assets		Liabilities	
M	Reserves	Deposits	D
F^+	Fed funds lending	Fed funds borrowing	F^-
B	Govmt bonds	Equity	
$Q^b\theta$	Bank trees		

- Liquidity shocks
  - bank enters period with reserves M, deposits D
  - $\tilde{\lambda}D$ = net funds sent to other banks (or received if $\tilde{\lambda} < 0$)
  - $\tilde{\lambda}$ iid across banks with $E\left[\tilde{\lambda}\right] = 0$, $\tilde{\lambda} \leq \bar{\lambda}$
- Bank liquidity constraint

$$\tilde{\lambda}D \leq M + F^{-\prime}$$

- Liquidity management
  - liquidity ratio $\lambda := M/D$
  - ex post: borrow only if liquidity ratio too low: $\lambda < \tilde{\lambda}$
  - ex ante: reserves provide liquidity benefit if $\lambda < \bar{\lambda}$

Equilibrium

- Government
  - path of nominal liabilities M_g, B_g and reserve rate i_R
  - lump sum transfers adjust to satisfy budget constraint
  - leverage costs depend on $(M_g + B_g)/$ tax base
- Market clearing: goods, reserves, overnight credit, deposits, trees
- Steady state
  - constant output Y, growth rate of $M_g, B_g =$ inflation π
  - after unanticipated shock, new steady state reached after one period

Characterizing steady state equilibrium

- Bank optimization
  - choose positions to equate MC equity = MB assets = MC debt
  - only liquidity & collateral ratios determinate, same for all banks

  → summarize role of payment system by (λ, κ)

- Nominal price level: quantity equation with money multiplier $1/\lambda$

$$PY = D = \frac{M}{\lambda}$$

- Prices of assets held by banks
  - related to κ by bank first order conditions

- Determination of equilibrium λ, κ
  - from bank FOC & balance sheet identities

Valuation of collateral benefits

- Bank FOC for short bonds

$$\underbrace{\delta}_{\text{return on equity}} = i - \pi + \underbrace{mb(\kappa)}_{\text{collateral benefit}}$$

  - marginal benefit of more collateral is positive $mb(\kappa) = -c'(\kappa) > 0$
  - diminishing as more collateral gets added $mb'(\kappa) < 0$
  - lower real interest rate on bonds: banks choose lower collateral ratio, increase leverage to maintain ROE

    $\rightarrow$ real interest rate $i - \pi$ and collateral ratio κ comove

- Intermediary asset pricing
  - standard Euler equation does not hold
  - banks value short bonds as collateral, households don't
  - endogenous market segmentation: all bonds held inside bank

Valuation of liquidity benefits

- Bank FOCs for short bonds, reserves

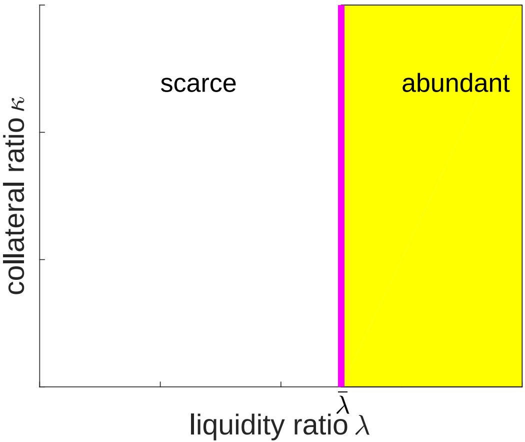
$$\delta = i - \pi + mb(\kappa)$$
$$\delta = i_R - \pi + mb(\kappa) + \text{Prob}(\tilde{\lambda} > \lambda) mcl(\kappa)$$

  - $i - i_R$ = liquidity benefit = exp. marginal cost of overnight borrowing
  - more collateral lowers marginal cost: $mcl'(\kappa) < 0$

- Since upper bound on liquidity shock, two regions in (λ, κ) plane
  - $\lambda < \bar{\lambda} \Rightarrow$ positive liquidity benefit
  - $\lambda \geq \bar{\lambda} \Rightarrow i - i_R = 0$, reserves and bonds perfect substitutes *for banks*

Scarce vs abundant reserves

- Plot liquidity and collateral ratio



- scarce reserves $\lambda < \bar{\lambda}$
  $=$ banks borrow
  if large deposit outflow

- abundant reserves
  $=$ banks never borrow

Valuation of liquidity benefits

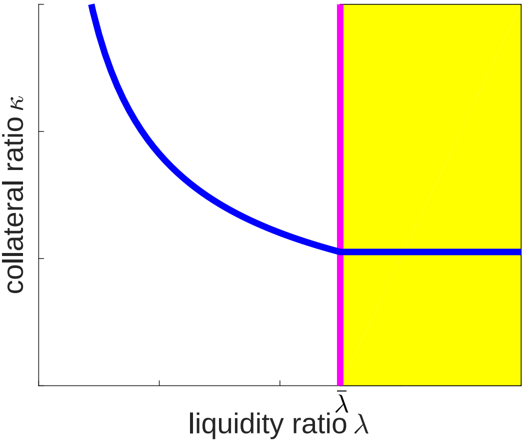
- Bank FOCs for short bonds, reserves

$$\delta = i - \pi + mb(\kappa)$$
$$\delta = i_R - \pi + mb(\kappa) + \underbrace{\text{Prob}(\tilde{\lambda} > \lambda) \; mcl(\kappa)}_{\text{liquidity benefit}}$$

- Liquidity management curve in (λ, κ) plane
  - "how many reserves are optimal given collateral κ"
  - slopes down: low collateral ratio $\kappa \Rightarrow$ high overnight borrowing costs $\Rightarrow$ high λ (won't borrow as often)
  - flat when reserves are abundant:
    banks are indifferent between reserves and bonds

Liquidity management curve

- How many reserves are optimal given collateral ratio κ?

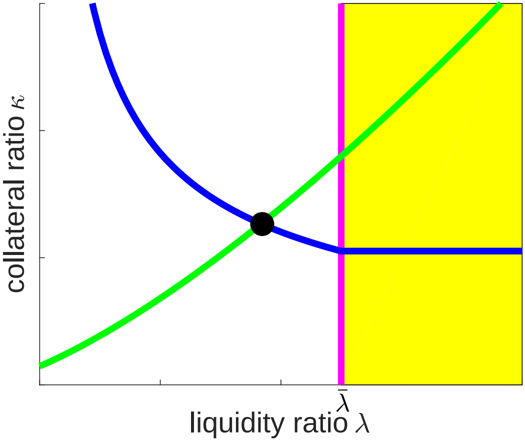


- "money demand":

  high collateral ratio
  $=$ high interest rate i
  $=$ high opp cost $i - i^R$
  $=$ low liquidity ratio
- "liquidity trap" for high λ
- shifts up if higher interest on reserves

Capital structure curve

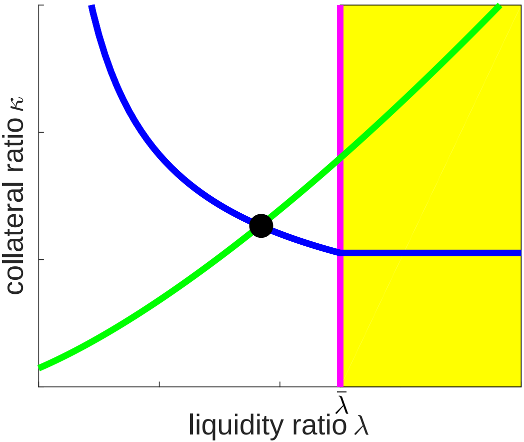
- Balance sheet relates liquidity ratio λ and collateral ratio κ
  - given other collateral available to banks, what λ needed to achieve κ?
  - curve slopes up: to get more collateral, add reserves



- narrow bank: $\kappa = \lambda$
- shifts right if lower value of bank trees

Equilibrium

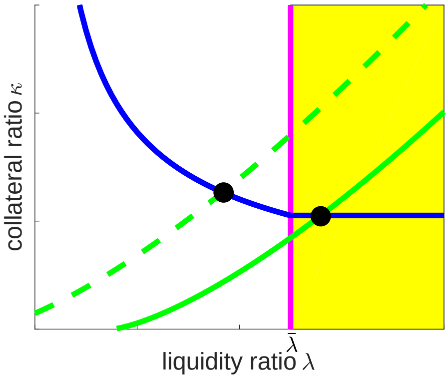
- Intersection of curves delivers steady state (λ, κ)
  - reserves can be scarce or abundant



- curves shift with policy, asset market shocks
- new steady state reached after one period
- read short-run price level response from $PY = M/\lambda$

Tighter money: central bank asset sale

- Sell bonds to banks in exchange for reserves
- CS shifts left: lower λ needed to maintain any collateral ratio κ

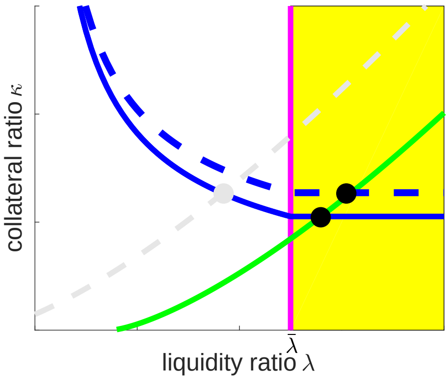


- bank ratios
  - higher κ, real rate
- inflation
  - lower reserves
  - higher money multiplier

  $\rightarrow$ overall deflationary
- financial structure
  - sale large enough to move to scarcity? if not, counteracting forces cancel
  - less netting helps

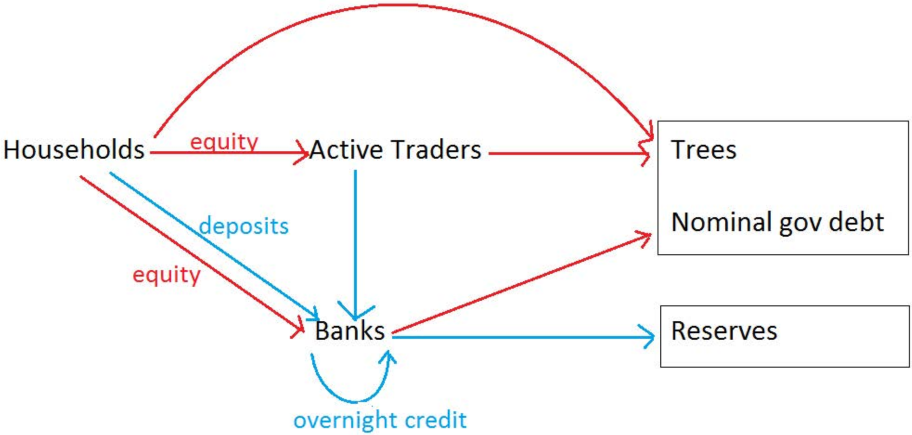
Tighter money: higher interest on reserves

- LM shifts up: banks hold more collateral at any λ
- here: same short rate as after bond sale, but higher λ



- bank ratios
  - higher κ, real rate
- inflation
  - lower money multiplier
  - reserves unchanged
  - $\rightarrow$ deflationary
- financial structure
  - more nominal collateral, steeper CS curve, less impact

Asset trades also require inside money



Active traders

- Households averse to Knightian uncertainty (ambiguity)
  - behave *as if* tree dividends drop by s percent next period
  - 1st order effects of uncertainty in steady state (Ilut et al. 2016)
- Active traders = competitive firms owned by household
  - issue equity, invest in deposits & subset of trees
  - each firm has favorite tree, identity changes every period
  - households perceive dividend drop $\hat{s} < s$ iff firm holds favorite tree
  - all trades must be paid with deposits or intraday credit
- Clearing and settlement with intraday netting
  - liquidity constraint

$$\hat{Q}\theta_t = I_t + \hat{D}_{t-1}$$

  - limit on intraday credit

$$I_t \leq \hat{\gamma}\hat{D}_{t-1}$$

  - limit binds if $i_D - \pi < \delta$, works like deposit-in-advance constraint

Equilibrium with active traders

- Value of tree traded by active traders

$$\hat{Q} = u\left(\hat{s}\right)\frac{P\hat{x}}{\delta + \frac{\delta-(i_D-\pi)}{1+\hat{\gamma}}}; \qquad u\left(\hat{s}\right) < 1$$

  - uncertainty premium $u(\hat{s}) < 1$ times present value of dividends
  - discount at higher rate if
    - ★ higher opportunity cost of deposits $\delta - (i_D - \pi)$
    - ★ lower netting efficiency $\hat{\gamma}$

- Share of inside money absorbed by active traders

$$\alpha\left(\kappa, \lambda\right) = \frac{\hat{Q}(1+\hat{\gamma})}{PY + \hat{Q}/(1+\hat{\gamma})}$$

  - higher if trees more valuable; decreasing in uncertainty $\hat{s}$
  - decreasing in opportunity cost of deposits $\rightarrow$ increasing in κ, λ

Asset prices & inflation with active traders

- Price level depends on institutional investors' money demand
  - lower if larger share of money absorbed by active traders

$$PY = \frac{M}{\lambda} \left(1 - \alpha\left(\kappa, \lambda\right)\right)$$

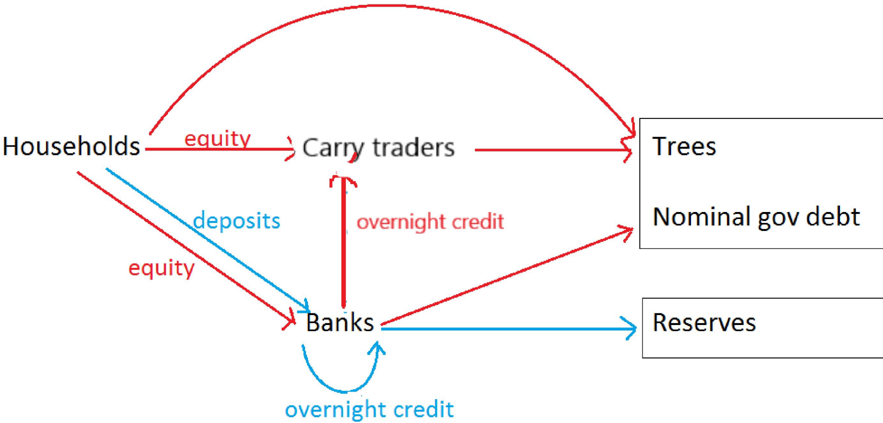
  - $1 - \alpha =$ velocity of inside money; moves with uncertainty $\hat{s}$

  $\rightarrow$ Lower inflation in asset price booms!

- Flatter capital structure curve
  - before: upward slope since banks want higher κ, need more λ
  - now also more deposit demand from active traders
  - even more λ needed $\rightarrow$ money multiplier drops more

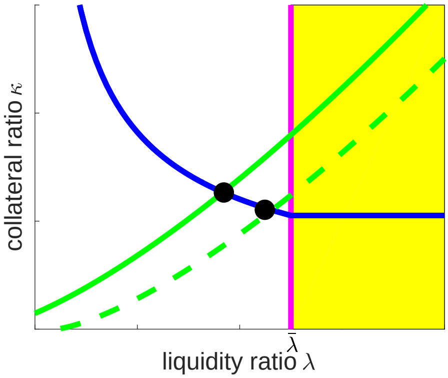
  $\rightarrow$ increase in reserve rate more deflationary

Extension: "carry traders" borrow from banks, hold trees



Bad shock to broker dealers

- Increase in leverage cost or uncertainty of trees
- CS shifts right: higher λ needed to maintain any collateral ratio κ



- dealer borrowing $\downarrow$
- less bank collateral
- need more λ
- money multiplier $\downarrow$

$\rightarrow$ deflationary!

Summary of implications

- Baseline: Lucas 1980
  - quantity equation connects outside money, output
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- This paper
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